Impact of the Inflation Reduction Act on the US. stock market

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January 2024

Abstract

The present article evaluates the impact of the Inflation Reduction Act's approval on the United States stock market, specifically on the renewable energy segment and in the automotive industry. The article applies the event study methodology by estimating a Mean-adjusted return model and a Market return model with dummy variables for the key events. The model is estimated around four key events related to the bill's presentation and approval. The article concludes that despite the IRA's considerable investment in renewable energies and the automotive industry, the renewable energy sector and the automotive industry group did not experience abnormal returns around the key events related to the bill's approval. Neither did the market as a whole.

1 Introduction

On September 27 of 2021, the US administration presented the Build Back Better Act. Almost one year later and after a long negotiation process, the bill was substantially transformed and was finally approved with the name of Inflation Reduction Act (IRA). The bill includes a massive stimulus to accelerate investments in renewable energy and the production of electric vehicles in the United States.

According to the Penn-Wharton Budget Model (Huntley Ricco & Arnon 2022), the bill contains a total provision of $384.9 billion for climate change and renewable energy, from which 63.7% is dedicated to renewable energies and 5.9% is dedicated to stimulating the electric vehicles adoption and production in the United States, 12.1
The present study uses the standard event study methodology to evaluate the impact of the bill's approval on the United States stock market. In particular, it analyses the impact on the renewable energy sector and the automotive industry group. For that, I use two benchmark indexes: the Wilder Hill Clean Energy Index (ECO) and the S&P 500 Automobiles Industry Index.

The event study methodology is applied by estimating a Mean-adjusted return model and a Market return model with dummy variables for the key events. The model is estimated using 5 day window (2 days before, 2 days after, and the day of the event) around four key events: the presentation of the bill to Congress, the announcement of Senator's Manchin opposition to the bill, the agreement with Senator Manchin which was key to the approval, and the vote of the bill by the Senate. Normally, the use of event study methodologies to evaluate the impact of legislation approval has particular challenges, as the result of legislative approvals or rejections is known in advance given the number of representatives each party has. For this study, I take advantage of several particularities of the IRA approval that allow to apply successfully the event study methodology.

2 Literature Review

The event study methodology is well-established in the field of financial economics. There is plenty of literature that discusses and replicates the methodology, beginning in the late sixties until today. In their seminal article Fama Fisher, Jensen, and Roll (1969) evaluated how stock prices incorporate the information of stock splits. By doing so, they settled the basis of what we know today as event studies. To evaluate the price reaction to stock split, they estimate the regression $log_e(R_{ij}) = \alpha_j + \beta_j log_e L_t + \epsilon_{jt}$, where R_{ij} is the stock's return, and L_t is the market's return.

It is important to highlight that, Fama Fisher, Jensen, and Roll do not include the period of the analyzed event in the estimation. They estimate the parameters without the event´s period and then, with the estimated parameters, they calculate the error ϵ_{jt} for the event's dates, the mean of the error is considered as the measure of the abnormal return. The authors evaluate the different estimation methods, they conclude that even when the data is not normally distributed, OLS provides estimators that are unbiased and consistent. They also highlight the problems of the T-statistic for hypothesis testing given the non-normality of residuals.

In Brown and Warner's article (1980), the authors extend Fama Fisher, Jensen, and Roll's methodology. By using the same principle, they evaluate three different regression models for stock prices and evaluate the accuracy of each one of them. According to them, the notion of abnormal return requires a benchmark value for comparisons, which leads them to evaluate three possible benchmarks. The first model called the Mean Adjusted Return Model establishes that the expected return of an asset i is given by a constant $E(\tilde{R}_{it}) = K_i$, where the abnormal return of asset i on period t corresponds simply to the difference between the observed return and the mean return¿ $\epsilon_{i,t} = R_{i,t} - K_i$.

The second model evaluated by Brown and Warner is the Market Return model in which the expected return of an asset is equal to the market return $E(\tilde{R}_{i,t}) = E(\tilde{R}_{m,t})$. Finally the authors evaluate the Market and Risk Adjusted Return model in which the expected return of an asset is given by the CAPM model with $E(\tilde{R}_{it}) = E(\tilde{R}_{zt}) + \beta_i \left[E(\tilde{R}_{mt}) - E(\tilde{R}_{zt}) \right])$. Here the abnormal return is given by $R_{it} - R_{zt} - \beta_i [R_{mt}) - E(R_{zt})])$.

The authors select randomly 250 securities and introduce artificial abnormal returns into the historical data using monthly returns, then they evaluate the capacity of the three models to identify the abnormal returns. Surprisingly they find that the models produce similar results and that "beyond a simple, one-factor market model, there is no evidence that more complicated methodologies convey any benefit. In fact, we have presented evidence that more complicated methodologies can actually make the researcher worse off" (Brown & Warner 1980).

Dyckman, Philbrick, and Stephan (1984) replicate Brown and Warner's simulation with daily data and include 2 additional return models: Scholes-Williams and Dimson models. The article concludes that the Market Return Model is slightly better than the Mean Adjusted Return and the Market Adjusted Return models in detecting abnormal returns. The Scholes-Williams and Dimson did not improve the capacity to detect abnormal returns, which reinforces the argument in favor of simple models. Finally, the authors conclude that the capacity to detect abnormal returns of models decreases considerably when the date is unknown and the portfolios are smaller. Dyckman, Philbrick, and Stephan also analyzed the potential problems of T-tests given the non-normality of residuals, they conclude that "nonnormality of individual-security daily-return residuals has little effect on the inferences drawn from the use of the t-test applied to portfolios" (Dyckman, Philbrick, and Stephan 1984).

In a second article, Brown and Warner evaluate again different return models using daily data and reinforce the evidence in favor of simpler return models. Additionally, the authors conclude that estimation methods different from OLS do not provide clear advantages for the return models. MacKinlay (1997) uses a market return model with the specification $R_{it} + \alpha_i +$
$beta_i R_{mt} + \epsilon_{it}$ to evaluate the impact of news on the market return. The author highlights the limited gains of using multifactor models for event studies and concludes that a fundamental requirement for event studies to be successful is that the event date can be identified precisely, otherwise, the methodology loses much of its statistical power.

Blinder (1998) makes a review of the evolution of event studies methodology. Blinder underlines the increasing popularity at that time for an estimation method that includes the event period on the dataset while including at the same time a dummy variable for the analyzed events. This way, the return equation will be: $R_{i,t} = \alpha_i + \beta_i R_{mt} + \Sigma_{j=1}^{N} \gamma_j Dta + \epsilon_{it}$ where is the dummy variable equal to 1 for each event j and γ_j is the abnormal return parameter for event j. The existence or not of the abnormal return is evaluated by the significance of γ_j. One important warning of Blinder regarding this specification is that the hypothesis test will not be very powerful statistically speaking if the signs of the effects are different. In those cases, it is better to estimate different regressions for each event.

Khotari and Warner (2006)review the evolution of event studies through time. They conclude that the core methodology has not changed substantially since Fama, Fisher, Jensen, and Roll's (1969) seminar article, however, new methodological consensus has appeared to improve estimations. For example, Khotari and Warner point out that events with long-horizon impacts have important limitations, while events with short-term impacts remain effective and statistically powerful.

Ali and Kallapur (2001) apply the event study methodology to the bill approval process to determine the effects of the Private Securities Litigation Reform Act of 1995. They measured the price reactions of events that changed the likelihood of the approval of the law. The authors include a set of events that provided new information to markets regarding the law's approval, this included a presidential veto and its subsequent override by Congress.

Ali and Kallapur identify three particular challenges to applying the event study methodology for law approval processes: first, it is difficult to identify all the major events that affect the approval process. Second, It is necessary to identify the precise date in which that information is provided to the markets. Third, it is necessary to identify when the markets first anticipated the effects of such events. For the estimation they use the Market Return model with dummy variable for the dates of the events: $R_t = \alpha_0 + \Sigma_{j=1}^{N} \beta_j D_j + \epsilon_{it}$. The authors conclude there is evidence of negative market price reactions to events that increased the likelihood of the law's approval.

Rezaee and Pankaj (2005) apply the event study methodology to the The Sarbanes-Oxley Act approval process in 2002. Using a three-day cumulative abnormal return window the authors evaluate 12 Congressional events using the Mean Adjusted Return Model with dummy variables for the events: $R_t = \alpha_0 + \Sigma_{j=1}^{N} \beta_j D_j + \epsilon_{it}$. Rezaee and Pankaj found positive significant abnormal returns around the events that increased the probabilities of the law's approval.

3 Data

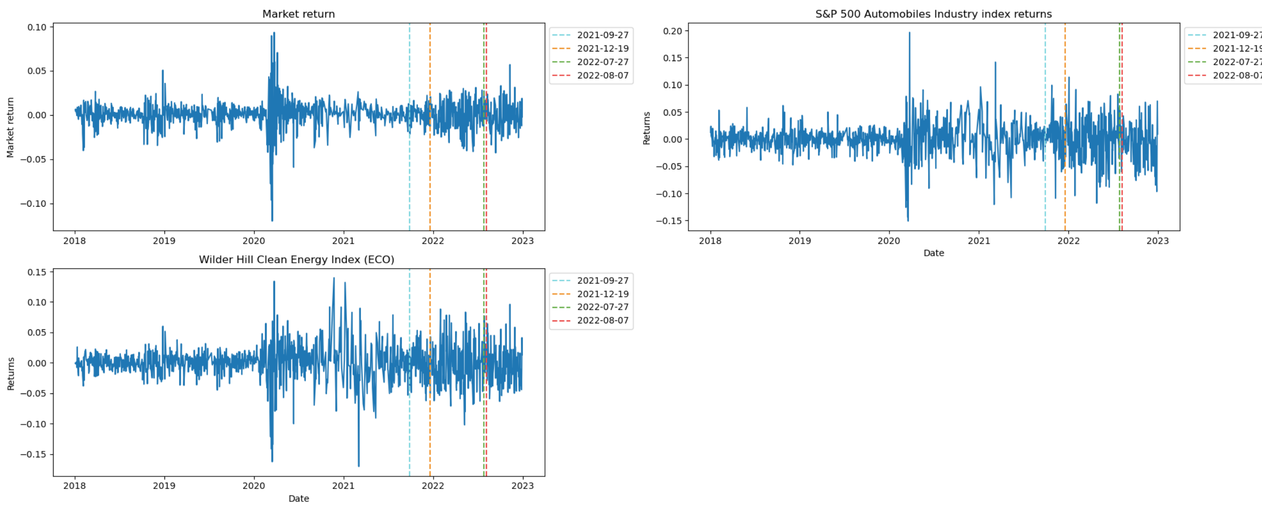
The data used for the stock indexes and the market return corresponds to the daily closing values for the period between January 2 of 2018 and December 30, 2022. As the the IRA's investments focus mainly on the clean energy sector and the automotive industry group, I will analyze those two sectors. Following Reboredo,Rivera-Castro, & Ugolini (2016) and Song, Ji,Du & Geng (2019) I will use the Wilder Hill Clean Energy Index (ECO) to measure the impact on the clean energy sector. Computed by the American Stock Exchange for a set of companies involved in activities related with the use of cleaner energies and conservation Wilder Hill Clean Energy Index (ECO)is a consolidated benchmark. The data was extracted from Google Finance (ECO. 2023) .

For the automotive industry I will use the S&P 500 Automobiles Industry index. The index time series was extracted from Yahoo Finance using Python's yfinance Package (SP500-251020, 2023).

For the market return data I used Fama and French market daily risk premium and daily risk free return (Fama & French 2024). Fama and French calculate the market return variable using as basis the data from the Center for Research in Security Prices (CRSP), specifically from the CRSP US Total Market Index, which represents 100% of US equity market. However, the market index on Fama-French library refers to the market risk premium $R_m - R_{riskfree}$, therefore, to obtain the market risk return I added back the risk free rate. The data of the risk free rate was also obtained from Fama and French library (Fama & French 2024). The detail of the construction of the Fama-French library can be found on (Fama & French 2023)

Graph 1 presents the historical behavior of the variables, while table 1 presents basic descriptive statistics of the data.

Graph 1: Daily returns between January 2, 2018 and December 30 2022



Source: Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

Note: Market return was obtained from Fama-French data library (Fama & French 2024), which is built based on the Center for Research in Security Prices market index, which represents 100% of the US equity market.

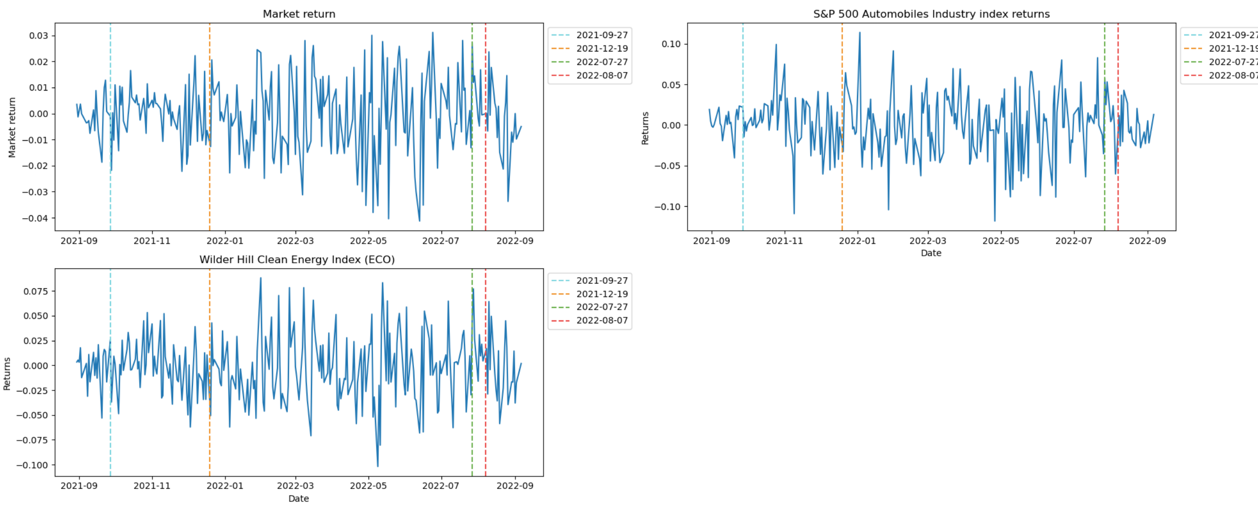
Table 1: Descriptive statistics

	Mkt	Ret_^ECO	Ret_^SP500-251020
count	1149	1149	1149
mean	0.000	0.000	-0.001
min	-0.120	-0.170	-0.151
25%	-0.005	-0.013	-0.013
50%	0.001	0.001	0.001
75%	0.007	0.014	0.013
max	0.093	0.140	0.197
std	0.015	0.029	0.030
Kurtosis	4.594	4.790	10.344
Skewness	-0.121	-0.281	-0.545

Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

The visualization of the data show that the 3 variables are centered around 0, this is confirmed by the summary statistics on Table 1. It is possible to observe an important increase on volatility around the pandemic. In the period that encompasses the four events, there is also an increase of volatility, this may be explained by the increases of the United States Fed Fund rates, which begun on April 2022. Both indexes have very similar standard deviations, and both have higher volatility than the market. To observe clearly the variables' behavior around the events dates, I present on Graph 2 a zoom around the analyzed events.

Graph 2: Daily returns between July 27 2021 and September 07 2022



Source: Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

Table 2: Correlation coefficients

	Ret_^SP500-251020	Ret_^ECO	Mkt
Ret_^SP500-251020	1.000	0.685	0.648
Ret_^ECO	0.685	1.000	0.716
Mkt	0.648	0.716	1.000

Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

Table 2 presents the correlation coefficient between the variables. We observe that the Wilder Clean Energy Index has a high correlation with the Maket return (0.716), while the S&P 500 automotive index has a higher correlation with the ECO index (0.685) than with the market return (0.648) .To evaluate the normality of the variables, I applied the Jarque-Bera normality test to the 3 variables. The results are presented in Table 2. As can be seen, the null hypothesis of normality is rejected for the three variables. In line with what was observed by Fama, Fisher, Jensen, and Roll (1969), the returns do not follow a normal distribution. The histogram Kernel Density plots for each variable are presented in Annex 1.

Table 3: Jarque-Bera normality tests

	Mkt	Ret_^ECO	Ret_^SP500-251020
Statistic	5129.765	5129.765	5129.765
p-value	0.000	0.000	0.000

Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

4 Methodology

To determine the existence of abnormal returns, it is necessary to compare an asset or portfolio with a benchmark, normally, the benchmark commonly used is the market portfolio. However, if the Benchmark used also experienced abnormal returns, the event study would fail to identify the abnormal returns of the analyzed asset. Therefore, in this case, it is necessary to evaluate if the market portfolio experiences abnormal returns. Following Rezaee and Pankaj (2004), I evaluate this possibility using the Mean Adjusted Return model as proposed by Brown and Warner (1980) with additional dummy variables for the events. The estimated model is:

$$R_{m,t} = \alpha_{i,0} + \Sigma_{j=1}^{4} \beta_{i,j} D_j + \epsilon_{i,t} \quad (1)$$

Where:

- $R_{m,t}$ is the market return for period t.
- $\alpha_{i,0}$ is the average market return.
- D_j is the dummy variable for the event j.
- β_j is the abnormal return of the event j.

Following Fama, Fisher, Jensen and Roll(1969) and Dyckman, Philbrick, & Stephan (1984), I will estimate the model using OLS estimators and apply the T-test for significance as the indexes evaluated give shape to portfolios big enough to avoid the problems generated by non-normality.

For the estimation I will use an abnormal return model with dummy variables for the 4 events of interests, therefore, the event period is included in the estimation. Following Ali and Kallapur (2001) and Khotari and Warner (2006),the specification of the model to estimate is:

$$R_{i,t} = \alpha_{i,0} + \beta_{i,1} R_{m,t} + \Sigma_{j=1}^{4} \beta_{i,j} D_j + \epsilon_{i,t} \quad (2)$$

Where:

- R_t is the return of the correspoding index.
- R_{mt} is the market return.
- D_j is the dummy variable for the event j.
- β_j is the abnormal return of the event j.

As mentioned, one of the main challenges of event study for law approvals as highlighted by Ali and Kallapur (2001)is that the dates of the events analyzed must be identifiable and they must provide new information that was not previously available. However, the information regarding the approval process of a law or regulation is something known in advance given the congressional composition and the previous stances of congress members. As I will explain, due to particular situations surrounding its approval, the Inflation Reduction Act approval process had several events clearly identifiable that provided new information to markets.

During the period of the bill debate Democrats had a comfortable majority on Congress, with 235 Democrats vs. 200 Republicans. However, in the Senate the composition was 50 Senators for Democrats and 50 for Republicans. In this situations the Vicepresident had the tie-breaker vote, which implied that the bill required all the 50 Democrat votes to be approved. However, on December 19 of 2021, after the bill had been approved by the Congress, Democrat Senator Bill Manchin publicly announced its vote against the bill and forced a negotiation with the Administration.

During several weeks Senator Manchin's negative to vote the bill created incertitude whether it will be approved or not. On July 27 of 2022, the White House announced an agreement with Senator Manchin to pass the bill. My hypothesis is that the announcement of Manchin vote against and later the vote in favor, provide new information for markets to internalize.

Consequently I will analyze 4 key dates related with the Inflation Reduction Act approval process:

- First, the bill's presentation on September 27 of 2021 under the original name of the Build Back Better act.
- Second, the Senator Manchin's announcement of its opposition to the Build Back Better act on December 19 of 2021.
- Third the agreement with Senator Manchin on July 27 of 2022.
- And fourth, the Senate approval on August 7 of 2022.

Around this 4 key dates I will evaluate a window of two days before and after the events, for a total of five trading days including the event. For the hypothesis test I will use ordinary T statistics to evaluate the significance of the event parameters, this in line with Dyckman, Philbrick, and Stephan (1984).

5 Results

First I evaluate if the market in general experienced abnormal returns during the analyzed events. The estimation results for Equation 1 are presented in Table 3. As it can be observed, the parameters for the events' dummy variables are not significant, which means that the market as a whole did not experience abnormal returns during the events, and therefore market return can be used as a benchmark.

Table 4: OLS estimation of equation 1 for daily Market abnormal returns between January first 2018 and December 30 2022

No. Observations:		1149		R-squared:		0.002
Dep. Variable:		Mkt		Adj. R-squared:		-0.002
Model:		OLS		F-statistic:		0.5068
Covariance Type:		nonrobust		Prob (F-statistic):		0.731
	coef	std err	t	P>|t|	[0.025	0.975]
const (alpha)	0.0004	0	0.852	0.394	0	0.001
sept_27_2021*	-0.0021	0.007	-0.33	0.742	-0.015	0.011
dec_19_2021*	-0.0005	0.007	-0.084	0.933	-0.013	0.012
jul_27_2022*	0.0082	0.007	1.26	0.208	-0.005	0.021
aug_07_2022*	0.0037	0.007	0.569	0.569	-0.009	0.016
Omnibus:		266.654		Durbin-Watson:		2.332
Prob(Omnibus):		0		Jarque-Bera (JB):		5161.057
Skew:		-0.545		Prob(JB):		0
Kurtosis:		13.326		Cond. No.		15.3

*sept_27_2021 corresponds to the date of the original bill presentation, dec_19_2021 is the date when Senator Manchin announced its opposition to the bill, jul_27_2022 corresponds to the agreement with Senator Manchin, and aug_07_2022 is the date when the bill was approved by Senate.

Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

In the next step, I estimated equation 2 using OLS method to evaluate the presence of abnormal returns on the Wilder Hill Clean Energy Index (ECO). Results presented in Table 4 indicate that the four dummy variables for events are not statistically significant, therefore, the key events related to the Inflation Reduction Act's approval did not generate abnormal returns for the Wilder Hill Clean Energy Index. Annex 2 presents the scatter plot between the daily market returns and the Wilder Hill Clean Energy Index daily returns.

Table 5: OLS estimation of equation 2 for daily ECO index abnormal returns between January first 2018 and December 30 2022

No. Observations:		1149		R-squared:		0.514
Dep. Variable:		Ret_^ECO		Adj. R-squared:		0.512
Model:		OLS		F-statistic:		241.4
Covariance Type:		nonrobust		Prob (F-statistic):		4.78E-176
	coef	std err	t	P>|t|	[0.025	0.975]
const (alpha)	-0.0003	0.001	-0.455	0.649	-0.001	0.001
Mkt (Beta)	1.4058	0.041	34.611	0	1.326	1.486
sept_27_2021*	-0.0026	0.009	-0.296	0.767	-0.02	0.015
dec_19_2021*	-0.0059	0.009	-0.656	0.512	-0.023	0.012
jul_27_2022*	0.0107	0.009	1.192	0.233	-0.007	0.028
aug_07_2022*	0.0075	0.009	0.837	0.403	-0.01	0.025
Omnibus:		172.147		Durbin-Watson:		1.852
Prob(Omnibus):		0		Jarque-Bera (JB):		2420.643
Skew:		0.012		Prob(JB):		0
Kurtosis:		10.111		Cond. No.		68.9

*sept_27_2021 corresponds to the date of the original bill presentation, dec_19_2021 is the date when Senator Manchin announced its opposition to the bill, jul_27_2022 corresponds to the agreement with Senator Manchin, and aug_07_2022 is the date when the bill was approved by Senate.

Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

In the case of the automotive industry represented by the S&P 500 Automobiles Industry Group Index, the results of the estimation of equation 2 are presented in Table 5. The results show that all the parameters for the event dummy variables are non-significant. Therefore, the S&P 500 Automobiles Industry Group index did not experience abnormal returns during any of the events related to the approval of the Inflation Reduction Act. Annex 2 presents the scatter plot between the daily market returns and 500 Automobiles Industry Group daily returns.

Table 6: OLS estimation of equation 2 for daily S&P 500 Automobiles Industry index abnormal returns between January first 2018 and December 30 2022.

No. Observations:		1149		R-squared:		0.422
Dep. Variable:		Ret_^SP500-251020		Adj. R-squared:		0.419
Model:		OLS		F-statistic:		166.7
Covariance Type:		nonrobust		Prob (F-statistic):		3.50E-133
	coef	std err	t	P>|t|	[0.025	0.975]
const (alpha)	-0.0013	0.001	-1.948	0.052	-0.003	9.81e-06
Mkt (Beta)	1.3259	0.046	28.721	0	1.235	1.416
sept_27_2021*	0.012	0.01	1.177	0.239	-0.008	0.032
dec_19_2021*	0.0063	0.01	0.617	0.538	-0.014	0.026
jul_27_2022*	0.0146	0.01	1.436	0.151	-0.005	0.035
aug_07_2022*	0.0058	0.01	0.574	0.566	-0.014	0.026
Omnibus:		117.735		Durbin-Watson:		1.9
Prob(Omnibus):		0		Jarque-Bera (JB):		803.236
Skew:		-0.146		Prob(JB):		3.80E-175
Kurtosis:		7.086		Cond. No.		68.9

*sept_27_2021 corresponds to the date of the original bill presentation, dec_19_2021 is the date when Senator Manchin announced its opposition to the bill, jul_27_2022 corresponds to the agreement with Senator Manchin, and aug_07_2022 is the date when the bill was approved by Senate.

Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

6 Conclusions

The Inflation Reduction Act represents one of the major policy decisions in history to address climate change and reduce emissions. It has an estimated total investment of $384.9 billion (Huntley Ricco and Arnon 2022) during the next 10 years, mainly on renewable energies and electric vehicles. The present article applied the event study methodology to analyze the impact of the bill on the US stock market specifically on the renewable energy segment and in the automotive industry.
By analyzing the abnormal returns of the market in general, the renewable energy sector, and the automotive industry group, the present study concludes that the market as a whole did not experience abnormal returns during the main events related to the bill approval.

Despite the investments contained in the Inflation Reduction Act for the renewable energy industry in the United States, the article concludes that the key events related to the Act's approval did not generate abnormal returns for the Wilder Hill Clean Energy Index which represents the sector, neither for the S&P 500 Automobiles Industry group index. Therefore it is possible to conclude that the bill did not have a significant impact on the US stock market, neither in the industries that benefit directly from its approval.

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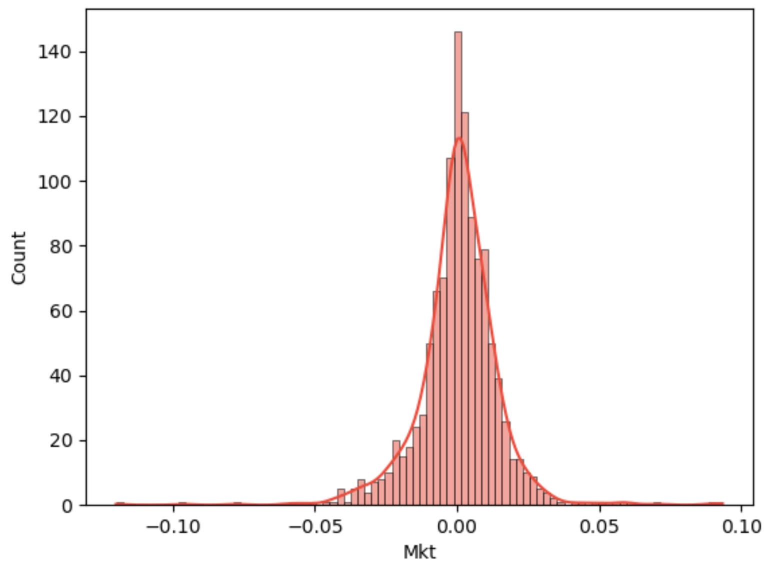
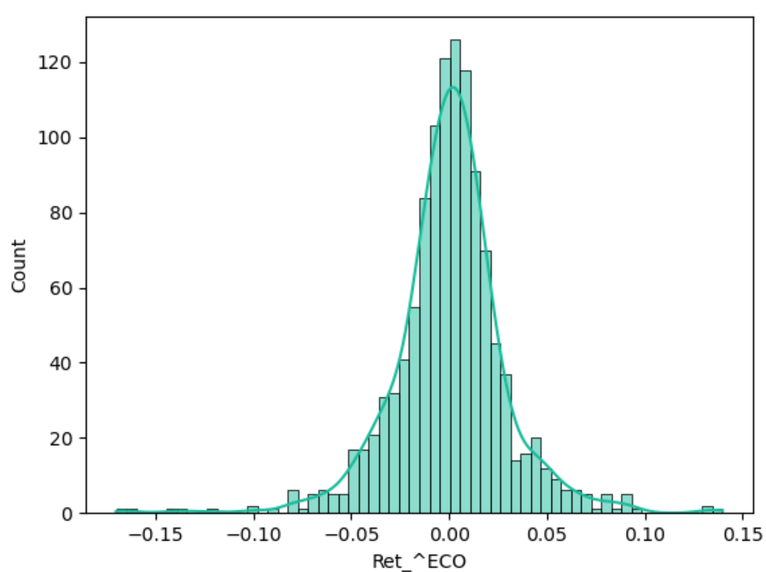
8 Annex 1: Histograms and Kernel density plots

Graph 3: Market return histogram and Kernel density plot



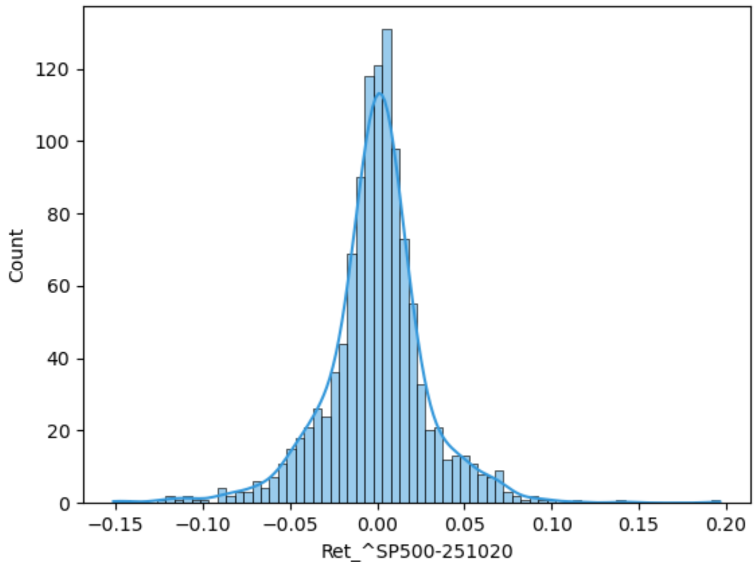
Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

Graph 4: Wilder Hill Clean Energy Index (ECO) histogram and Kernel density plot



Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

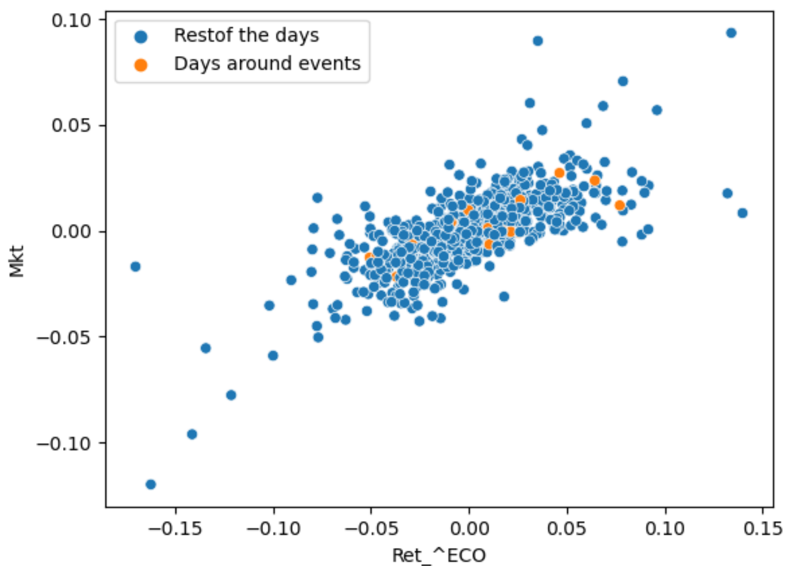
Graph 5: S&P 500 Automobiles Industry index histogram and Kernel density plot



Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

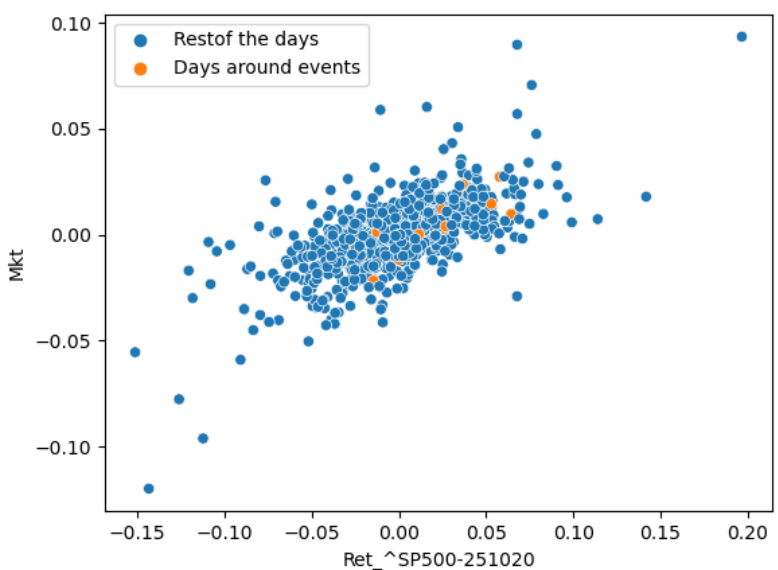
9 Annex 2: Scatter plots between Market Returns and the two indexes

Graph 6: Scatter plot between daily Market returns and the Wilder Hill Clean Energy Index (ECO) daily returns



Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)

Graph 7: Scatter plot between daily Market returns and the S&P 500 Automobiles Industry Group Index daily returns



Source: Own elaboration with data from Fama & French (2023), ECO. (2023) and SP500-251020, (2023)