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IS THE RIN MARKET EFFICIENT?

AN EVENT STUDY OF THE BLENDERS' TAX CREDIT

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ABSTRACT

The purpose of this study is to investigate if the Renewable Identification Numbers (RIN) markets have operated efficiently, a controversial and unexplored area in prior research. This is done through an event study of the retroactive introductions of the Blenders Tax Credit (BTC) and its effect on the RIN Credit Market, related commodity markets and relevant firm stocks.

The study applies a sample consisting of daily RIN prices from 2010-2017 for various RIN categories, with 14 identified events (stages) related to and including the retroactive introductions of the BTC. Further, the paper applies an event study methodology, with relevant adjustments and considerations made for the special characteristics of the markets under investigation and the regulatory nature of the events.

We find no evidence to reject the hypothesis of efficient RIN, related commodity and biofuel markets in their reaction to the BTC events. Additionally, the empirical results suggest a degree of market anticipation and information leakage to the BTC events. Last, we find indication that reactions vary based on the information content of the various legislative stages, with the largest reaction for stage 4 events, which are conclusive and final in their nature. This suggests ambiguity in the reaction to intermediate events leading to final policy outcomes.

These findings set the stage for further research on the novel RIN market, the effects of tax credits and their usefulness as a policy tool, in addition to exploration of similar credit markets.

Keywords: Renewable Identification Numbers (RINs), Blenders' Tax Credit (BTC), Event Study, Renewable Fuel Standard (RFS)

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ABBREVIATIONS

BTC – Blenders Tax Credit

CAA - Clean Air Act

EISA - Energy Independence and Security Act of 2007

EMTS - EPA moderated transaction system

EPA – Environmental Protection Agency

GHG (emissions) – Greenhouse Gas

OTC (market) – Over the Counter

RFS – Renewable Fuel Standard

RFS2 – Renewable Fuel Standard (extended)

RIN – Renewable Identification Number

RVO - Renewable Volume Obligation

SBO – Soybean Oil

SEC – Securities and Exchange Commission

SME – Soy Methyl Ester

SPR – Strategic Petroleum Reserve (U.S.)

VEETC – Volumetric Ethanol Excise Tax Credit

1. INTRODUCTION

Universally, it is necessitated by numerous governments that a minimum percentage of sold transportation fuels should contain biofuels. A 2007 FAO study posits that “virtually all existing laws to promote . . . biofuels set blending requirements, meaning the percentages of biofuels that should be mixed with conventional fuels” (Jull, Redondo, Mosoti, & Vapnek, 2007, s. 21). This focus is especially high on the agenda in the US, and in 2005, as a part of a push for increased use of biofuels, the Environmental Protection Agency (EPA) introduced the Renewable Fuel Standard (RFS), specifying an annual minimum blending requirement (mandates) for obligates parties in the US. This standard is enforced through a trading credit scheme, where credits, labelled Renewable Identification Numbers (RINs), are used as evidence of compliance with the blending requirement (Mcphail, Westcott, & Lutman, The Renewable Identification Number System and U.S. Biofuel Mandates, 2011). Originally, this was intended as a mechanism of pure compliance to achieve cost-effective and economic reductions in greenhouse gas (GHG) emissions (Lepone, Rahman, & Yang, 2011). However, over the last years, the mechanism has advanced in several directions. Investors looking to profit from these credits are now entering the market, and several scandals involving Wall Street banks and RIN fraud has been prevalent (Geberloff & Morgenson, 2013). Due to the newfound nature of this market there is scant literature available, and owing to this fact in combination with growing focus and scandals, there have been calls for increasing the amount of research on this new credit market.

Linked to the blending mandates, biofuel tax credits are similarly numerous worldwide. A 2007 World Bank study outlines that “among various support measures [for biofuels], fuel tax credits are most widely used” (Kojima, D, & Ward, 2007, s. 51). In relation to the RIN market, the Blenders Tax Credit (BTC) has been a hot topic of discussion, mainly centered on a debate of winners, losers and the effect on biofuels and feedstocks through supply and demand analysis. Little focus or analysis has, however, been placed on how the BTC affects the RIN credit market directly. In addition, the BTC has been allowed to expire and subsequently been retroactively reinstated. This, in turn has increased market uncertainty, complicating and further obfuscating the effect on RINs and its underlying pricing fundamentals.

Due to the above controversies, the unique characteristics of the RIN market and low market regulation, several observers have questioned if RIN markets have operated efficiently (Geberloff & Morgenson, 2013). Announcement and informational (event) studies have been performed on the European version of tradable credits, the EU Emission Trading System (ETS) and carbon prices, with various and largely inconclusive findings, ranging from lack of market efficiency to strong market effects, in part depending on the content of the announcement (Lepone, Rahman, & Yang, 2011). In an efficient market, market fundamentals and prices for input fuels are expected to determine the emission credit prices (Koch, Fuss, Grosjean, & Edenhofer, 2014). A consensus has emerged that emission credit prices are significantly linked to fuel prices and other variables affecting the likely amount of needed abatement, such as economic activity or policy changes. However, the relationship is not robust (Hinterman, Peterson, & Rickels, 2014)

As such, the aim of this thesis is to test whether the RIN market has fulfilled the conditions for a "rational" market in the customary economic logic of financial markets (Fama F. E., 1965). This is attempted by investigating the reactions to the retroactive introductions and related stages of the BTC at various dates, applying an event study methodology. We identify this as a gap in the current literature, and thus the research question that will guide this paper is:

"Is the market for RINs efficient, and how does it react to events leading to, and including the retroactive introductions of the Blenders Tax Credit?"

In addition, the paper examines the impact of the BTC introductions on underlying and connected variables of the RIN credits, namely feedstocks and biofuels, in order to increase the power of our research and results. Finally, we also report the impact of the BTC on a selection of biofuel firm stocks.

Previous studies have focused on the economic and welfare effects of the biofuel tax credits in addition to the RIN and biofuel market reactions of other regulatory events. However, to our knowledge, no research has been conducted on the financial effects and market reaction to the BTC on RIN, biofuel and feedstock returns in a strict event study fashion.

By performing this study, we hope to extend the limited literature available on the RIN market, the BTC and related variables. We believe improved information can be of great use to firms involved in the RIN and other similar markets, be it a blender, biofuel producer, importer or investor. Further, the findings of this thesis could aid governmental agencies in the design and implementation of similar policies in the future. Last, we aspire to provide insight into the efficiency of similar credit and trade markets that do not conform to the "standard security or commodity (spot, future or derivative) classification", thereby extending the applicability of the market efficiency hypothesis to new areas.

As the RIN market is multifaceted and largely complicated, additional variables and considerations, such as pricing determinants, the nested characteristics and RIN hierarchy could have been included and researched, however, such considerations are outside the scope of this study.

The remainder of the paper is organized as follows. In the next section we provide a concise background on the RFS and the RIN markets. In section 3, we compile the relevant research made on RINs, the BTC and other relevant areas. In section 4, we present our hypotheses. Subsequently, section 5 prescribes our sample after which section 6 outlines the applied methodology. Next, section 7 reports our findings and section 8 discusses and analyses the results in addition to providing relevant criticism. The last section concludes and provides some suggestions for future research.

2. BACKGROUND

In order to comprehend and research the retroactive introductions of the BTC and its financial effect on RIN returns, biofuels & feedstocks and producer & blender firm stocks, it is crucial to understand the framework under which the RFS operates and the tortuous nature of its main components. In addition, the background for the BTC and its link to the RIN credits and related variables needs to be established.

The following section covers the establishment of the RFS, the main changes having occurred after its founding and its scope. Next, we introduce the EPA, responsible for administration of the program, and the RIN credits as a currency for compliance. Subsequently the requirements for compliance and the RIN lifecycle is presented, including identification of obligated parties, before the history and background of the BTC is provided. All information is taken from the EPA Website (United States Environmental Protection Agency, 2017) (See EPA website for more extensive background)

2.1 THE RENEWABLE FUEL STANDARD

The Renewable Fuel Standard (RFS) was established as mean to increase the use of biofuels and to replace or reduce the use of petroleum-based transportation fuel, heating oil or jet fuel, for the purpose of reducing Greenhouse Gas Emissions (GHG). The standard was built on existing legislation, namely the Energy Policy Act of 2005, and later modified by the Energy Independence and Security Act of 2007 (EISA). In consequence, as the amendments took place, the RFS became referred to as RFS2, which was officially put into effect in mid-2010. The standard puts forth requirements (mandated volume levels) for a specified amount of renewable fuel that needs to be used as transportation fuel, heating oil and jet fuel each year.

2.2 THE ENVIRONMENTAL PROTECTION AGENCY AND RIN CREDITS

The Environmental Protection Agency (EPA) is the governmental agency responsible for the administration of the RFS. In order to ensure that mandated levels are met, the EPA has established an exhaustive compliance system; a tracking system based on Renewable Identification Numbers (RINs). These RINs serve as credits for blending requirement compliance purposes, and are also traded amongst parties to promote efficiency and keep the overall costs of complying with the standard at a minimum. There are four main categories of RIN Credits, namely D3/D7, D5, D4 and D6. Each category of credits corresponds to a different fuel pathway, meaning it can be used to show compliance for blending a different kind of biofuel. There are different vintages (for each of the 4 main categories), referring to the year in which a particular RIN materialized. RINs have a limited life-span for which it can be used for compliance, and as such newer RINs are assigned a higher value than older RINs. Further, based on the type of biofuel and its resulting level of GHG emission, there is a nested nature of compliance, meaning some RINs can be used for compliance in several fuel categories and as such are also assigned a higher worth.

2.3 COMPLIANCE

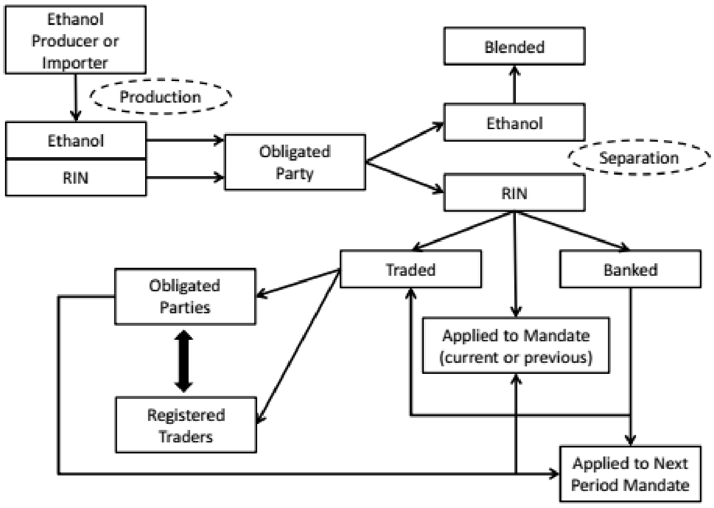
Who are required to comply and how do they meet the volume requirements? Each year the EPA specifies a Renewable Volume Obligation (RVO) for each of the fuel pathways based on calculations of what the overall fuel consumption is estimated to be and how the market for biofuels is progressing. Essentially, the RVO shows how much of biofuel needs to be blended into the fuel pool. Obligated parties, who are refiners or importers of gasoline or diesel fuel within the USA, then have to meet this RVO. As described above, each fuel pathway has its own separate RVO, which is a percentage amount.

Obligated parties can show their compliance in two ways; either the obligated party can blend biofuel into its fuel pool to obtain Renewable Identification Numbers (RINs), or it can purchase RIN credits from the market. In both cases, RINs are involved and obligated parties are required to retire a sufficient amount of RINs to meet its RVO in each of the fuel pathways. The idea behind RINs is to have a "currency" for the RFS program. Primarily, RINs are intended for meeting the RVO; however, as we outlined earlier, RINs are also traded on the market.

2.4 THE RIN LIFECYCLE

A RIN is generated when a gallon of biofuel is produced or imported to the USA. Each RIN is always attached to a specific gallon of biofuel with a 38-digit identification number. Once a gallon of biofuel is blended with fuel the RIN of that gallon is separated and can be used for compliance purpose. Depending on the obligated parties' preferences, obligated parties that engage in the production of biofuels benefit from the flexibility of the RIN system. For instance, if there is a shortfall in production they can then purchase needed RINs from the market, or in case of a surplus, they are able to sell excess RINs to the market. On the other hand, obligated parties, who do not wish to engage in the production or blending of biofuels, can purchase RINs from other market participants that produce or obtain an excess of RINs.

FIGURE 1 – RINs Generation to Retirement (From Paulson, 2012)



The above figure shows the lifecycle of a RIN. In general, RINs can take a few different paths; if not used directly for compliance for the given year, they can either be banked for later compliance or traded on the market.

All RIN transactions, whether creating, retiring, selling or buying, are recorded in the EPA moderated transaction system (EMTS). The EMTS is an Over the Counter (OTC) market, controlled and administered by the EPA, with barely any regulation, except for its restrictions on its market participants. The market participants include obligated parties, renewable fuel exporters and producers, as well as registered RIN market participants. According to the EPA, participants negotiate RIN trade agreements outside EMTS, and EMTS only matches trades and transfers RINs between accounts.

2.5 THE BLENDERS TAX CREDIT

The blenders' tax credits are offered to promote the blending of ethanol, biofuel and renewable fuel into the existing fuel pool (Yacobucci, 2012). They are offered to the party that blends the particular biofuel with the conventional fuel, be it a producer or a blender. Since the tax credits were established in 2005 by the American Jobs Creation Act of 2004 and by the EPA act of 2005, the tax credits for biodiesel and renewable diesel have expired five times and have been reinstated retroactively four times. Most recently, the tax credits expired in the end of last year (2016) and have not yet been reinstated. This short-termism of the tax credits as well as the uncertainty around whether there will be a tax credit is troublesome as the future growth of the biofuel industry is severely dependent on them (Kruse, et al., 2007). The three different types of tax credits that have been in place are outlined in the table below. Note that we provide information on the Volumetric Ethanol Excise Tax Credit, despite it is not the focus of our research, but to allow for a more comprehensive understanding of the complex field.

TABLE 1 – Biofuel Blenders' Tax Credits (From Yacobucci, 2012)

NAME	**DESCRIPTION**	**QUALIFIED APPLICANT**	**TIMES IN EFFECT**
BIODIESEL TAX CREDIT	Biodiesel producers (or producers of diesel/biodiesel blends) can claim a per-gallon tax credit through the end of 2011. The credit is valued at $1.00 per gallon. Before amendment by P.L. 110-343, the credit was valued at $1.00 per gallon of "agri-biodiesel" (biodiesel produced from virgin agricultural products such as soybean oil or animal fats), or 50 cents per gallon of biodiesel produced from previously used agricultural products (e.g., recycled fryer grease).	Biodiesel producers and blenders	2007-2009, R2010-2011, R2012-2013, R2014, R2015-2016 **R stands for retroactively*
RENEWABLE DIESEL TAX CREDIT	Producers of biomass-based diesel fuel (or producers of diesel/renewable biodiesel blends) can claim $1.00 per gallon tax credit through the end of 2011. Renewable diesel is similar to biodiesel, but it is produced through different processes and thus is ineligible for the (above) biodiesel credits.	Renewable diesel producers and blenders	2007-2009, R2010-2011, R2012-2013, R2014, R2015-2016 **R stands for retroactively*
VOLUMETRIC ETHANOL EXCISE TAX CREDIT (VEETC)	Gasoline suppliers who blend ethanol with gasoline are eligible for a tax credit of 45 cents per gallon of ethanol through the end of 2011. VEETC included also a 54 cents per gallon tariff on ethanol imports	Blenders of gasohol (i.e., gasoline suppliers and marketers)	2005-2010, extended 2011

Having established the background for the RIN market and the BTC, we move on to highlighting relevant studies for our topic and research direction.

3. LITERATURE REVIEW

This section presents and discusses the literature of highest relevancy for our study, highlighting the bearing it has on our paper and the research question guiding it. Furthermore, it provides a backdrop and identifies what we can expect given previous investigation, and allows us to hypothesize potential and expected outcomes and form our arguments. Owing to the fact that there is limited financial RIN specific literature, we combine findings from various strands of financial research to construct our hypotheses.

The following literary areas will now be covered. First, the available theory on RIN price determinants is covered, before the BTC credit and its effects are discussed. Next, we cover the only event study performed on the RIN market and its results, before presenting regulatory nature event studies and their effect on commodity and stock returns. The section ends with a presentation of literature and findings on the most comparable market to date, the EU Emission Trading Scheme credit market.

3.1 RESEARCH ON RIN PRICE DETERMINANTS

Thompson et al. (2009a&b, 2010) outline the aspects of how the RIN price is determined. In their research, they theorize about the components and sub-components that make up the RIN price. Essentially, they show that the RIN price is based on the price of underlying feedstocks, corresponding biofuel and conventional fuel prices, as well as the level of compliance required by the mandate. Further, it has been established that the RIN price is made up of three main components: a core value, transaction costs and speculative costs. For further discussion on RIN pricing fundamentals, we refer to other research papers establishing and complementing research on RIN pricing fundamentals and determinants, such as Thompson, et al. (2009a&b, 2010), McPhail (2010), McPhail, et al. (2011), and Guidice (2013).

As there are multiple categories for RINs it is recognizable that the price components vary between them. As a result, few researchers have taken to the task of further rendering the prices. McPhail et al. (2011) hypothesize that as the RIN prices increase, and the overall incentive to produce and engage in biodiesel production increases, the demand for biodiesel increases, which results directly in a rise in soybean oil and other competing feedstocks. More recently, Irwin (2014a) shows that the D4 RIN price positively correlates with the respective biodiesel, soy methyl ester (SME) prices. In addition, he establishes by Granger-causality that SME is led by its major feedstock, the soybean oil (SBO), which is not surprising as SBO constitutes over 80% of the general production costs for SME (Irwin, 2015).

As stated earlier, policies have a significant bearing on RINs, and as such, the BTC has a direct impact on specific RINs. Irwin (2014b, 2015) demonstrates that investors price the probability of the BTC in the RIN prices. He illustrates that in theory, when the BTC becomes retroactively reinstated, it will decrease the RIN prices, more specifically the D4 RINs.

Research on D6 RINs has found similar results. As corn is the main feedstock for ethanol, decreases in corn price cause the price of ethanol to decrease, which in turn depresses RIN prices (McPhail et al. 2011; McPhail, 2012; and Babcock, 2012). Research on the tax credit offered for ethanol blenders' in the past has shown that as the tax credit increases the demand for ethanol, the supply of RINs increases, and as such the RIN prices decreases (McPhail & Babcock, 2012; McPhail, 2012).

3.2 THE BLENDERS TAX CREDIT

Taheripour and Tyner (2007) explore the occurrence and outcome of the ethanol subsidy in an analytic framework, finding that the ethanol industry receives most of the ethanol tax credit, with potential for eventual effect on fuel prices. Babcock (2008) finds the policy to cause large transfers and large welfare losses, with current subsidies having modest impact on supply and demand prices. Kruse et al. (2007) theorize that future growth in biofuels depends severely on the extension of the tax credits, and that commodity prices will fall without such extensions. However, Abbott (2014), taking a different route, develops a simple analytic model of corn supply, ethanol production, and gasoline blending and uses short-term data on supply, use, and prices to explain the mechanisms through which biofuel demand influenced corn and other agricultural commodity prices over the period of 2005-2012. The focus of the paper is on investigating how and at which points in time a variety of policy-induced constraints influenced the behavior of agricultural and biofuels markets over the time period. The paper highlights, in part, that policies such as the RFS and Tax Credits have contributed to higher market prices and volatilities (Abbott, 2014).

The difference between what the RIN price is with and without the tax credit should equal exactly the BTC. However, in the real world, it would be just a coincidence if this would be true (Babcock B. A., 2010). It is therefore important to understand the existing literature on how the BTC affects the RIN prices. Essentially, if there was no BTC then RIN prices would be higher as a result, since it would impair the ability to meet the RFS mandate (Thompson, Meyer, & Westhoff, The New Markets for Renewable Identification Numbers, 2010). In contrast, if the BTC is in place it will make blenders more willing to blend biofuels. McPhail, et al., (2011) show that the demand curve shifts upwards when the BTC is in place, which in turn causes a reduction in the core value of RIN. On the other hand, if the mandated level were below the equilibrium price (i.e. non-binding mandate) then RIN prices would be zero, ignoring transaction and speculative costs. In this case, the BTC would only increase the amount of blending and leave RIN price unchanged at zero. As presented in the background & history section, the BTC has been reinstated retroactively four times, which has caused the market to experience periods in which no BTC is present. The lack of BTC during these periods has not, however, been fully reflected in the RIN prices. The most likely reason for this is that the market anticipates that the BTC will be reinstated retroactively (Irwin S. , Understanding the Behavior of Biodiesel RIN Prices, 2014).

3.3 RINS, BIOFUELS AND THE EFFECT OF REGULATORY CHANGES AND EVENTS

Lade et. Al (2016) investigates specific policy shocks and market based regulations, and their resulting effect on RIN markets and RFS compliance costs. In detail, they make three main contributions to the literature. By developing a dynamic model of RFS2 compliance they show how changes in expectations about future policy affects current compliance costs for blenders/producers, and through a market efficiency test, show how the market for RINs has operated efficiently, concordant with the predictions of their conceptual model. Last, and perhaps most importantly, through an event study, the authors estimate the empirical effect of three “policy shocks” that reduced the expected mandates in 2013, and detail how these events led to large decreases in RIN prices. It should be noted that this is the only study performed on the RIN market in a strict event study fashion, and due to its “working paper” status, we are careful in drawing conclusions from it and do not take any inspiration from its methodological approach and suggestions.

3.4 EVENT STUDIES OF COMMODITY RETURN IMPACT

Demirer and Kutan (2010) investigate the “informational efficiency” and behavior of the crude oil spot and futures markets. They do so by examining abnormal returns around two categories of oil-related events, from 1938 to 2008. They suggest that the market is efficient for Strategic Petroleum Reserve (SPR) announcements and OPEC production increase announcements, while recording a significant market reaction to production cut announcements. Draper (1984) scrutinizes the behavior of heating oil futures around both known and unknown OPEC events (meetings), discovering that the market reacted and adjusted slowly to information or a possible misestimate of the informational impact. In addition, Deaves and Krinsky (2009) examine the behavior of crude and heating oil future prices around OPEC conferences, testing if the market reaction to these events are in line with the reactions prescribed by the efficient market hypothesis. They find that if investors took long positions in oil futures on the day following the end of the conferences associated with good news, they were able to generate substantial positive and abnormal returns.

Milonas (1987) bases his study of the effects of USFA Crop Announcements on Commodity Prices on the idea that equilibrium prices are determined by information driven commodity markets. He states that if markets are active, any information will be quickly dispersed amid market actors, who determine a fair price through trading. Further, he hypothesizes that commodity prices will reflect information not publicly announced by governmental agencies, but instead effectively anticipated by private actors, suggesting semi-strong market efficiency of commodity markets. For additional studies we refer to Schroeder et al (1990), Patterson and Brorsen (1993), whom examine the effects of government announcements and reports on daily commodity cash or futures price changes.

3.5 EVENT STUDIES OF STOCK RETURN IMPACT

Bushnell et. Al (2013) investigate how regulation on the EU cap and trade market affects the profits in major industries and firms through performing an event study. They find that stock prices fell for firms in both carbon- and electricity-intensive industries. Further Ayres (1987) analyses and empirically tests the effects of the introduction of investment tax credits on security returns. He finds a statistically significant relationship between abnormal security price performance and the level of tax credit benefit received (lost) as a result of changes in the legislation. This indicates that the investment tax credit was associated with short-term gains and losses among equity holders of the affected firms (Ayres, 1987).

3.6 EVENT STUDIES OF THE EU ETS

The RINs and EU ETS credits share certain important market and credit characteristics, central for hypothesizing about the outcome of similar event studies on the RIN market and in evaluating its efficiency. Due to, in part, the “asset” being a product of legislation, with supply and demand operating within governmental ruling constraints, there is a political risk not present in other markets to similar extent. Indeed, as argued by Gronwald & Ketterer (2012) various studies show that markets subject to political influences are more likely to exhibit extreme price movements (Jorion, 1988). As outlined, due to the market characteristics there is also a possibility for increased leakage and insider trading. Overall Lepone et al. (2011) argues that this introduces a large degree of information asymmetry into the market. Further, they empirically examine to which extent participants in the carbon market identify various policy announcements related to the EU ETS as containing informational value. Their findings point to systematic leakage of information across all types of announcements**.**

Mansanet-Bataller et al. (2007) study the effect of various policy related information releases on prices, and document significantly higher returns on days when the European Commission released additional information and approved National Allocation Plans (NAP)[1]. Studying the same announcements Mi-clăuş et al., (2008) find that verifications material announcements exerted a greater influence on market dynamics than NAP announcements, pointing to various market effects depending on the policy information content. In a similar vein, Rotfuß et al., (2010) find that the EU ETS is not fully informationally efficient, while Chevailler et al., (2009), studying the impact of the 2006 emission verification announcement, find in part that Phase I verification information has a strong market effect[2].

Based on the presented literature and its findings, we now present our hypotheses and subsequently sample collection and methodology.

4. HYPOTHESES

As ethanol tax credits are no longer present in the marketplace, the current BTC directly impacts the RINs that are derived from the fuels subsidized by the BTC, which are the fuel pathways that create D4 and D5 RINs. When in place, the BTC functions, alongside with the RFS mandate, to incentivize the blending and production of biofuels. However, when both systems are in place the BTC works against the incentive system of the RFS, the RINs. Based on the previous research on ethanol tax credits, and as outlined by Thompson, Meyer, and Westhoff (2010) amongst others, when there is no BTC the RIN prices are expected to be higher, and vice versa. In addition, the research conducted on the ethanol tax credits by McPhail & Babcock (2012) and McPhail (2012) find that the tax credits caused D6 prices to decrease, which supports our expectation that the biodiesel tax credit would result in lower D4 and D5 prices. This leads us to our first hypothesis:

[1] National Allocation Plan (NAPs): Sets the cap on emission allowances, at a national level
[2] EU ETS Phase I & Phase II - The first two trading periods in the EU ETS system, from 2005-2012.

H1: D4 and D5 RINs experience negative abnormal returns, while the abnormal returns for D6 RINs remain indifferent, around the event periods leading up to and including the announcement day of the retroactive reinstatement of the BTC

To build on the interdependencies of RINs and its underlying biofuels and feedstocks, we continue to our second hypothesis. As Abbott (2014) points out in his research, biofuel policies such as the RFS and ethanol tax credits increased the demand for biofuels and also causes the demand for feedstocks to increase, which results in the increase of feedstock prices. Similarly, the current BTCs contributes to the creation of incentives for biofuel producers and blenders, and as such we formulate our second hypotheses around these findings:

H2: Biofuel feedstocks (SBO) experience positive abnormal returns around the event periods leading up to and including the announcement day of the retroactive reinstatement of the BTC

If our second hypothesis stands, we would expect biofuel prices to follow the increase in feedstock prices. Drawing on the research conducted by Irwin (2014a, 2015) on the relationship between SME and SBO, we would expect this relationship to hold. In addition, a recent article by Irwin (2017) sheds light on possible "sharing" provisions in marketing agreements between blenders and producers in which the proceeds of a retroactively reinstated BTC are shared. We hypothesize that the sharing of the BTC is incorporated in the price of the biofuels sold, which would further result in an increase in the price of biofuels. That said, our third hypothesis is:

H3: Biofuels (SME) experience positive abnormal returns around the event periods leading up to and including the announcement day of the retroactive reinstatement of the BTC

If the sequence of our prior hypothesis holds then the increased price of SME would enhance the businesses engaged in the biofuel industry, and therefore, the impact of the retroactive reinstatement of the BTC on producers and blenders is non-trivial. According to Irwin (2015), the past two reinstatements resulted in significant net benefits for major biofuel producers, which became evident from reported SEC filings. As such, it is reasonable to expect that blenders and producers profit from the activity. Therefore, our final hypothesis is as follows:

H4: Biofuel producers experience positive abnormal returns around the event periods leading up to and including the announcement day of the retroactive reinstatement of the BTC

We now present our data and detail the sample collection.

5. SAMPLE COLLECTION

Daily price data on RINs and biodiesel are received from Standard & Poor's (S&P) Global Platts, which is a leading independent provider of information and benchmark prices for the commodities and energy markets (S&P Global Platts, 2017). Daily price data on fuel and oil, feedstock and biofuel firm stocks are extracted from the Bloomberg terminal. Correct data matching between the different information providers is ensured manually. An overview is presented in Tables 2 and 3 below.

TABLE 2 – Collected Prices

NAME	TICKER	SOURCE
D4 RIN	BDRCY01, BDRCY02 & BDRCY03	S&P Platts
D5 RIN	ABRCY01, ABRYCY02 & ABRCY03	S&P Platts
D6 RIN	RINCY01, RINCY02 & RINCY03	S&P Platts
SME CHICAGO	AAURR00	S&P Platts
SME HOUSTON	AAURS00	S&P Platts
SBO	BO1:COM	Bloomberg
BLOOMBERG CMD INDEX	BCOM:INDX	Bloomberg
S&P 500	SPX:INDX	Bloomberg
COMPANY DATA	(See Table 3)	Bloomberg

TABLE 3 – Collected Company Data (all data from Bloomberg)

FIRM	CATEGORY	TICKER
AMEETIS, INC.	Biofuel	AMTX
ALGAE TECH LTD.	Biofuel	ALGXY
BLUEFIRE RENEWABLES	Biofuel	BFRE US
FUTUREFUEL CORP	Biofuel	FF US
NESTE OYJ	Biofuel	NESTE FH
RENEWABLE ENERGY GROUP	Biofuel	REGI
AMYRIS, INC.	Consulting	AMRS
ARCHER DANIELS MIDLAND COMPANY	Biofuel segment	ADM
NOVOZYMES	Biofuel segment	NVZMY US
THE ANDERSONS, INC.	Biofuel segment	ANDE US
COSAN	Sugarcane Ethanol	CZZ US
GREEN PLAINS, INC.	Ethanol	GPRE
REX AMERICAN RESOURCES CORPORATION	Ethanol	REX
GREEN EARTH TECHNOLOGIES	Renewable Lubricants	GETG US

For the event date collection, our final sample consists of four main events occurring in 2010, 2013, 2014, and 2015 in which the BTC has been retroactively reinstated. Each event consists of four separate sub events, which represent the four stages of the legislative process of the passage of bills. The passage of bills begins when the bill is introduced either to the House of Representatives or the Senate. The second event occurs when it is voted for in the House of Representatives/Senate. If the bill was first introduced at the House of Representatives, then the third event period occurs when it is taken up to a vote at the Senate. The event ends when it is signed by the President, and here the bill becomes public law. In addition, we collect information on dates for tax credits bill proposals (new or alterations to existing) which were introduced in House/Senate but did not pass through further legislative stages (meaning they were voted down). This is done to compare market reactions of "unsuccessful" bills to introduction of an (eventually) "successful" tax credit proposal, and could allow us to make inference about market anticipation of the probability that an introduced bill will go on to be signed. As such, for methodological purposes, we label each stage (event) as following:

TABLE 4 – Event Stages

STAGE	**EVENT NUMBER**
Introduction	1
House Vote	2
Senate Vote	3
President Sign (Incorporated to Public Law)	4
Failed Introduction	5

Information, identification and discussion on the event dates for the various stages can be found from various online sources, including industry associations press releases and other news sites. In order to avoid using uncertain event dates, we do not rely on the former, but use exact dates collected from the official congress online database (i.e. congress.gov). Congress.gov is the official website for U.S. federal legislative information, providing access to accurate, timely and complete legislative information for Members of Congress, the public, and other parties. The database is continuously updated; typically, the morning after a session suspends, and has information (dates and descriptions) on the various actions taken for each bill (U.S. Federal Legislative Information, 2017). For this reason, we view this as the superlative source for identification of the event dates. Using this database and through extensive research we were able to identify each of the 4 retroactive BTC introductions, and disseminate and date the 4 stages for each, respectively (See GRAPH 1). Ensuing, we present our methodological approach.

6. METHODOLOGY

Next, we outline how we construct our methodology and at the same time discuss potential issues that require attention when conducting event studies in the regulatory context. In short, we define the events, event windows lengths of interest and estimation windows, after which we review the three different models that are used to predict the "normal" returns and subsequently applied to compute the abnormal returns. Last, we present our method for hypotheses testing and the significance test applied to measure whether the abnormal returns are statistically different from zero.

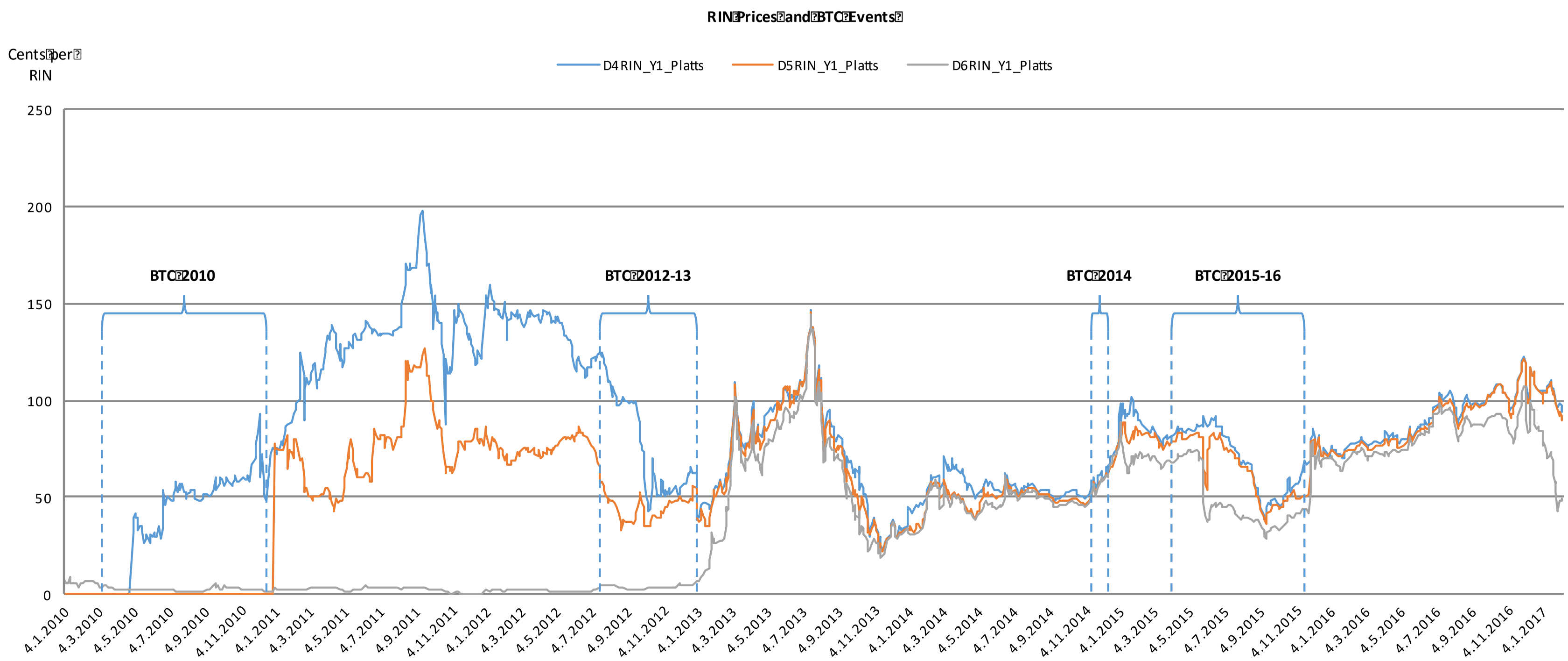
A standard tool in economics and financial literature and research is the investigation of how the security price reacts to various events. Although often applied to study the impact of events such as earnings announcements and mergers and acquisitions, applications in other fields are also common, for example measuring the impact of changes in the regulatory environment on firm stock price (MacKinlay, 1997) (Schwert, 1981). The event study methodology has also been applied and adjusted to study the impact on other factors, such as commodity spot and futures (Milonas, 1987). We use the event-study methodology, motivated by Fama et. Al (1969) and apply this methodology to three different markets that are likely to be affected by the BTC: the RINs, commodities (i.e. biofuels and feedstocks) and biofuel producers (firm stocks).

Schwert (1981) was one of the first to conduct event studies in order to evaluate the impact of a regulatory change. Following his paper, Joskow and Rose (1989) and Binder (1985a, 1985b) provided extensive reviews of the different methods applied to evaluate the effect of regulation changes. More recently, Binder (1998) and Lamdin (2001) both provide a discussion of the event study methodology in the regulatory change context, and address the major issues in test application and result interpretation while suggesting possible means to mitigate these issues.

6.1 EVENT WINDOW

As outlined in the sample collection, we have identified four retroactive reinstatements of BTC during the years 2010-2016 and five legislative introductions that failed. One retroactive reinstatement consists of four legislative stages and as such there are multiple events that take place within the event window. In theory, the event window should encompass the whole legislative process time frame; however, we successfully identify the exact dates for each stage. Therefore, we can treat each stage as its own event, with its own event window, however, a few limitations apply when determining the event window length for regulatory events (Schwert, 1981). First, Lamdin (2001) points out that as legislation is negotiated and debated before possible implementation (or non-implementation) the results might be anticipated, which could have hindering impact on the results. In order to measure whether information leaked prior to each stage we draw inspiration from Meznar & Kwok (1994) and measure cumulative abnormal returns over various event windows. Another issue conflicting our measurement of CARs is the potential overlapping of stages. In order to avoid overlapping we exclude certain stages from the CAR calculations where the event window overlaps. Even though this reduces our already limited sample and reduces our chances in finding significances, we consider the importance of limiting the impact of confounding events as peril.

GRAPH 1 – RIN prices and Blenders' Tax Credit Events



These various pitfalls and uncertainty surrounding the placements and length of the event periods could result in less powerful tests as one would be prone to rejecting the hypothesis of no regulatory effects, when the hypothesis is false, compared to events with well-known dates. If a change in regulation, such as the implementation or retroactive introduction of a tax credit, had no impact, this finding should surface. The problem does not lie here, but occurs as the low power tests will lead to the conclusion that a change in regulation did not have any impact, when it actually did (Type II error). However, this can also be viewed from a positive angle; if one is to find that a change in regulation did have an effect, such a finding is done in spite of a low power test colluding against it (Lamdin, 2001).

When choosing the event windows, MacKinlay (1997) suggests using (-1; +1). However, other windows are also common[3]. For example, Kanas (2005) uses (-3; +3), while Miyajima and Yafeh (2007) use (-5; +5). In addition, longer periods are used for some distinct cases, such as in Cox and Peterson (1994), who use (+4; +20).

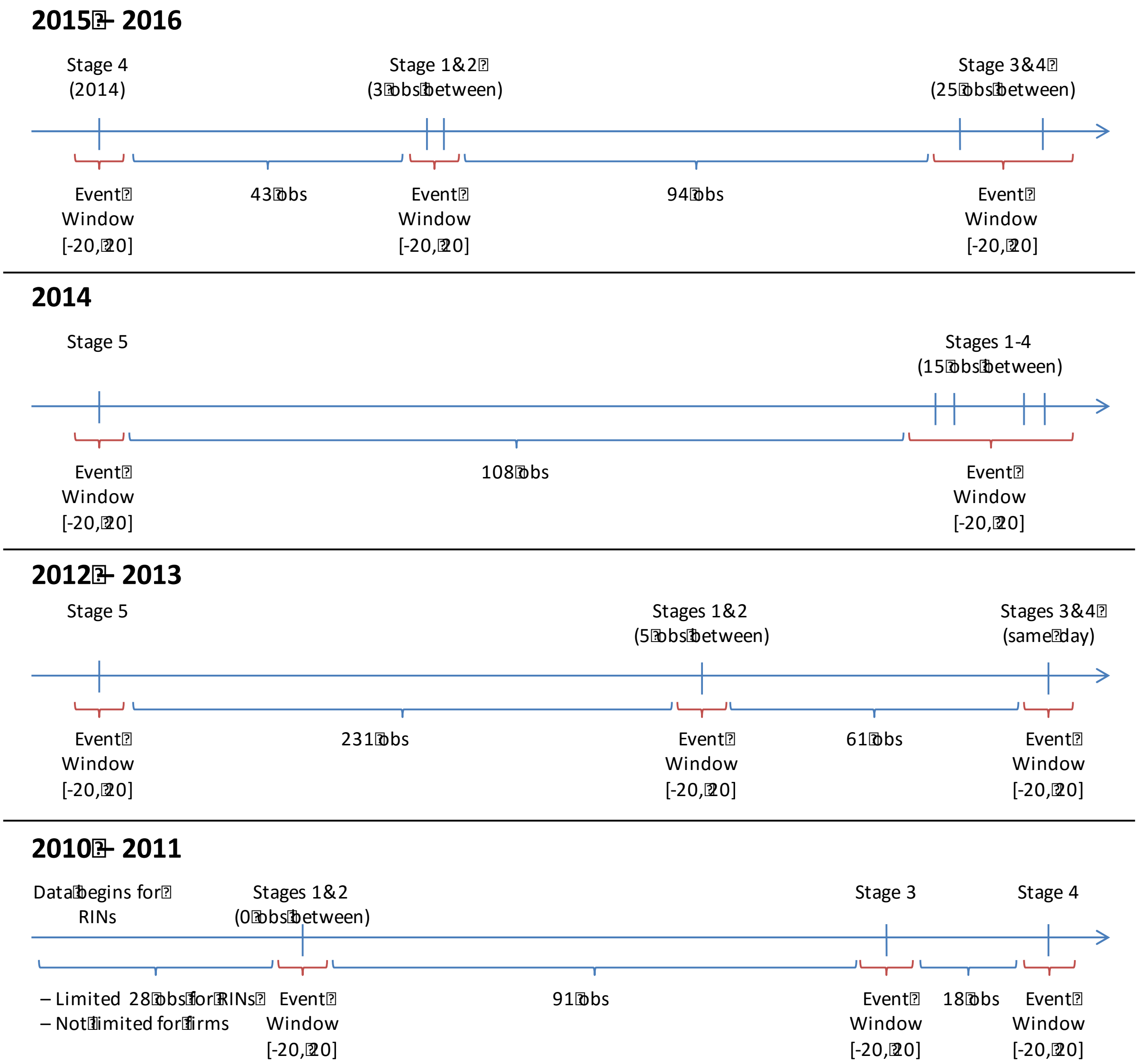
We use several event windows to examine the impact of the BTC. In order to address the potential leakage of information that can be likely in the legislative process we use longer event windows of [-20, 20] and [-10, 10]. To limit market noise and to focus on the impact of the announcement day and the days surrounding it we use shorter event windows of [-5, 5] and [-1, 1]. Additionally, we examine whether the returns prior to the announcement day are different from the returns after the announcement by utilizing a set of event windows prior the announcement [-20, 0], [-10, 0], [-5, 0] and [-1, 0] and after the announcement [0, 20], [0, 10], [0, 5] and [0, 1].

6.2 PLACING AND DEFINING ESTIMATION WINDOW

As highlighted earlier, when conducting event studies of regulatory changes, challenges exist in terms of placement and defining not just the length of event windows but also estimation windows. Below we present a graphical timeline representation of our event dates sample (FIGURE 2), previously discussed in the sample section.

[3] For a list of event studies with various event lengths refer to the appendix of Oler, D., Harrison, J., and Allen, M., 2008. The danger of misinterpreting short-window event study findings in strategic management research: an empirical illustration using horizontal acquisitions. *Strategic Organization, 6(2), 151-184.*

FIGURE 2 – Estimation windows



There are two details worth noting. First, there are irregular number of days between both the beginning and concluding stage of each policy change, in addition to the intermediate stages. In one case (2014 BTC), the time passed from introduction to signature by the president (Stage 1 to 4) is relatively short, totaling 15 days. In other cases, (2010-11, 2012-13, 2015-16) both the time between the various stages and total duration of the legislative process is much larger.

Second, the possibilities for estimation window lengths are compromised in some cases. The definition of an estimation window is not necessary for investigation of commodity returns and related calculation of normal returns, as a commodity market index can be utilized (discussed in the following section). However, for inference on RINs in addition producer and blender firm stock returns, we are required to define and apply normal returns calculated from an estimation period. Looking at the above timeline, we can see that this imposes certain constrains for some of the events. For example, the longest possible estimation window that can be applied without overlapping previous events is 43 days for firms and 28 for RINs, if we consider at most [-20, 20] event windows. For the remainder of events, it is possible to construct slightly longer event windows.

Yet, there does not appear to be any uniform agreement on the optimal estimation period length, neither in financial or other event studies. For example, Cox and Peterson (1994) use 100 days, Carow and Kane (2002) use 200 days, and Litvak (2007) uses 500 days. Further, MacKinlay (1997) suggests 250 days. Due to the constraints of the data we apply estimation windows with a length of 60 days for all of the events, except for the for Stage 1 in 2015-16 and in 2010-11, where we apply the maximum possible length available without overlapping with other stages. In addition, for the estimation window of Stage 4 in 2010-11 we use the same estimated parameters as for the Stage 3 in the same year in order to avoid bias in the normal return calculation. We are aware that this might be less than optimal and represents a possible limitation for the validity or our results, but as there appears to be a lack of consensus in the literature on the optimal length of the estimation window, and due to longer windows overlapping or confounding other events, we apply this length.

6.3 CALCULATING NORMAL RETURNS

Central to the performance of any event study is the estimation of abnormal returns. This can be defined as the difference between the actual or realized ex post (event) returns of the underlying asset, less the predicted normal return

$$AR_{it} = r_{it} - E(R_{it})$$

Where $AR_t =$ represents the abnormal return of assets on period t (MacKinlay, 1997).

To measure abnormal returns one has to calculate the expected or “normal” returns by utilizing various models. Due to data availability and the different characteristics of the variables under investigation (RINs, feedstocks & biofuels and biofuel stocks) we apply different models for each of the three variable categories in question. In order to compute the normal returns for RINs, the Mean-Adjusted Model is applied; for commodities (feedstocks & biofuels) the Beta-1 model is applied; while for biofuel producer and blender firm stocks, the market model is utilized.

Application of different models is common practice in event studies, both to accommodate for the characteristics of the variables under investigation, and for comparability analysis. It has been argued that simple models often yield the same results as more sophisticated models, and that the gains from applying multi-factor models for event studies are limited (MacKinlay, 1997). In addition, the application of different models is also dictated by the availability of data. For example, the market or mean adjusted models can be implemented in situations of limited data, and when the events render it less feasible to have a pre-event estimation period for computing the normal model parameters. In general, it is recommended to only apply these models if necessary, and consider the possibilities of potential biases as a result of the restrictions imposed in these models (MacKinlay, 1997). Further, as highlighted by Milonas (1987), there exist evidence that when performing statistical test concerning commodity markets the special characteristics of these markets should be considered. We also consider this to be the case for other special markets, such as that for RINs. Each model and its specifications will now be covered in turn.

Market Model

In order examine the effect of the BTC on producer and blender firm stock prices, we apply the market model**.** This takes the form of the standard CAPM, with the S&P 500 index utilized as a proxy of the market return. Similar to Draper (1984), Demirer & Kutan (2010), Binder (1998) and McKinlay (1997), amongst others, we estimate the model as

$$R_{it} = \alpha_i + \beta_i R_{mt} + \epsilon_{it}$$

where R_{it} = the return on an asset i during period t, and r_{mt} = the return on a market portfolio, here the S&P 500 index during period t. Assuming the residual term ϵ_{it} has an expected value of zero, it is in fact the abnormal return at t in event time in the area of event i denoted as

$$AR1_{it} = \epsilon_{it}$$

Mean-Adjusted model

To examine the effect of the BTC on RIN returns, the mean-adjusted returns model is applied, as suggested by McKinlay (1997). This entails imposing further restrictions on the above covered market model, and assuming $\beta_i = 0$, the mean-adjusted model is given by

$$R_{it} = \alpha_i$$

Provided $\alpha_i = \bar{R}_{it}$, where $\bar{R}_{it}$ is the mean-average return on security i over the estimation period. This entails that the RIN normal returns will be estimated as the mean return over the chosen estimation window.

Due to the characteristics of RIN credits, differing from stocks and commodities, we find this approach and model to be the most suitable to calculate RIN normal (and abnormal) returns, as we are not able to compute meaningful parameters applying other models. Another approach could be to apply the market-adjusted model, as done for commodities. However, as we were unable to identify a suitable index to represent normal returns, and not being able compute meaningful parameters, we deem this model to be the most suitable for RIN normal returns (MacKinlay, 1997).

Beta 1/Market-Adjusted returns model

Imposing further restrictions on the above mean-adjusted return equation, yields the market-adjusted returns model. Assuming $\beta_i = 1 \ and \ \alpha_i = 0,$ the model is given by

$$R_{it} = R_{mt}$$

As detailed, due to the model's coefficients being pre-specified, we do no need an estimation period to obtain the parameter estimates, which is useful due to the characteristics of commodities, data availability and lack of feasibility for a pre-estimation period (MacKinlay, 1997).

In the literature this is also referred to as the Beta-1 model, which has recently been employed in several large-scale empirical event studies (Fuller et al. 2002; Moeller et al. 2004; 2005). In addition to basing our choice of this model on the nature and characteristics of commodities, rendering parameter estimation less useful, it has also been applied to avoid using data from an estimation window which itself contains other event windows/events, which would further make beta estimations less meaningful. In addition, it has been shown that for short event window studies, weighting the market return by firm beta does not improve approximation to any significant level (Fueller at. Al 2002; Aktas, et al., 2007, Cable & Holland, 1999).

6.4 AVERAGE AND CUMULATIVE ABNORMAL RETURNS

After computing the daily abnormal returns, as outlined in the beginning of this section, we calculate the average daily abnormal returns (AAR) for each stage separately by

$$\overline{AR_t} = \frac{1}{N}\sum_{i=1}^{N} AR_{it}$$

Where N is the number of stages in the sample.

Subsequently the average abnormal returns are employed to compute cumulative average abnormal returns (CAAR), given by

$$\overline{CAR}_{\mathrm{t}} = \sum_{t=-1}^{T} \overline{AR_t}$$

The Cumulative Abnormal Returns (CAR) are given by

$$CAR_i = \sum_{t=-1}^{1} AR_{it}$$

6.5 HYPOTHESIS TESTING

In terms of our results we are primarily interested finding consistent trends and reactions in $\overline{CAR}$ values and its statistical significance. To estimate statistical significance of $\overline{CAR}$ we follow the cross sectional t-test developed by Brown & Warner (1980). First, we calculate standard deviation as follows,

$$\hat{\sigma}_{CAAR_{T_1,T_2}} = \sqrt{\frac{1}{N(N-d)} \sum_{i=1}^{N} (CAR_i(T_1,T_2) - CAAR(T_1,T_2)^2}$$

After which we use the obtained standard deviation to compute the t-value

$$T_{cross} = \frac{CAAR(T_1, T_2)}{\hat{\sigma}_{CAAR(T_1,T_2)}}$$

The obtained t-values are then compared against their critical values at 1%, 5% and 10% confidence levels.

The following chapter presents our empirical findings, before analyzing and discussing the result. Subsequently potential limitations and criticisms are discussed, and a conclusion if offered providing suggestions for future research.

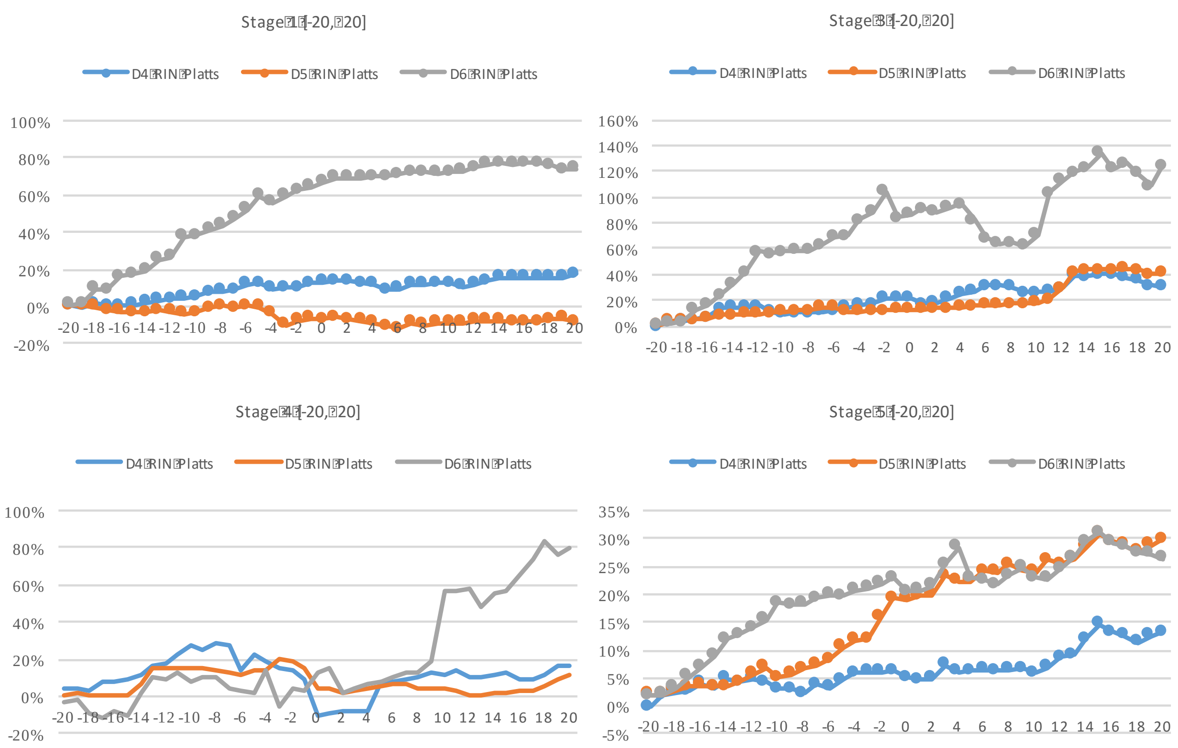
7. PRESENTATION OF EMPIRICAL FINDINGS

This section sets and analyses our key empirical findings, including statistical analysis of significance. The abnormal return observations must be aggregated in order to draw overall inferences for the events of interest (MacKinlay, 1997). Thus, we provide and analyze CAAR values and the results of the statistical significance (t) tests for RINs, Commodities (Feedstocks & Biofuels) and Biofuel firm stocks, in respective order. Following, the empirical findings for the various markets (areas) are compared and discussed in relation to each other in order to provide holistic results and overview.

7.1 RINS

Illustrated in the graphs below are the CAAR paths of the various RIN categories, D4, D5 and D6 for the different legislative stages (1-5), over the event window [-20, 20]. We refer to the appendix for other event window graphs, such as [-10, 10], [-5, 5] and [-1, 1]. Note that, even though we discuss results for various event windows we only illustrate CAAR graphs for the [-20, 20] event window, in order to avoid clouding the results section. For all results on CAARs and significances see the Appendix.

GRAPH 2 – CAARs [-20, 20] RINs



Observing the reaction of the RINs to the **stage 1 events** over the various event windows, both the D4 and D6 RINs generally experience increasingly positive CAARs, both pre and post-event. The path of the D5 RIN is not significantly impacted. Overall, the results are not in accordance with our expectations of negative abnormal returns. On the contrary, we generally observe the opposite result and reaction. One could argue that that the increasing and persistent CAAR paths with no sudden spikes indicate a degree of market anticipation to the introduction of the BTC, though this makes little sense when considering that the reaction is in the opposite direction of our hypothesis. Further, there are no significant results for the t-tests.

TABLE 5 – CAARs and Significances for RINs

	D4	**D5**	**D6**		**D4**	**D5**	**D6**
STAGE 1				**STAGE 3**			
[-1, 1]	3,30 %	2,74 %	3,56 %	**[-1, 1]**	-4,33 %	1,30 %	-18,23 %
	0,65	0,80	1,20		-0,56	0,00	-0,92
[-5, 5]	-3,86 %	-10,51 %	7,35 %	**[-5, 5]**	11,96 %	-3,06 %	1,27 %
	-0,70	-0,86	0,66		1,99	0,00	0,19
[-10, 10]	9,57 %	-1,08 %	22,5%*	**[-10, 10]**	9,36 %	8,11 %	-5,54 %
	0,74	-0,04	2,56		0,47	0,00	-0,57
[-20, 20]	17,38 %	-8,05 %	74,18 %	**[-20, 20]**	30,77 %	81,68 %	124,67 %
	0,70	-0,15	1,15		0,65	0,00	3,19
STAGE 4				**STAGE 5**			
[-1, 1]	-24,29 %	-24,2%***	6,65 %	**[-1, 1]**	-3,05 %	1,68 %	-2,85 %
	-1,66	-2,59	0,46		-0,53	0,16	-0,67
[-5, 5]	-11,86 %	-13,1%***	-7,60 %	**[-5, 5]**	-0,62 %	9,24 %	-2,25 %
	-0,70	-19,61	-0,23		-0,07	0,84	-0,19
[-10, 10]	-20,28 %	-28,54 %	23,61 %	**[-10, 10]**	-5,69 %	8,25 %	-1,30 %
	-1,50	-19,31	0,52		-0,69	0,83	-0,13
[-20, 20]	16,77 %	20,18 %	80,09 %	**[-20, 20]**	13,14 %	29,84 %	26,29 %
	0,74	0,94	1,38		0,52	1,06	1,03

For the **stage 3 events**, again, the observations do not lend much support to our hypothesis. Again, we find no significant results to the t-tests. For the **stage 4 events**, it is clearly observable that we find the largest negative reactions for all event windows. For all RIN categories there is a clear indication of a negative trend for the CAAR paths prior to the event date, which could indicate market anticipation of the event. Subsequently, we identify a large negative spike on the day and days surrounding it for the D4 and D5 RINs, in accordance with our hypothesis. Following, for these two RINs, we observe persistent and increasingly negative CAARs during the post event period, before a degree of re-adjustment. As can be seen in Table 5, here we also find the most statistical significances, although few in number. The observation that the D6

RIN does not react in the same way as the other RINs provides further support of our hypothesis, as the D6 RIN is not directly impacted by the BTC.

For stage 5, we observe that all RIN categories experience increasing and persistent positive CAARs, both pre and post event, especially evident for the longer event windows. If the market would anticipate that the introduction of the BTC would not go through to further stages, we would expect a positive reaction. As such, this is in line with our expectations. However, on closer scrutiny, as the event window narrows, the trend becomes less clear, making it less viable for any well-founded conclusion making.

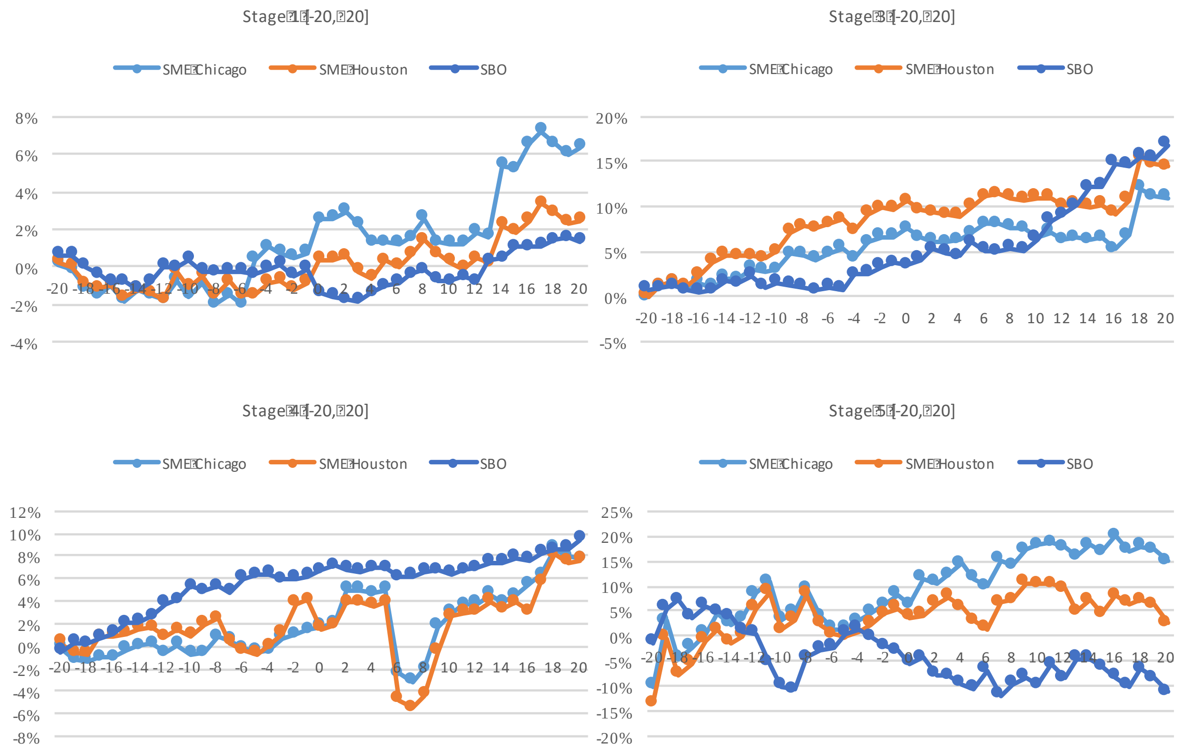
With regards to the CAAR signs, stage 4 provides interesting results for D4 and D5 RINs as nearly all event window lengths have a negative sign. When looking at the magnitudes, the largest negative CAARs are found in stage 4, for all the event windows. For instance, in event windows [-10, 10], [-5, 5] and [-1, 1] the CAARs are -20.3%, -11.86% and -24.3% for D4 RINs and -28.5%, 13.1% and 24.2% for D5 RINs. In addition, when observing event windows, where the end is limited to the announcement day, we observe even higher negative CAAR (e.g. [-10, 0], [-5, 0] and [-1, 0]). This could be seen as adding further support to the largest effect stemming from the stage 4 events and to the potential market anticipation. Other stages do experience various and high magnitudes, but these are often found where the market reacted opposite to our hypothesis.

Overall, the findings from observing the CAAR value signs and paths over the various legislative stages vary and are often inconclusive, similar to the outcome of many studies performed on the EU ETS credit system (Lepone, 2011; Hinterman et al, 2014). The CAARs show the most significant negative reaction to event stage 4, the actual signing of the BTC into law, and this is the only clear cut finding of conformity to our hypothesis. Here we also find the most significant t-test results. This is more in line with the EU ETS studies finding a strong market effect, though our results are not significant (Mi-clăuş et al., (2008); Chevailler et al., (2009), and also conforms to the general literary findings on RIN pricing fundamentals (Irwin, 2014b, 2015). For most other events (1, 3 and 5) we observe CAAR signs and paths opposite to what we would expect based on theory and relevant literature, with sporadic statistical significance. Comparing stage 1 and 5, the successful and unsuccessful introductions, we would expect different reactions, however we are unable to clearly establish such results, as the reactions are largely similar or unclear. Overall, we cannot reject the null hypothesis of market efficiency for the RIN market due to the lack of statistical significances, and only make inferences by visually inspecting the CAAR results and paths. Basically, we find (or cannot reject) that the RIN market is not efficient in accordance with Lade et. Al (2016) and we do find a negative reaction as hypothesized by the RIN and BTC literature (Thompson et al, 2010; McPhail et al, 2011), however primarily to stage 4.

7.3 COMMODITIES

Observing the reactions of the SME and SBO to the **stage 1 events** over the various event windows, we identify chiefly positive and increasing CAAR paths for the two SME's, including a jump on the event date, in accordance with our hypothesis. The reaction for the SBO is, however, not what we would expect. Further, we find no significances to the t-tests. For the **stage 3 events,** we observe a similar positive trend, especially for longer event windows. However, scrutinizing the shorter event window graphs, we observe a large drop in SME CAARs at the event date, followed by a large and more drastic increase again the ensuing day. The SBO, however, experiences a positive reaction. One could argue that these results are in accordance with our expectations, but they are unclear when viewed in unity.

GRAPH 3 - CAARs [-20, 20] Commodities



For the **stage 4 events,** we observe increasing and positive CAARs prior to the event, with indication of a positive reaction at the event date, according our expectations. Notably, the SME Houston experiences a different and slightly negative reaction on the event day, apparent from the smallest event window. Also interesting is the observation of a large drop in CAARs 4-5 days following the event for both SME's. The SBO however, experiences a slight positive reaction and a persistent and increasing trend, in accordance with our hypothesis. Last, for the **event 5 stages,** it is apparent that both SME and SBO experiences a negative reaction at the event, visible especially in the smallest event windows, in accordance with our hypothesis of opposite reactions due to the different success rates of the events. In addition, the SBO shows the largest reaction and negative CAAR trend, while the two SME's CAARs in the pre and post event windows show mainly an increasing trend. Overall there is a lack of findings of statistical significances for the t-test, with the most significances found for the stage 4 events. We also note that the increasing or decreasing trends pre-event could indicate market anticipation.

TABLE 6 – CAARs and Significances for Commodities

	SME CHICAGO	SME HOUSTON	SBO		SME CHICAGO	SME HOUSTON	SBO
STAGE 1				**STAGE 3**			
[-1, 1]	2,02 %	1,61 %	-1,08 %	**[-1, 1]**	-0,24 %	-0,29 %	0,70 %
	0,68	0,98	-0,93		-0,09	-0,11	0,37
[-5, 5]	3,28 %	1,86 %	-0,84 %	**[-5, 5]**	2,27 %	1,91 %	5,0%**
	0,73	0,82	-0,25		0,75	0,77	18,98
[-10, 10]	1,91 %	0,49 %	-0,74 %	**[-10, 10]**	3,73 %	6,74 %	5,27 %
	0,72	0,25	-0,13		0,61	1,23	2,27
[-20, 20]	6,40 %	2,48 %	1,40 %	**[-20, 20]**	10,94 %	14,39 %	16,83 %
	0,91	0,60	0,45		1,13	3,87	2,14
STAGE 4				**STAGE 5**			
[-1, 1]	0,98 %	-1,90 %	1,09 %	**[-1, 1]**	1,03 %	-0,05 %	-0,46 %
	0,94	-0,59	0,86		1,30	-0,07	-0,49
[-5, 5]	5,25 %	4,32 %	0,87 %	**[-5, 5]**	2,03 %	0,53 %	-1,61 %
	1,02	1,49	0,35		0,51	0,16	-0,50
[-10, 10]	2,94 %	1,26 %	2,25 %	**[-10, 10]**	1,46 %	0,34 %	-0,87 %
	0,18	0,08	2,19		1,17	0,23	-0,27
[-20, 20]	7,75 %	7,63 %	9,46 %	**[-20, 20]**	2,97 %	0,54 %	-2,22 %
	0,41	0,44	1,26		1,03	0,15	-0,34

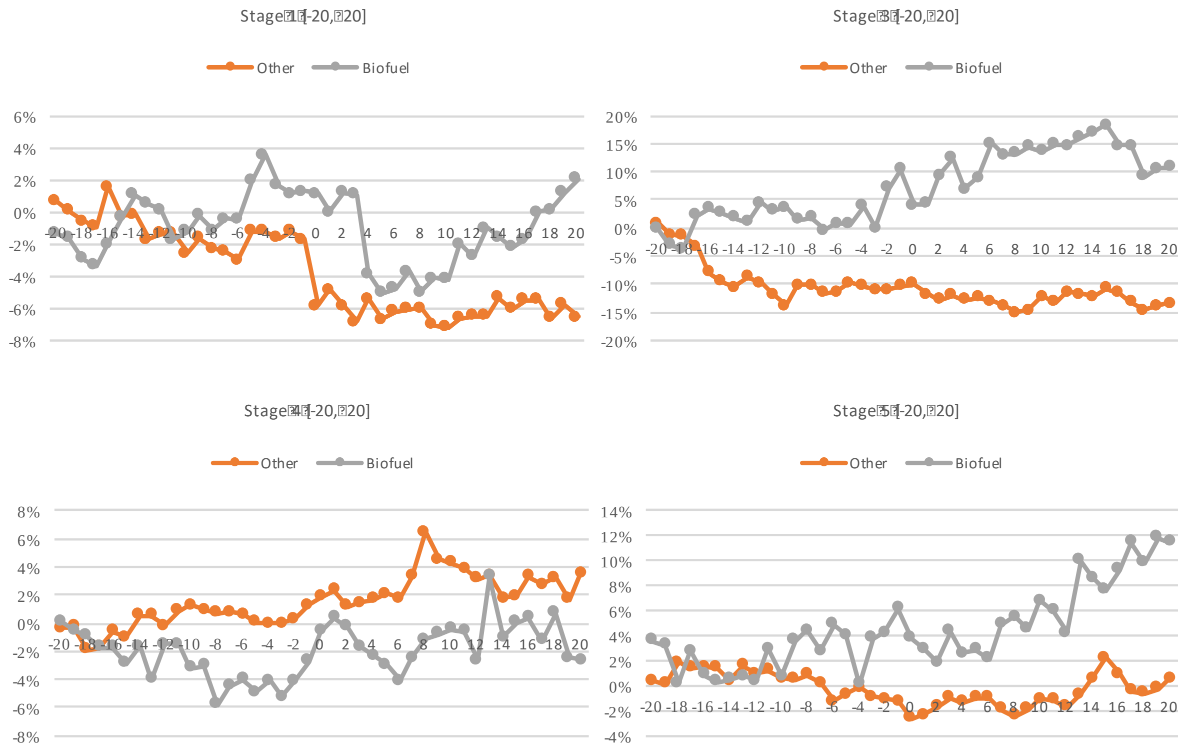
When observing the signs of the CAARs for all commodities, we find that in stage 3 and 4 nearly all signs are positive, which is accordance with our hypothesis. In stage 1 and 5, we find that SME CAARs were primarily positive while SBO CAARs were negative. In terms of the magnitudes, we find that in both stages 3 and 4 largest magnitudes are present in the [-20, 20] event window, and that the magnitudes are between 10.9%-16.8% for stage 3 and 7.6%-9.5% for stage 4. For the other event windows, CAAR magnitudes are less extreme.

Overall, based on the results of extremely few statistical significances across the board, we cannot reject the null hypothesis of market efficiency, and only infer based on the visual CAAR path inspections. We find, as Demirer and Kutan (2010) different market reactions for the various stages. Looking at the result of Draper (1984), who finds a slow market reaction to OPEC meetings, one could argue that there is indication of this, due to the trending and post-event persistent results. Deaves and Krinsky (2009) find significant results and abnormal returns. Even though the visual inspection of the CAARs show abnormal returns at and surrounding the event, our results are not significant. It is worth noting that there have been no directly comparable studies performed. The discussed authors do research similar areas (policy announcements) on commodities, but due to the special case of the RIN markets and the BTC it is challenging to compare and generalize the results. We also find a slightly larger frequency of results for all stages conforming to our hypotheses for the commodities compared to the RIN market, with much of the commodity behavior and reactions to the various BTC stages in accordance with expectations based on pricing fundamental analysis and research. Our results and conclusion, especially, on stage 4 reactions, are similar to the finding made on the ethanol tax credits by McPhail & Babcock (2012) and McPhail (2012). In addition, the relationship between SME and SBO holds to large extent (Irwin, 2014a; and Irwin, 2015).

7.3 BIOFUEL FIRMS AND OTHER RELATED BUSINESSES

When observing **stage 1** we do not find any significant results for any event window length. However, as we inspect the graphs and the [-20, 20] event window we can visually infer that the CAARs stay semi stable prior to the announcement of the introduction, and on the announcement date the CAARs plunge for other firms, whereas biofuel CAARs drop four days after the announcement. After the drop, biofuel CAARs begin to rebound back to prior announcement levels in contrast to the CAARs of other firms, which stagnate on the lower level. The reaction is similar and visible in the [-10, 10] and [-5, 5] event windows as well, except for the rebound in biofuel CAARs which starts to materialize 10 days after the announcement. From the narrowest event window [-1, 1], we clearly observe that the announcement impacted other firms negatively to a large extent, whereas biofuel firms only experienced minor decline. Reviewing our hypotheses, stage 1 provides opposite results to what we hypothesized.

GRAPH 4 – CAARs [-20, 20] for Biofuel and Other Related Firms



A few points stand out from the **stage 3** results. First, there are no significant results. In terms of other firms, the CAARs remain relatively stable throughout all event window lengths, except for the drop in CAAR faced by other firms 20-15 days before the announcement. On the other hand, biofuel firms experienced an increasing trend in CAARs that began three days prior to the announcement and resulted in a higher level post announcement, which is in support of our hypotheses. However, the negative impact on biofuel firms on the announcement day remains unclear, contrary to what we expected.

Somewhat surprisingly we do not observe any trend in neither biofuel or other businesses in the longer event windows in **stage 4**. However, a closer inspection of the narrower event windows evidently shows us that the CAARs for the three days leading to the announcement and on the announcement day itself were positive for all firms and as we hypothesized. Throughout these days biofuel firms experience a cumulatively gain of nearly 7% during [-2 to 1] after which the CAR recoils back slightly during the following four days. Similar observations can be made on other firms, however, the reactions are smaller in magnitude. In **stage 5**, biofuel firm CAAR displays erratic behavior and the volatility is considerably greater compared to other businesses. Despite this, the CAAR is observed to grow throughout the window while the CAARs for other businesses remain close to zero, which is against what we expected. From all of the event windows we can observe that the CAARs decreased on the announcement day, and that the greatest drop was faced by biofuel firms, which is the anticipated reaction. Worth noting, the high variation in biofuel firm CAARs, both prior and after the announcement, renders result interpretation difficult.

TABLE 7 – CAARs and Significances for Biofuel and Other Related Businesses

	BIOFUEL	OTHER BUSINESSES		BIOFUEL	OTHER BUSINESSES
STAGE 1			**STAGE 3**		
[-1, 1]	-1,18 %	-3,69 %	**[-1, 1]**	-3,21 %	-0,34 %
	-0,17	-1,16		-1,15	-0,11
[-5, 5]	-5,26 %	-3,54 %	**[-5, 5]**	7,21 %	0,43 %
	-0,57	-1,28		0,25	0,05
[-10, 10]	-3,32 %	-6,08 %	**[-10, 10]**	8,75 %	2,63 %
	-0,27	-0,94		0,32	0,23
[-20, 20]	2,06 %	-6,51 %	**[-20, 20]**	10,76 %	-13,38 %
	0,17	-1,19		0,22	-0,54
STAGE 4			**STAGE 5**		
[-1, 1]	4,91 %	2,34 %	**[-1, 1]**	-1,80 %	-1,21 %
	1,34	0,40		-0,63	-1,12
[-5, 5]	4,72 %	1,59 %	**[-5, 5]**	-4,32 %	0,58 %
	0,36	0,36		-0,74	0,15
[-10, 10]	3,24 %	5,24 %	**[-10, 10]**	2,55 %	-1,99 %
	0,15	0,38		0,14	-0,28
[-20, 20]	-2,64 %	3,54 %	**[-20, 20]**	11,51 %	0,62 %
	-0,12	0,23		0,43	0,08

Observing the signs of the CAARs in stages 1, 3 and 5, we do not detect any evident pattern, with alternating signs. As with earlier results, the signs for stage 4 prevail and are chiefly positive. In terms of the magnitudes, [-5, 0], [-1, 1] and [-5, 5] display the greatest values, 5.5%, 4.9% and 4.7%, respectively. The commanding positive signs are in support of our hypotheses that biofuel firms benefit from the BTC.

Overall, we do not find statistical significances in any stage, which could be an indication of market efficiency. However, as outlined earlier we are cautious in terms of generalizing this as a fact. We do find results that are aligned with our hypotheses, however, we also find unclear and contradicting reactions. Regardless of statistical significance, once again, the most interesting results appear in stage 4. The CAARs clearly demonstrate the positive impact of the BTC for biofuel firms as hypothesized and expected from the findings made by Ayres (1987). In addition, as we find positive reactions for compliance credit producers (the supply side), Bushnell, et al. (2013) find that obligated parties who create the demand in EU ETS react negatively. Moreover, the CAAR graphs show indisputably how the market begins to anticipate the outcome of stage 4 a couple days in advance. One implicit reason for the anticipation could be the fact that in some of the BTC reinstatements, the congress had to resolve differences and amend the bill before it was presented to the President. In spite of the opposite reaction in stage 1, we do find that the negative reaction in stage 1 is less negative than in stage 5, which could indicate that the market is able to detect a substandard introduction of the BTC. On the other hand, comparing the stages 1 and 5, where the market only places minor significance, if any, might cause us to make spurious inference.

7.4 ADDITIONAL RESULTS (FIRMS SORTED BY SIZE)

When firms are sorted by size, we are able to observe some statistically significant results, however, we lack power to make generalizing conclusion based solely on the significances. Therefore, we attempt to interpret and provide a comprehensive analysis of the CAAR movements by utilizing graphical representations.

Similar to prior results, the **stage 1** CAARs reacts negatively to and around the announcement day, which opposite from our expectations. However, five days prior to the announcement the CAARs for small firms spikes, but declines soon after. Overall, there seems to be a negative trend present for all firm CAARs despite the size. When looking at stage 3, large and medium firms are chiefly unaffected throughout the stage, while small firms display volatile CAAR movements in both directions but still centered around a stable trend. From observing CAAR reactions to stage 4, two things become evident for longer event windows. First, small firms experience positive abnormal returns during the days leading up to and on the announcement day after which the returns rebound and eventually end up in noticeably higher levels than prior to the announcement, in accordance with our expectations. Second, large firms maintain a constant trend of increasing CARs, which result in similar levels, post announcement, as small firms. A closer inspection reveals that smaller firms tend to react more powerfully to the reinstatement of BTC compared to larger firms. Stage 5, again, is unclear as it displays different characteristics compared to all other stages. Large and medium firm CAARs tangle around each other, with no recognizable trend. Small firm CAARs are volatile and making inferences on whether the announcement caused the CAAR to move becomes problematic.

GRAPH 5 – CAARs [-20, 20] Firms Sorted by Size

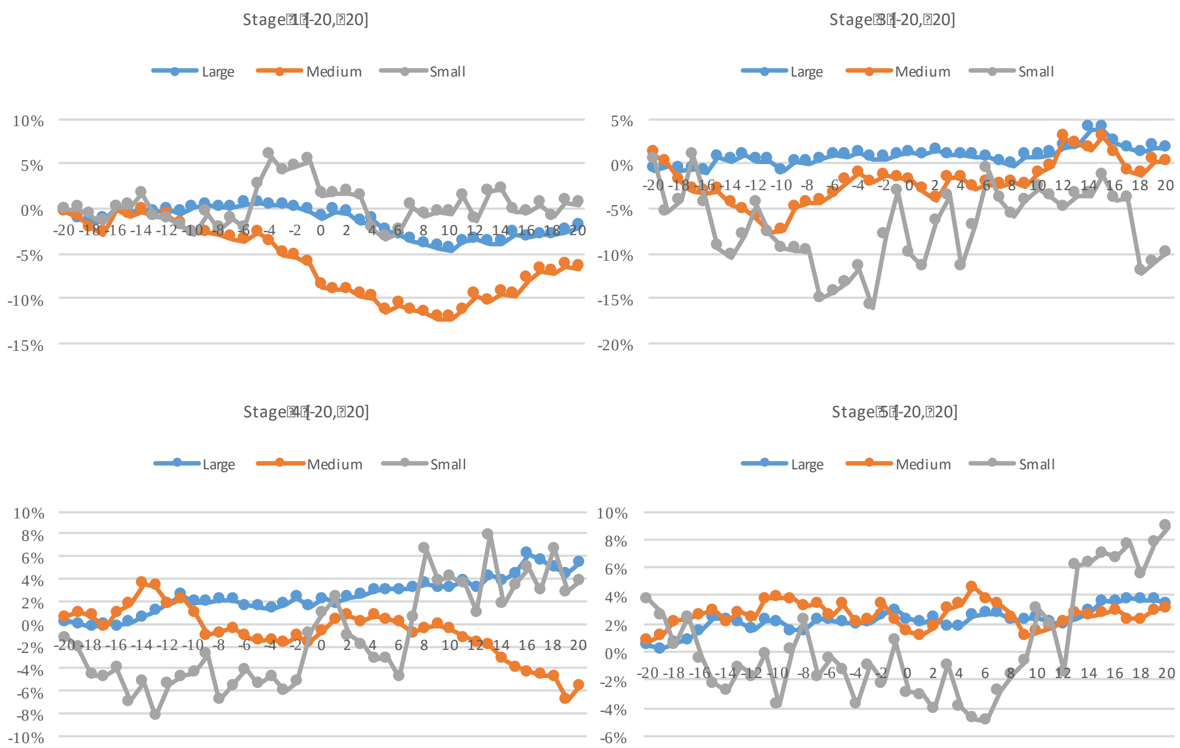


TABLE 8 – CAARs and Significances for Firms Sorted by Size

	LARGE	MEDIUM	SMALL		LARGE	MEDIUM	SMALL
STAGE 1				**STAGE 3**			
[-1, 1]	-0,31 %	-3,45 %	-3,63 %	**[-1, 1]**	0,35 %	-1,61 %	-3,06 %
	-0,14	-1,16	-0,46		0,18	-1,08	-0,69
[-5, 5]	-2,91 %	-7,12 %	-2,54 %	**[-5, 5]**	-0,24 %	0,23 %	9,32 %
	-1,75	-1,09	-0,33		-0,03	0,04	0,29
[-10, 10]	-4,03 %	-9,02 %	-1,46 %	**[-10, 10]**	1,37 %	8,42 %	5,18 %
	-1,00	-1,16	-0,12		0,11	0,77	0,17
[-20, 20]	-2,10 %	-6,70 %	0,43 %	**[-20, 20]**	1,66 %	0,17 %	-10,00 %
	-1,09	-1,07	0,03		0,12	0,02	-0,16
STAGE 4				**STAGE 5**			
[-1, 1]	-0,66 %	1,95 %	8,21 %	**[-1, 1]**	-0,62 %	-2,45 %*	-1,16 %
	-0,36	0,49	1,95		-0,62	-2,69	-0,39
[-5, 5]	0,59 %	2,64 %	5,10 %	**[-5, 5]**	0,50 %	1,36 %	-6,01 %
	0,19	0,46	0,36		0,68	0,86	-0,88
[-10, 10]	1,09 %	-1,38 %	12,77 %	**[-10, 10]**	0,32 %	-4,47 %	4,09 %
	0,27	-0,22	0,49		0,18	-2,13	0,19
[-20, 20]	5,37 %	-5,55 %	3,75 %	**[-20, 20]**	3,45 %	3,14 %	8,90 %
	1,05	-0,94	0,13		0,99	0,45	0,29

In nearly all stages, the size dictates the magnitude of the reactions. The same order is maintained in all stages when the announcement day is examined, except in stage 5. Typically, smaller firms tend to react more compared to medium and larger firms. Also, large firms are in most instances less influenced by any stage. This can be related to the niche focus of smaller businesses whereas larger firms have multiple business segments, which mitigate the impact of regulatory changes such as the BTC. In addition, the results as such are interesting as to why smaller firms experience considerably greater CAARs than larger firms if we consider the fact that smaller firms have relatively less leverage in negotiating portions of the BTC to themselves compared to larger firms. In terms of stage 1 vs 5, large firms are again largely unaffected, whereas greater movements are seen in small and medium size firms. Interestingly, stage 5 reactions are smaller in magnitude compared to stage 1. In essence, the opposite reactions are observed to what we would have expected.

8. DISCUSSION AND ANALYSIS

This section discusses and relates the empirical findings from the three previous sections, presenting the overall results and points of critical importance. Analyzing the results in conjunction will allow us to see if the findings support or validate each other.

8.1 MARKET EFFICIENCY

Overall, we find lack of statistical significances for all the markets. Moreover, the largest reaction and conformity to our hypotheses is a result of the stage 4 BTC events, for all markets. The lack of statistical significances does not allow us to reject the null hypothesis of market efficiency for any of the markets. Based on these findings, we could suggest, as done by other related studies (Demirer and Kutan, 2010), that this provides evidence of efficient markets, and our results do indeed point in this direction. However, in light of the issues prescribed by Lamdin (2001), we highlight our small sample of 14 events in total and the resulting low power of the t-test as possible sources of bias, affecting our results and the ability to draw such conclusions from our findings. It is interesting to note though, that studies with a similar constrained sample size, such as Demirer and Kutan (2010), suggest that lack of significant results point in the direction of market efficiency, without providing any discussion of the effect of their limited sample (15 events for the SPR announcement). Further, Milonas (1987) stresses that he is constrained by the placement of the USDA announcements under scrutiny, and as such limited in application of long event and estimation windows (number of usable days after and before the announcements). He therefore, as done in our study, applies the mean-adjusted model, and points to Brown and Warner (1980) showing that despite its simplicity, the mean-adjusted model can robustly identify abnormal returns in an event type methodology. He does not appear to present any concern of how this would make possible findings with regards to market efficiency less robust. As such, we do conclude that we cannot reject the null hypothesis of market efficiency for neither markets based on the reaction to the BTC, suggesting efficient markets and an efficient subsidy/policy instrument in the BTC. This finding is in line with Lade et. Al (2016), though it should be recognized that their study is a working paper performing an event study with a different approach. Yet, we recognize that this result should be interpreted and applied in light of our limited sample and the accompanying effects. One could also argue that the lack of statistical significances and inability to reject the null hypothesis of market efficiency for the underlying commodity and biofuel firm markets strengthen the result of the findings for the RIN market and the effect of the BTC in general.

In this vein, it could be viewed as a positive result that we find no consistent significances. An argument could be formed that due to the highlighted pricing fundamentals, where various commodities function as input to RIN credits and determine and affect their prices, it would make less sense to find strong and plentiful statistical significances for the price determinant commodities while no such pattern or results for RINs. As outlined by Koch et. Al (2014), market fundamentals and prices for input fuels are expected to determine the emission credit prices, although as suggested by Hinterman et. Al (2014), the relationship is not robust.

8.2 MARKET ANTICIPATION AND INFORMATION LEAKAGE

In addition, we observe indications of market anticipation and possible information leakage in several cases, with visually increasing or decreasing CAAR paths prior to the events, also often persistent in the post-event window. One could argue that this finding is in accordance with the political nature of the markets, especially prevalent for RINs, and the nature of the policy events coupled with the process of various legislative stages for deciding on the final passing of the BTC. As outlined earlier, there is a large possibility of possible information leakage, and in many instances we make such observations for the longer event windows and by comparing the magnitudes of the different event window lengths. It could be argued that this finding is in line with those of the comparable EU ETS market, with both assets being products of legislation, and subject to political risk not present in other markets (Gronwald & Ketterer, 2012). Such findings could also indicate insider trading and high possibility of information leakage with following information asymmetry (Lepone et. Al 2011). As outlined, Demirer and Kutan (2010) points to information leakage and market anticipation of OPEC announcements, while Lepone et. Al (2011) points to systematic leakage across all types of announcements in his study on the EU ETS market, and this is something we find for many of the different types of stages. Further, as hypothesized by Milonas (1987), prices will reflect information from private actors**,** and it could be contended that this is the case with the RIN market due to the large amount of lobbying and the structure of the US political system.

Further, Irwin (2017) posits that the market anticipates that the BTC will be reinstated retroactively, also corresponding to our findings. Nevertheless, we note that this could be a result of market noise, a possibility increasing with longer event windows, especially as we do not find many statistically significant results and can only infer the presence of such characteristics from the CAAR paths. It should be noted that we consider these findings to be most interesting for the stage 4 events, as for many other stages where we observe a decreasing or increasing trend prior to the event, the reaction is opposite to our hypotheses.

8.3 DIFFERENT INFORMATIONAL CONTENT DEPENDING ON STAGE

Our study clearly outlines and identifies the various "intermediate" stages leading up to the signing of the BTC into actual law. Although the stages are related to the BTC and its retroactive reinstatement, one could argue that they (and their outcome) contain different information and as such would lead to different market reactions. Indeed, as stated by Milonas (1987), not all announcements carry the same information. In essence, the 3 events (Introduction and votes) prior to the signing into law are not "final" events with a certain future outcome, and there is room for speculation and various interpretations by the different market actors for what the outcome entails, especially if it is viewed as decreasing or increasing the probability of eventual BTC passing into law and effect. One view could for example be that the probability for a final BTC increases as we pass through the stages successfully. As such, it is an interesting finding that overall, the reactions and the signs (in the CAARs) seems to be strongest and most in accordance with our hypothesis and the general literature for the stage 4 events, when the BTC is actually passed as an official law. In this case we observe negative CAARs and large negative reactions at the event date, and although few, here we also find the most significant results for all markets. In essence, it could be theorized that the market actors are uncertain about the probability of a passing of the bill into law, and do not react until the actual signing into law is officially announced. This might explain the lack of clear findings and "opposite direction reactions" for stage 1, 3 and 5, explained by their different "informational content". For the stage 4 events the BTC is actually signed into law, and as such it is here we find the most significant reaction. This suggest that when hypothesizing about the outcome of similar events, the market reactions to event stages that might increase the probability of a bill passing into law are ambiguous, due to the various interpretation by market actors. There appears to be similar findings in the majority of studies performed on the EU ETS markets, with various and largely inconclusive results, depending on the content of the announcement (Lepone et. Al, 2011). Further, Mi-clăuş et al., (2008) finds various market effects depending on the policy information content., while Demirer & Kutan (2010) also find varying reactions depending on the content of the OPEC announcement (Increase, decrease or no decrease). They do not however, to our knowledge, take into account that there could be related "pre-event" stages, such as applied in our thesis, which could be involved. As such one could question if better results might be achieved by only focusing on the stage 4 announcement in our case, conforming more to the general method in the literature of not considering intermediate events, or providing alternative hypotheses for "intermediate" legislative event stages. It is worth highlighting that, even though these are the results we observe overall, some reactions to the stage 5 is in conformity to our hypotheses, for example for the commodities.

Having presented, analyzed and discussed our empirical findings, we now highlight important criticisms to our paper and its research approach, and detail possibilities for improvement and future research.

8.4 CRITICISM

The main weakness of the paper rendering is less feasible to make firm conclusions is the low sample size, due to the nature of our event study, different from more prevalent studies on M&As and earnings announcements. As highlighted, one could conclude that the lack of significances points to efficient markets, though we believe it is critical to consider the sample size and low power of the test. To our knowledge and best of our abilities, we have tried to address and remedy potential shortcomings and constraints appearing to do the political nature of the RIN market and the available data, in part by adjusting and applying various models to measure the normal and subsequently the abnormal returns. In order to further improve our methodological approach and increase the usefulness and conclusive nature of our findings, additional diagnostics and different models could have been applied. Lamdin (2001) suggests to use various models to estimate normal returns as his research shows that different models could provide contradictory results. Moreover, as t-test is widely used by event studies it is prone to its simplicity. Therefore, using more advanced significance test such as the Patell Z, which can better address abnormal returns in the cumulated event window, could have yielded more prominent results (Patell, 1976). It will be interesting to see if future development in the market and increased sample sizes will show more statistically significant results. Further, the lack of clear-cut and established literature on the specific RIN market is a major limitation, having forced us to hypothesize in part by combining various parts of related literature. The special market characteristics of the RIN market further complicates the ability for perform solid research, and it is our hope to the future will bring more insight and conformity on such special credit markets.

Furthermore, we judged it best to apply the same length estimation windows for computing biofuel firm parameters and RIN normal return, though a possible approach could have been to apply the maximum possible length for individual each case (giving us different estimation windows for various years depending on the "spread" of the various event stages). Subsequently comparing the results with each other and the results from using same length estimation windows could have yielded interesting insight. In this vein, it could also be possible that the short estimation windows of 60 days contribute to our findings and lack of statistically significant results.

9. CONCLUSION

The central aim of this study was to investigate if the market for Renewable Identification Number Credits have operated efficiently, examined through performance of event studies on the retroactive reinstatements of the Blenders Tax Credit. The effect of the BTC was investigated on three key markets: The RIN market, input commodities for the RIN credits, namely feedstocks & biofuels and last biofuel firms. Essential to the performance of the study was the identification of the various legislative stages involved in reinstatement of the BTC, categorized as separate events. Further, due to the special characteristics of the various markets and constraints for event and estimation windows, different models were applied to compute the normal returns.

The main results indicate that the market for RINs, feedstocks & biofuels and biofuel firms operate and react in an efficient manner, as we were unable to reject the null hypothesis of market efficiency due to lack of and few consistent statistical significances, for neither markets. Further, the lack of significant results for the feedstock & biofuel and biofuel firm markets offers supporting evidence for the efficiency of RIN markets, in part due to the strong relationship between these market and the RIN markets. This could indicate that the BTC is an efficient policy tool for certain applications.

The results also suggest a degree of information leakage and market anticipation to the retroactive reinstatement stages of the BTC, in line with our expectations due to the political nature of and influence on the market and forecasting by private actors, similar to the EU ETS credit system findings and other connected research. Further, a major finding is that the market appears to react more significantly and in accordance with our hypotheses to the stage 4 events, representing the actual signing of the BTC into law. Here RINs experience decreasing and negative CAARs, while commodities and biofuel firms experience positive and increasing CAARs. For this stage we also find the largest number of statistical significances. The reactions to other event stages remain largely ambiguous and do, for the most part, not support our hypotheses. We suggest this could be a result of the uncertainty surrounding intermediate events, with the probability of further progress and outcome open to interpretation by various market actors. This could entail the need for additional theorizing on how various intermediate stages leading to a final law or policy affect the RIN or other markets, for example through categorization of main and sub events and the effect on final outcome success probability. In addition, we are unable to make firm conclusions on market anticipation of the success of stage 1 introductions of bills for the BTC, finding largely similar reactions to successful and unsuccessful introductions, with the exception of feedstock and biofuel commodities. These latter results and suggestions are chiefly based on analysis and visual inspection of CAARs, with lack of statistically significant relationships.

As outlined, a limitation of the study and applicability of the results remain the low sample size and regulatory nature of the events, which provide explanations for the lack of statistically significant results. However, to our knowledge, we have recognized and addressed the relevant limitations in order to improve the strength and validity of our results. We note that similar approaches, models and methodological paths have been applied by various accredited studies, who in turn do not highlight this as major limitations, and ultimately make suggestive conclusions based on the results. Further, the novelty of the RIN market and lack of established returns on it and similar markets is an important limiting factor in terms of establishing viable hypotheses.

Thus, the main value of the study is the suggesting evidence of the efficiency of the RIN and related commodity and biofuel firm markets, with supportive and strengthening combined findings, and identification of market anticipation or information leakage. In addition, we believe the identification of different reactions based on the classification of the event stage or policy as intermediate or final is a critical finding that could lay the ground for future research and hypotheses.

Other suggestions for future research is to combine research on other relevant policy announcements for RINs, such as RVOs, either in combination with the BTC or as a standalone research area. Further, building on our research, the application of different models, diagnostics and estimation windows could yield interesting and additional results. Identification of similar credits and markets, aside from the RINs and EU ETS could also yield additional insight. Last, we expect that future developments in the RIN markets will allow for increased sample sizes and research opportunities.

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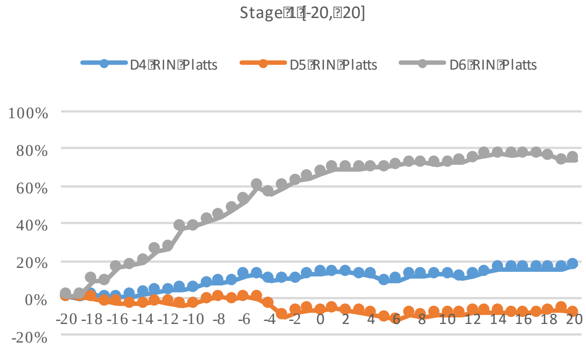
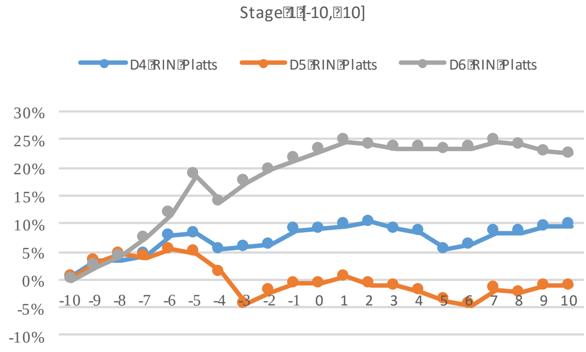
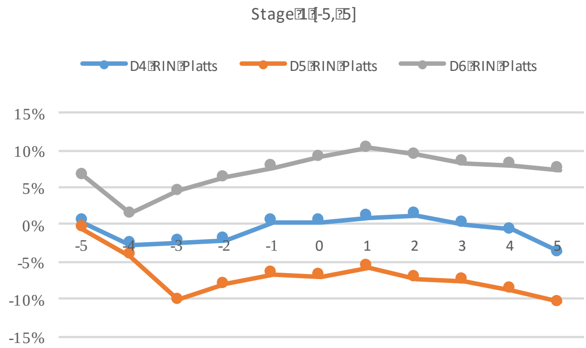
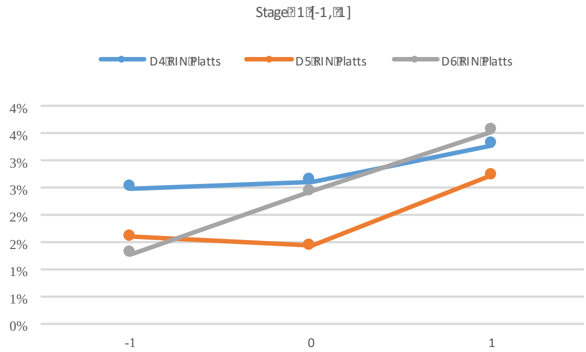
APPENDIX

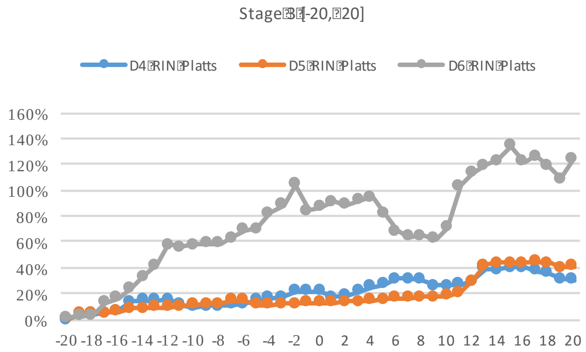
GRAPHS - CAARS RINS

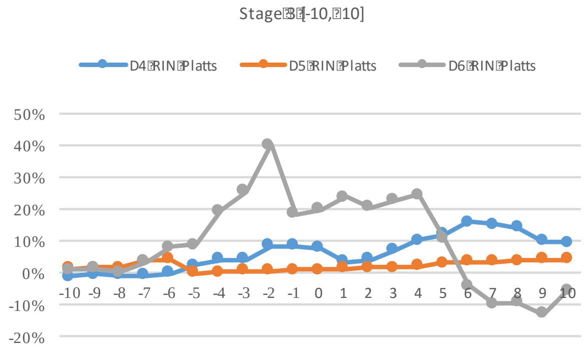


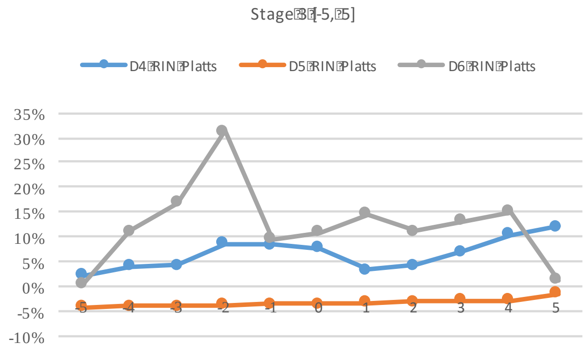


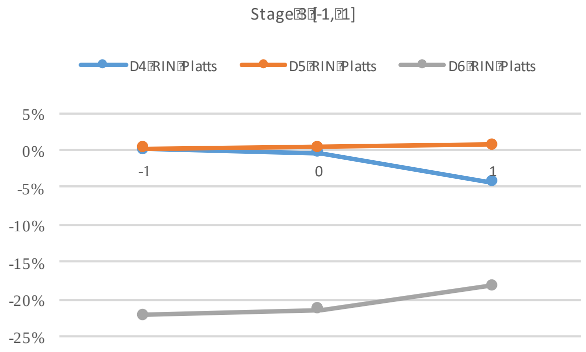


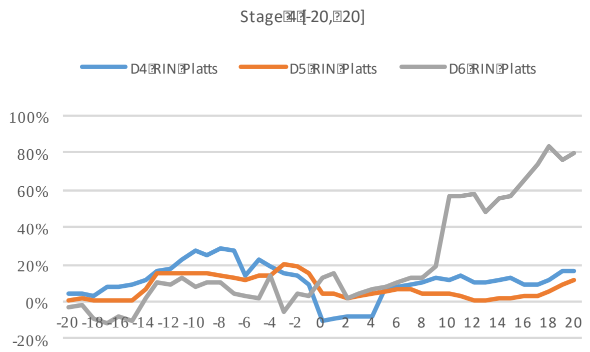








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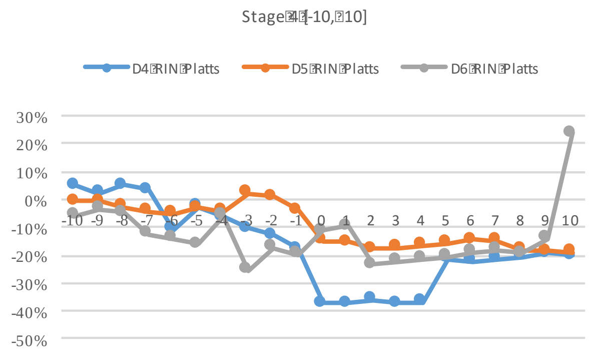
D5 RIN Platts
D6 RIN Platts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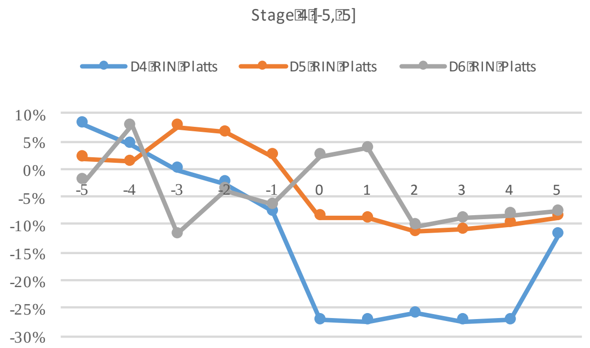
D5 RIN Platts
D6 RIN Platts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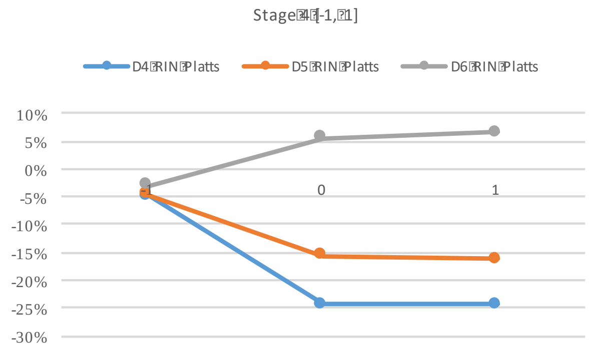
D5 RIN Platts
D6 RIN Platts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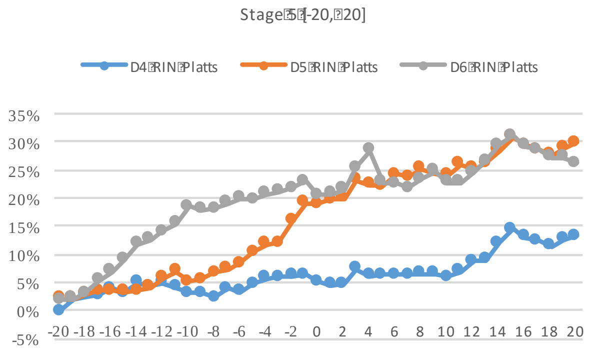
D6 RIN Platts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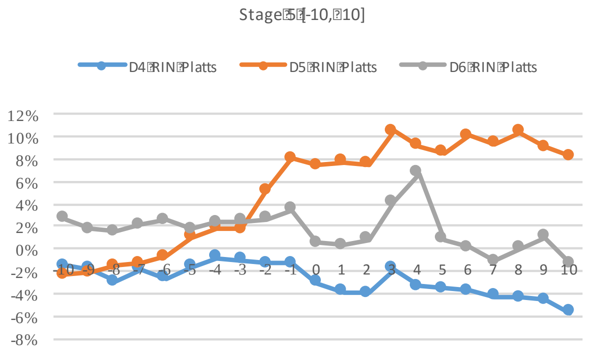
D5 RIN Platts
D6 RIN Platts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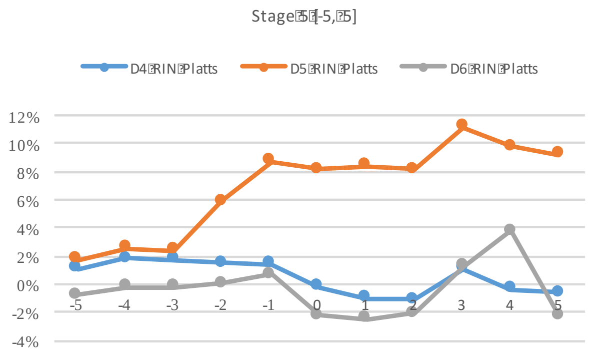
D6 RIN Platts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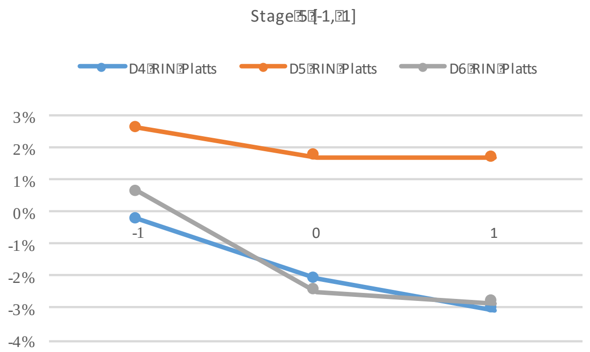
D5 RIN Platts
D6 RIN Platts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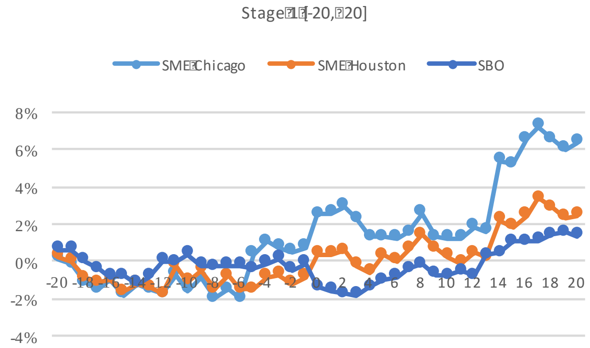
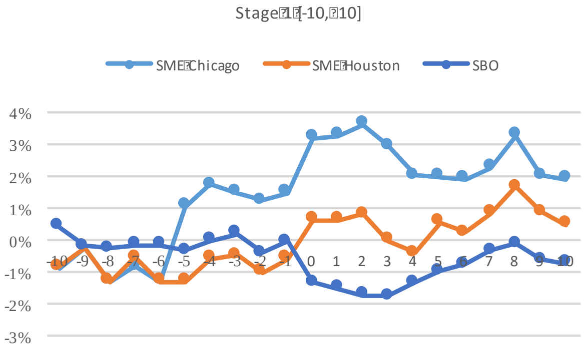
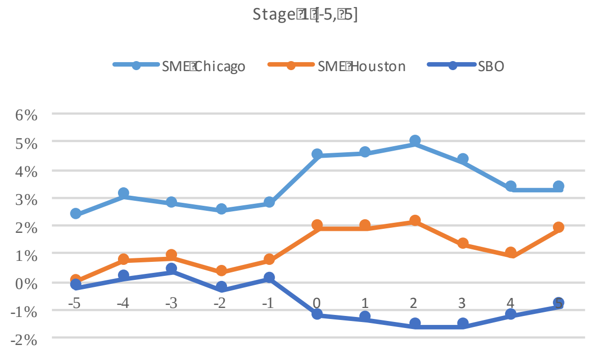
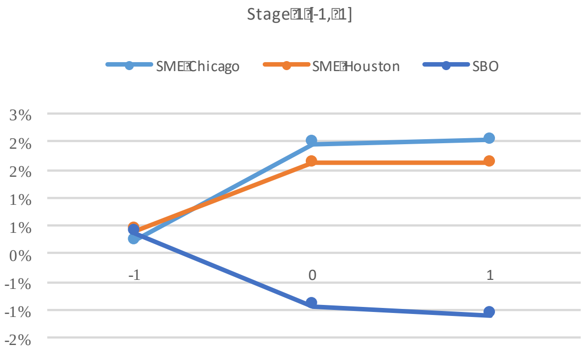
D5 RIN Platts
D6 RIN Platts

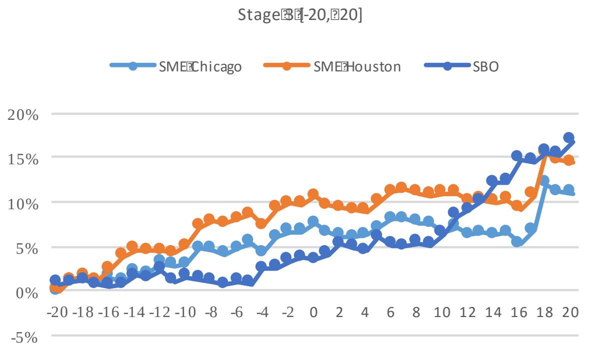
GRAPHS - CAARS COMMODITIES

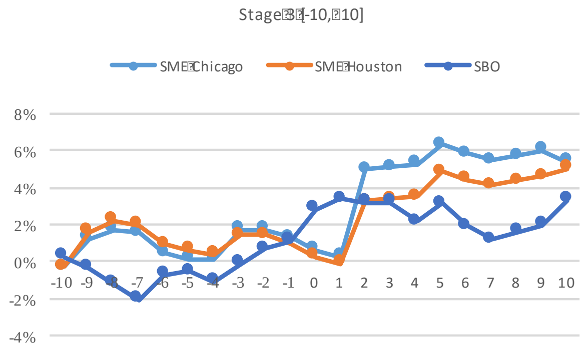


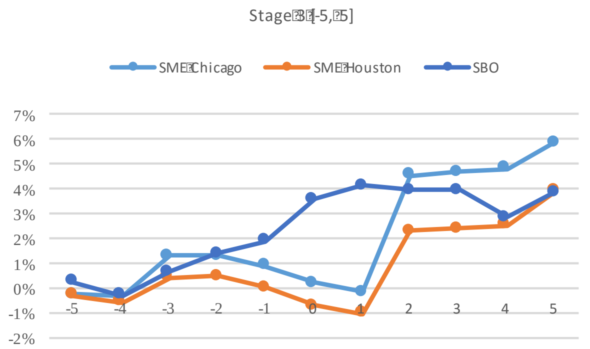


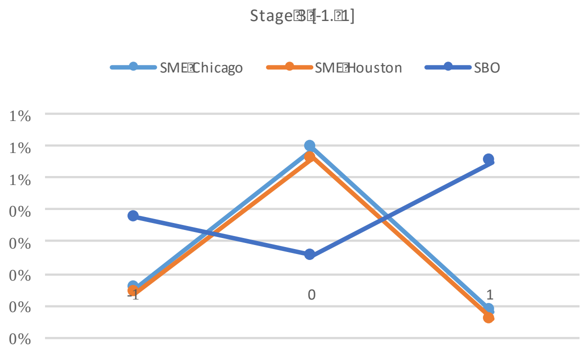


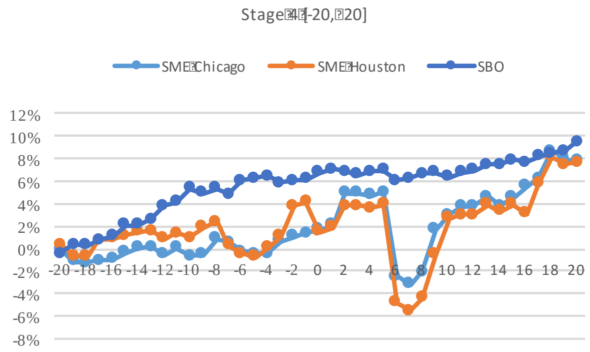


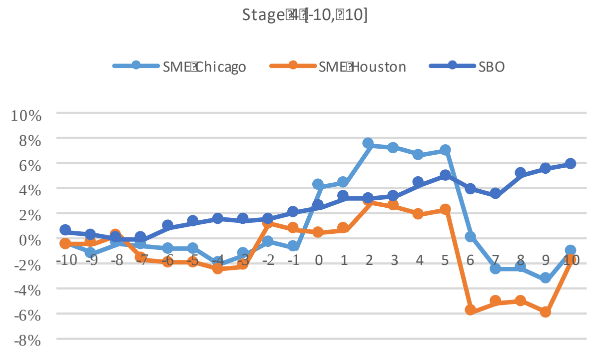









Stage 4 [-20, 20]
SME Chicago
SME Houston
SBO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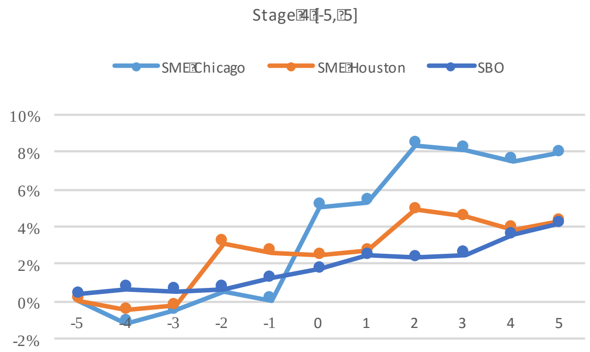
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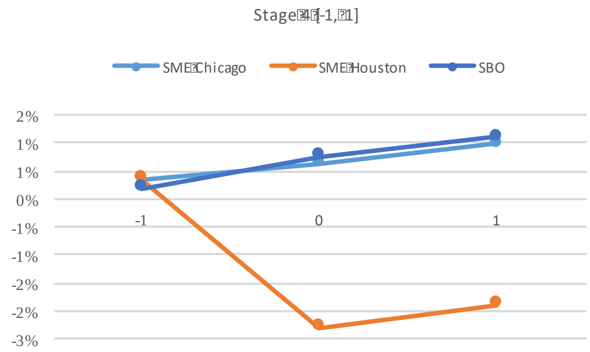
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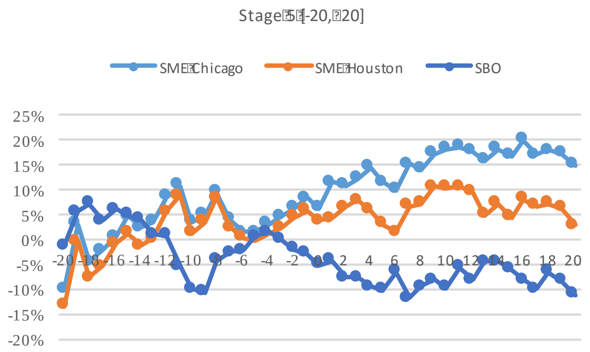
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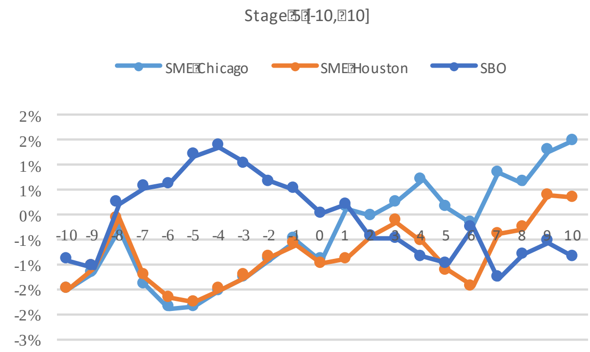
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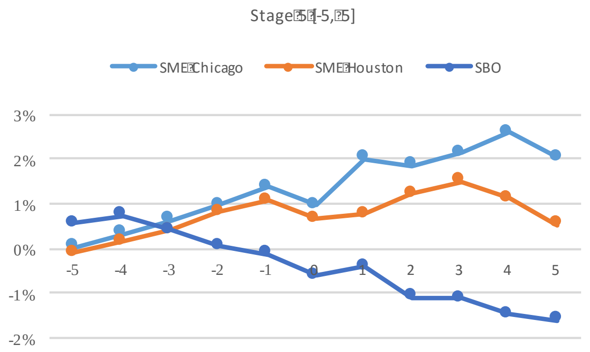
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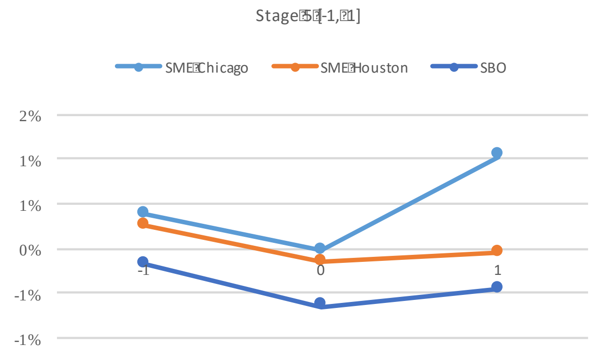
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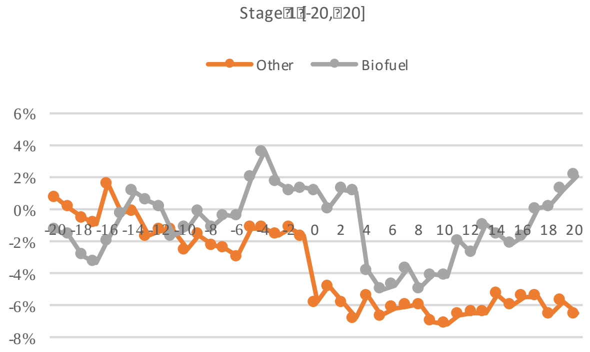
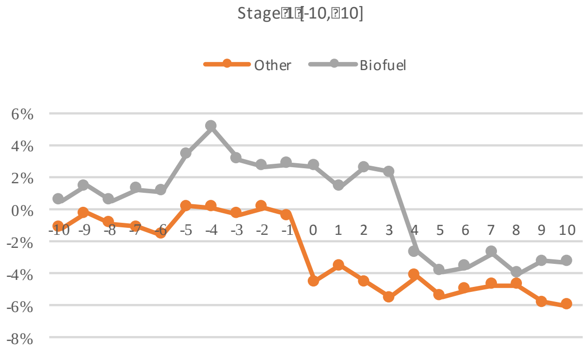
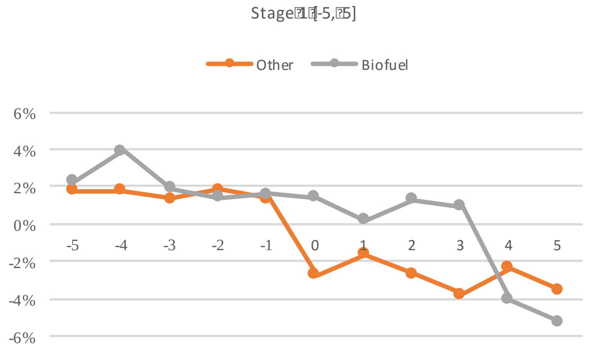
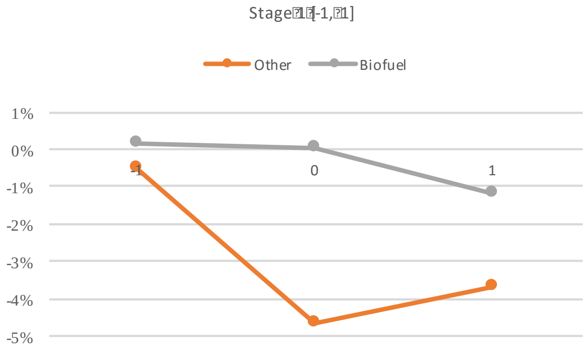
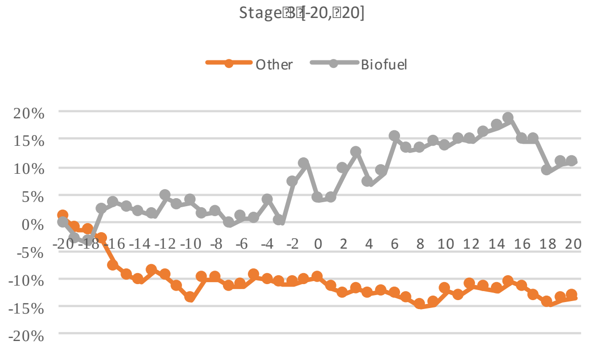
GRAPHS - CAARS BIOFUEL FIRMS AND OTHER RELATED BUSINESSES

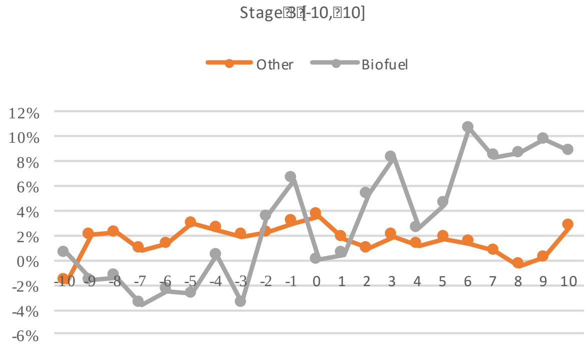


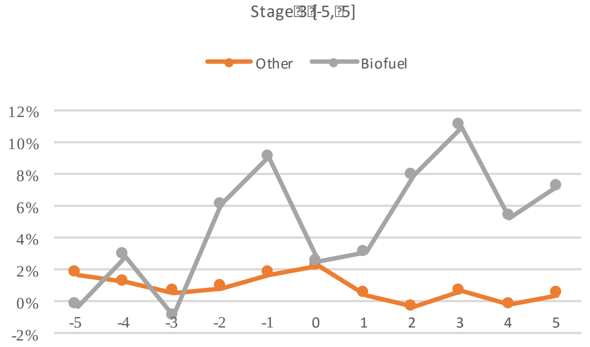


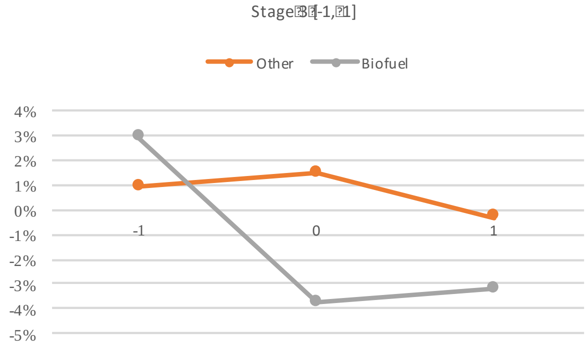


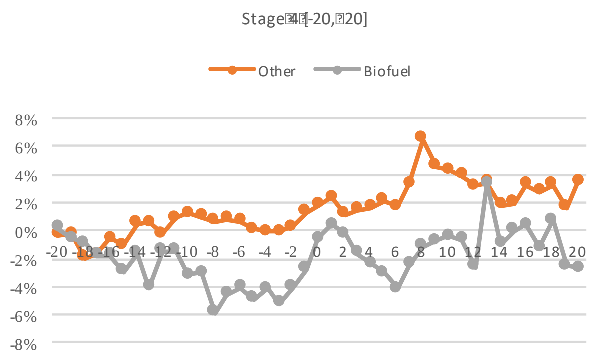








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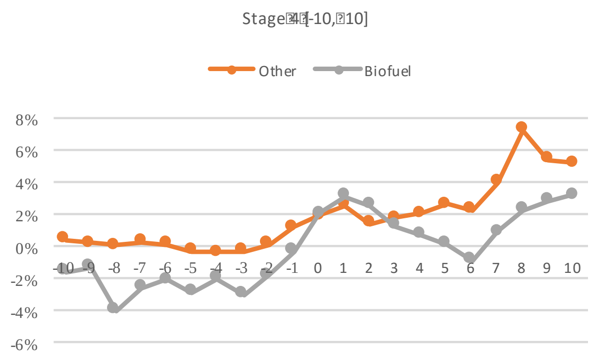
Other
Biofuel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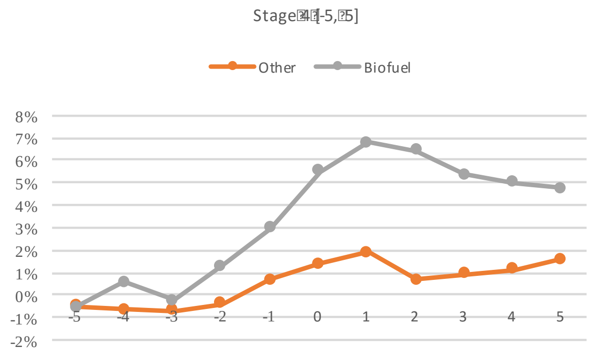
Other
Biofuel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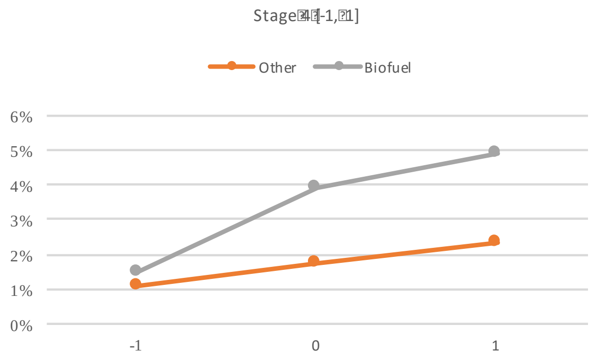
Other
Biofuel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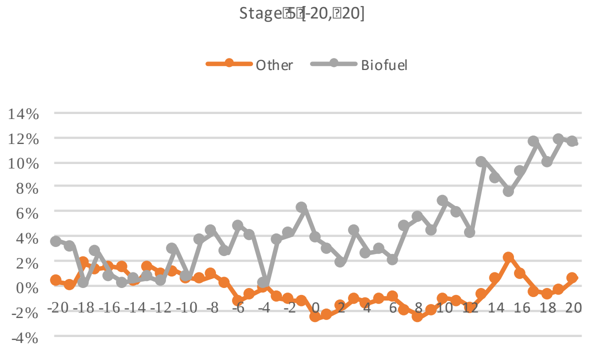
Other
Biofuel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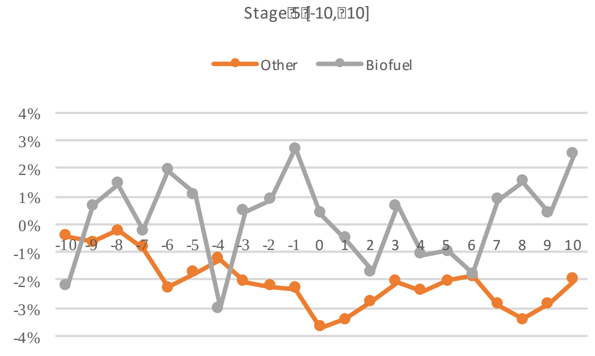
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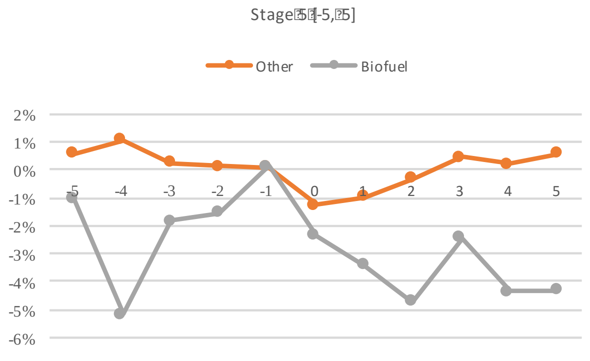
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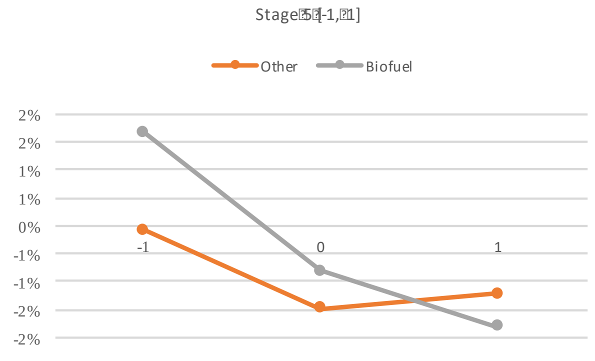
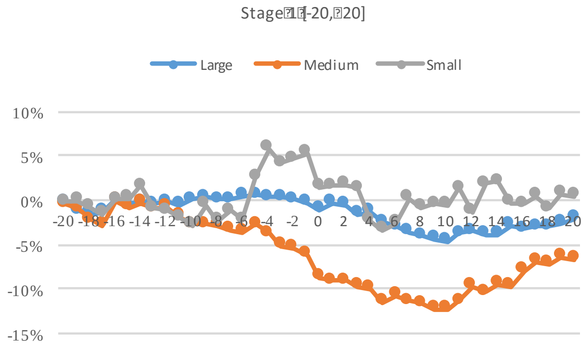
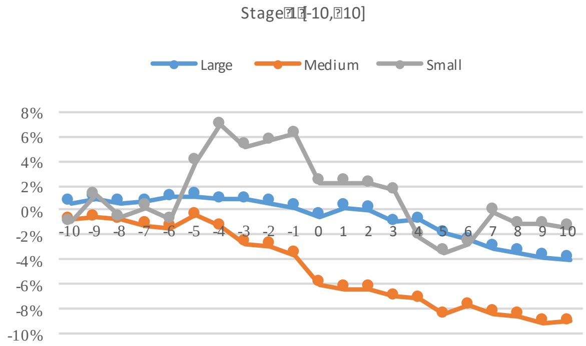
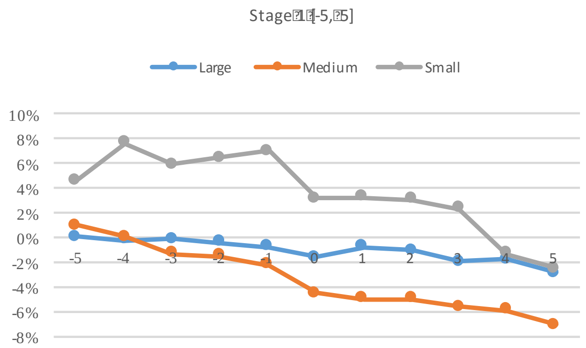
Biofuel

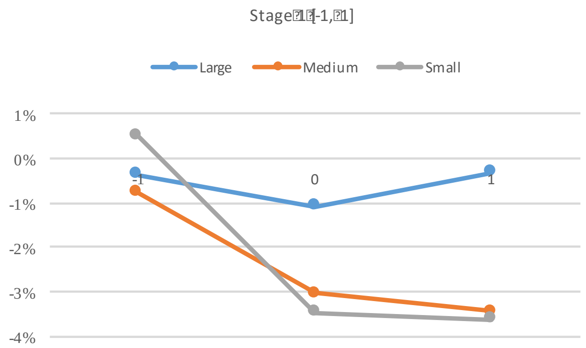

Stage 5 [-1, 1]
Other
Biofuel

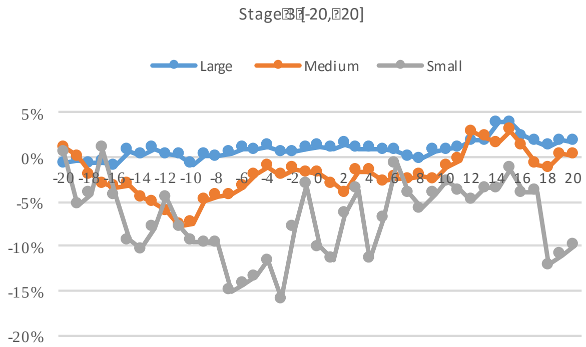
GRAPHS - CAARS BIOFUEL FIRMS AND OTHER RELATED BUSINESSES (SORTED BY SIZE)

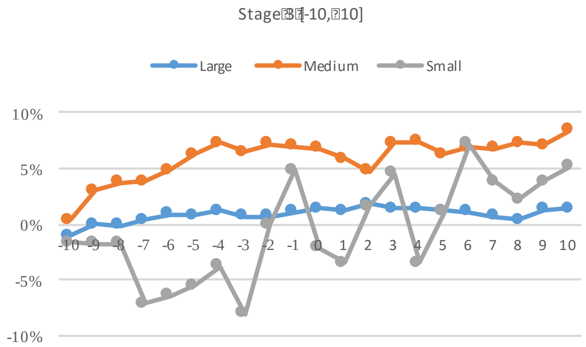


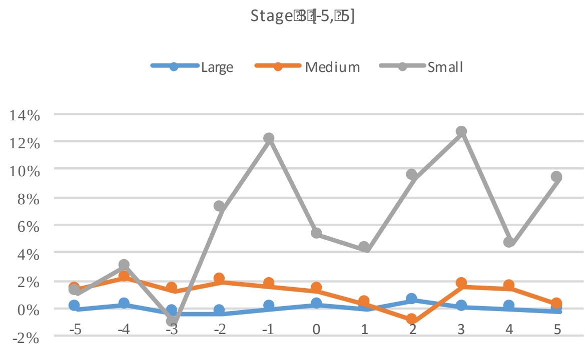


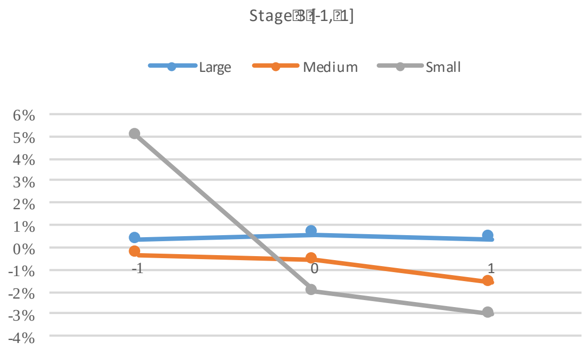


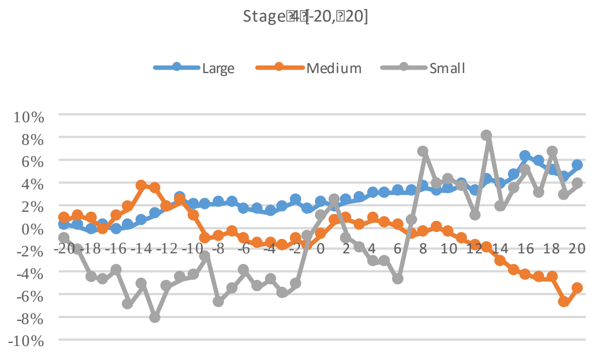


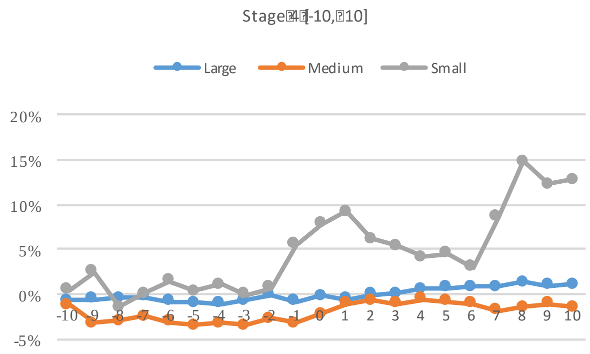


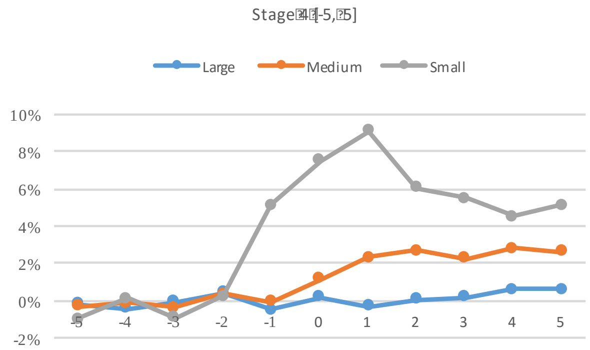


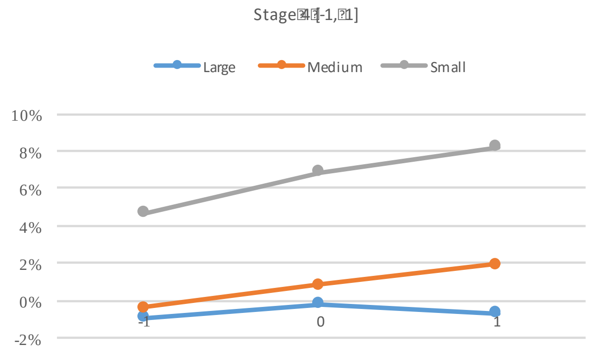


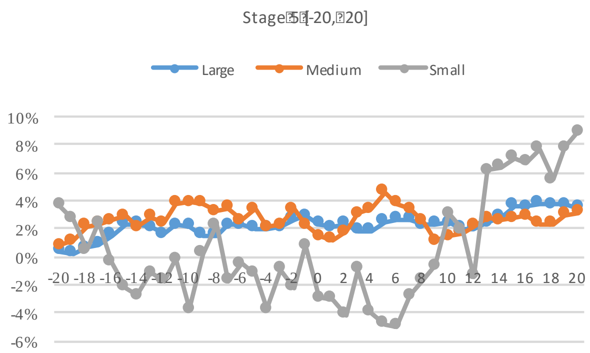


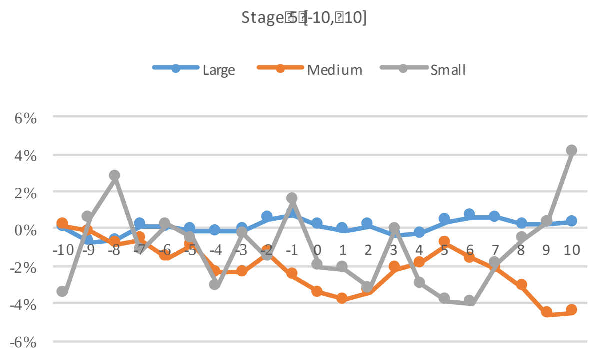

Stage4[-20,20]
Large
Medium
Small

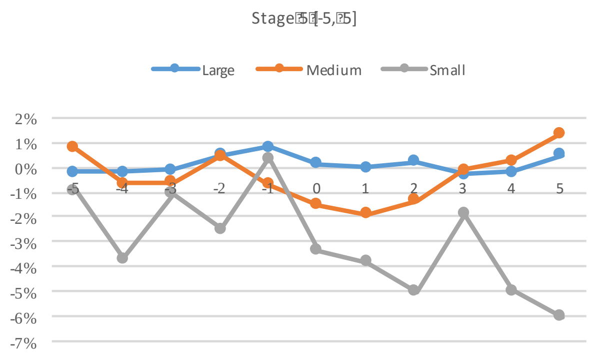

Stage4[-10,10]
Large
Medium
Small


Stage4[-5,5]
Large
Medium
Small


Stage4[-1,1]
Large
Medium
Small


Stage5[-20,20]
Large
Medium
Small


Stage5[-10,10]
Large
Medium
Small


Stage5[-5,5]
Large
Medium
Small

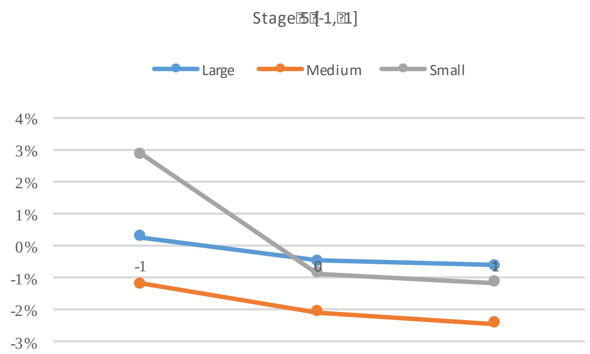

Stage5[-1,1]
Large
Medium
Small

TABLE – CAARS AND SIGNIFICANCES STAGE 1

	RINS			COMMODITIES			BIOFUEL FIRMS	
	D4	D5	D6	SME Chicago	SME Houston	SBO	Biofuel	Other Businesses
STAGE 1								
[-1, 1]	3,30 %	2,74 %	3,56 %	2,02 %	1,61 %	-1,08 %	-1,18 %	-3,69 %
	0,65	0,80	1,20	0,68	0,98	-0,93	-0,17	-1,16
[-5, 5]	-3,86 %	-10,51 %	7,35 %	3,28 %	1,86 %	-0,84 %	-5,26 %	-3,54 %
	-0,70	-0,86	0,66	0,73	0,82	-0,25	-0,57	-1,28
[-10, 10]	9,57 %	-1,08 %	22,5%*	1,91 %	0,49 %	-0,74 %	-3,32 %	-6,08 %
	0,74	-0,04	2,56	0,72	0,25	-0,13	-0,27	-0,94
[-20, 20]	17,38 %	-8,05 %	74,18 %	6,40 %	2,48 %	1,40 %	2,06 %	-6,51 %
	0,70	-0,15	1,15	0,91	0,60	0,45	0,17	-1,19
[-1, 0]	2,64 %	1,45 %	2,44 %	1,96 %	1,61 %	-0,93 %	0,06 %	-4,65 %
	0,78	0,55	2,10	0,66	0,99	-0,89	0,01	-1,06
[-5, 0]	0,36 %	-6,94 %	8,96 %	4,49 %	1,92 %	-1,20 %	1,44 %	-2,71 %
	0,47	-1,13	0,64	0,88	0,96	-0,42	0,12	-1,19
[-10, 0]	8,91 %	-0,86 %	22,95 %	3,19 %	0,61 %	-1,34 %	2,61 %	-4,56 %
	1,30	-0,04	1,54	0,73	0,23	-0,39	0,19	-0,76
[-20, 0]	12,94 %	-6,72 %	66,94 %	2,50 %	0,40 %	-1,40 %	1,17 %	-5,84 %
	1,12	-0,25	0,91	0,66	0,10	-0,40	0,11	-1,15
[0, 1]	0,71 %	1,06 %	2,15 %	1,78 %	1,21 %	-1,46 %	-1,39 %	-3,19 %
	0,31	0,30	0,60	0,72	0,91	-1,11	-0,33	-1,02
[0, 5]	-4,00 %	-3,15 %	-1,45 %	-0,49 %	-0,50 %	0,66 %	-7,01 %	-5,35 %
	-0,61	-0,35	-0,22	-0,12	-0,13	0,16	-1,43	-1,14
[0, 10]	-0,37 %	-0,53 %	-5,07 %	1,31 %	1,07 %	-1,56 %	-6,78 %	-6,16 %
	-0,05	-0,05	-0,36	0,39	0,55	-2,25	-0,93	-1,20
[0, 20]	3,75 %	2,14 %	-14,42 %	3,18 %	1,39 %	-1,67 %	-1,11 %	-5,99 %
	0,21	0,09	-0,35	1,55	1,41	-1,26	-0,13	-0,54

TABLE – CAARS AND SIGNIFICANCES STAGE 3

	RINS			COMMODITIES			BIOFUEL FIRMS	
	D4	D5	D6	SME Chicago	SME Houston	SBO	Biofuel	Other Businesses
STAGE 3								
[-1, 1]	-4,33 %	1,30 %	-18,23 %	-0,24 %	-0,29 %	0,70 %	-3,21 %	-0,34 %
	-0,56	0,00	-0,92	-0,09	-0,11	0,37	-1,15	-0,11
[-5, 5]	11,96 %	-3,06 %	1,27 %	2,27 %	1,91 %	5,0%**	7,21 %	0,43 %
	1,99	0,00	0,19	0,75	0,77	18,98	0,25	0,05
[-10, 10]	9,36 %	8,11 %	-5,54 %	3,73 %	6,74 %	5,27 %	8,75 %	2,63 %
	0,47	0,00	-0,57	0,61	1,23	2,27	0,32	0,23
[-20, 20]	30,77 %	81,68 %	124,67 %	10,94 %	14,39 %	16,83 %	10,76 %	-13,38 %
	0,65	0,00	3,19	1,13	3,87	2,14	0,22	-0,54
[-1, 0]	-0,34 %	0,86 %	-21,50 %	0,79 %	0,72 %	0,11 %	-3,76 %	1,46 %
	-0,08	0,00	-0,93	0,30	0,27	0,07	-1,20	0,61
[-5, 0]	7,68 %	-6,76 %	10,88 %	2,73 %	2,54 %	2,49 %	30,25 %	40,00 %
	5,02	0,00	1,76	0,68	0,60	1,93	0,30	0,40
[-10, 0]	7,42 %	1,75 %	19,69 %	4,64 %	6,38 %	2,41 %	-0,04 %	3,52 %
	1,18	0,00	1,16	0,81	0,92	2,82	0,00	0,48
[-20, 0]	21,59 %	25,92 %	86,33 %	7,51 %	10,63 %	3,53 %	4,00 %	-9,91 %
	1,11	0,00	1,42	0,77	1,46	5,09	0,21	-0,60
[0, 1]	-4,62 %	0,86 %	4,54 %	-0,14 %	-0,16 %	0,35 %	-6,25 %	-1,29 %
	-0,60	0,00	0,95	-0,08	-0,09	0,20	-0,64	-0,70
[0, 5]	4,63 %	4,61 %	-9,96 %	7,44 %	7,32 %	2,69 %	-2,86 %	-1,25 %
	0,64	0,00	-0,78	0,94	0,94	1,82	-0,20	-0,34
[0, 10]	3,23 %	6,77 %	-28,22 %	0,99 %	1,47 %	0,90 %	0,87 %	-0,55 %
	0,22	0,00	-0,96	0,31	0,53	1,08	0,09	-0,10
[0, 20]	6,19 %	48,25 %	11,59 %	1,62 %	-0,46 %	1,53 %	-4,37 %	-0,26 %
	0,27	0,00	0,30	1,82	-0,39	1,40	-0,17	-0,04

TABLE – CAARS AND SIGNIFICANCES STAGE 4

	RINS			COMMODITIES			BIOFUEL FIRMS	
	D4	D5	D6	SME Chicago	SME Houston	SBO	Biofuel	Other Businesses
STAGE 4								
[-1, 1]	-24,29 %	-24,2%***	6,65 %	0,98 %	-1,90 %	1,09 %	4,91 %	2,34 %
	-1,66	-2,59	0,46	0,94	-0,59	0,86	1,34	0,40
[-5, 5]	-11,86 %	-13,1%***	-7,60 %	5,25 %	4,32 %	0,87 %	4,72 %	1,59 %
	-0,70	-19,61	-0,23	1,02	1,49	0,35	0,36	0,36
[-10, 10]	-20,28 %	-28,54 %	23,61 %	2,94 %	1,26 %	2,25 %	3,24 %	5,24 %
	-1,50	-19,31	0,52	0,18	0,08	2,19	0,15	0,38
[-20, 20]	16,77 %	20,18 %	80,09 %	7,75 %	7,63 %	9,46 %	-2,64 %	3,54 %
	0,74	0,94	1,38	0,41	0,44	1,26	-0,12	0,23
[-1, 0]	-24,30 %	-23,53 %	5,45 %	0,62 %	-2,29 %	0,76 %	3,93 %	1,77 %
	-1,36	-2,45	0,34	0,38	-0,93	0,54	1,15	0,49
[-5, 0]	-27,28 %	-13,0%*	2,24 %	1,9%*	1,91 %	0,71 %	5,51 %	1,37 %
	-1,52	-2,98	0,12	3,28	1,56	0,38	0,61	0,20
[-10, 0]	-37,4%*	-22,2%***	-11,13 %	1,62 %	0,07 %	2,65 %	2,11 %	1,92 %
	-3,10	-17,74	-0,48	1,33	0,03	1,73	0,13	0,16
[-20, 0]	-9,86 %	6,76 %	12,34 %	1,69 %	1,49 %	6,77 %	-0,58 %	1,81 %
	-0,57	0,24	0,35	0,42	0,47	1,00	-0,03	0,23
[0, 1]	-19,51 %	-17,23 %	10,08 %	0,63 %	-2,24 %	0,91 %	3,44 %	1,21 %
	-1,13	-1,36	0,79	0,84	-0,64	0,75	0,75	0,44
[0, 5]	-3,23 %	-18,00 %	-1,38 %	5,28 %	5,7*	10,61 %	0,32 %	1,16 %
	-0,14	-1,71	-0,04	1,38	3,78	1,49	0,05	0,27
[0, 10]	-1,93 %	-22,94 %	42,07 %	-6,61 %	0,41 %	0,89 %	3,09 %	3,72 %
	-0,08	-1,59	1,21	-0,88	0,17	0,39	0,43	0,94
[0, 20]	-1,01 %	-14,6**	53,51 %	-0,73 %	-0,28 %	0,64 %	1,20 %	3,93 %
	-0,06	-5,35	0,73	-0,09	-0,05	0,99	0,20	0,32

TABLE – CAARS AND SIGNIFICANCES STAGE 5

	RINS			COMMODITIES			BIOFUEL FIRMS	
	D4	D5	D6	SME Chicago	SME Houston	SBO	Biofuel	Other Businesses
STAGE 5								
[-1, 1]	-3,05 %	1,68 %	-2,85 %	1,03 %	-0,05 %	-0,46 %	-1,80 %	-1,21 %
	-0,53	0,16	-0,67	1,30	-0,07	-0,49	-0,63	-1,12
[-5, 5]	-0,62 %	9,24 %	-2,25 %	2,03 %	0,53 %	-1,61 %	-4,32 %	0,58 %
	-0,07	0,84	-0,19	0,51	0,16	-0,50	-0,74	0,15
[-10, 10]	-5,69 %	8,25 %	-1,30 %	1,46 %	0,34 %	-0,87 %	2,55 %	-1,99 %
	-0,69	0,83	-0,13	1,17	0,23	-0,27	0,14	-0,28
[-20, 20]	13,14 %	29,84 %	26,29 %	2,97 %	0,54 %	-2,22 %	11,51 %	0,62 %
	0,52	1,06	1,03	1,03	0,15	-0,34	0,43	0,08
[-1, 0]	-2,09 %	1,69 %	-2,50 %	-0,02 %	-0,15 %	-0,65 %	-0,82 %	-1,48 %
	-0,69	0,17	-0,95	-0,02	-0,18	-0,66	-0,28	-1,19
[-5, 0]	-0,24 %	8,13 %	-2,28 %	0,96 %	0,67 %	-0,61 %	-2,34 %	-1,24 %
	-0,03	0,55	-0,22	0,67	0,40	-0,35	-1,09	-0,43
[-10, 0]	-3,05 %	7,45 %	0,49 %	-0,94 %	-1,00 %	0,00 %	-0,53 %	-3,41 %
	-0,26	0,36	0,02	-0,55	-0,91	0,00	0,03	-0,59
[-20, 0]	4,99 %	19,00 %	20,46 %	1,24 %	0,73 %	-1,06 %	3,80 %	-2,61 %
	0,28	0,65	0,62	0,80	0,44	-0,25	0,21	-0,27
[0, 1]	-3,20 %	-1,43 %	-3,78 %	0,64 %	-0,30 %	-0,28 %	-3,58 %	-1,15 %
	-0,76	-0,32	-1,09	0,41	-0,40	-0,17	-0,58	-0,97
[0, 5]	-4,37 %	-2,73 %	-4,62 %	-3,13 %	0,68 %	-1,18 %	-5,31 %	0,32 %
	-0,86	-0,56	-0,70	-0,37	0,08	-0,17	-0,67	0,08
[0, 10]	-8,28 %	-5,74 %	-8,33 %	0,82 %	0,25 %	-1,02 %	-1,28 %	0,18 %
	-0,75	-0,40	-0,45	1,03	0,25	-0,56	-0,28	0,06
[0, 20]	-8,14 %	-9,50 %	-12,34 %	0,61 %	0,16 %	-0,96 %	1,48 %	2,09 %
	-0,65	-0,58	-0,64	0,90	0,22	-0,63	0,29	0,37