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USING STOCK MARKET DATA TO MEASURE THE EFFECT OF EASA'S AMENDMENTS TO REGULATIONS GOVERNING COMPONENTS FOR THE AEROSPACE SECTOR.

NNAMDI NWAIGBO, MIKE KING

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NNAMDI NWAIGBO, DR MIKE KING
Analysis and Evaluation, Partnerships Directorate

ABSTRACT

Regulations and Standards are necessary for developing products that are “safe to use”, whether the product is a building, an aircraft, or a pressure vessel. The National Physical Laboratory (NPL) makes a significant contribution to standards and regulations. For example, In the field of polymer composites/fibre reinforced plastics NPL's work has contributed to 17 standards in the last two decades. To measure the effect of regulations and standards on the economy, we used the aerospace industry as a use case. The aerospace industry has an organisation, the European Aviation Safety Agency (EASA), dedicated to providing codified standards and guidelines for companies operating in the sectors. The standards cover aspects of aviation from unmanned aircraft systems to the use of composite materials. Furthermore, the EASA makes this information available in an open-source database. Using a methodology called Event Study, stock market data and the EASA's open-source database, we calculated the effect of 64 proposed amendments and published amendments by the EASA for large aircraft (called CS-25) on the stock prices of companies that supply parts made from composite materials to the aerospace sector.

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National Physical Laboratory
Hampton Road, Teddington, Middlesex, TW11 0LW

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Approved on behalf of NPLML by
David Skelton, Strategic Programme Manager.

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EXECUTIVE SUMMARY

Overview

Regulations and Standards are necessary for developing products that are “safe to use”, whether the product is a building, an aircraft, or a pressure vessel. In fact, these aspects need each other and interact closely. Regulations define aspects that need to be followed and meet to ensure that a product will safely perform its required purpose. These regulations may be European Directives or published by bodies charged with monitoring specific areas, such as the European Aviation Safety Agency (EASA) regulations for commercial aircraft. Standards are voluntary and derive their power and importance in demonstrating the product requirements as defined by the regulations, such as design data used, the stress analysis used, the safety margins have been met. These standards do not need to be used, but alternative approaches (i.e. test methods, material specifications) will need to be demonstrated as achieving the same levels of performance. Hence it is easier and quicker to use internationally agreed standards, hopefully with precision information covering repeatability (measurements at one place, by one operator at one time) and reproducibility (measurements at different sites, by different operators at different times.

The NPL has made considerable efforts in contributing to standards that would harmonise methods used for determining the properties of composite materials. In the field of polymer composites/fibre reinforced, NPL has directly contributed to drafting 17 ISO standards. For example, a new standard (ISO 20144:2019 - Fibre-reinforced plastic composites — Standard qualification plan (SQP) for composite materials, including reduced qualification plan (RQP) and extended qualification plan (EQP) schemes) has recently been published to make it easier and cheaper to qualify materials for the initial preliminary design and material down-selection aspects of product development. The standard started life as a Joint Industry Project, including interlaboratory trials, that was published as an NPL Good Practice Guide. Industry members included CAA – now EASA; small, medium, and large companies, research bodies etc. The document was used as the foundation of ISO 20144, with some updating for the material and process changes highlighted above. Internationally, there was wide support for and strong recognition of the need for this standard.

To measure the effect of regulations and standards on the economy, we used the aerospace industry as a use case. The aerospace industry has an organisation, the European Aviation Safety Agency (EASA), dedicated to providing codified standards and guidelines for companies operating in the sectors. Between 2003 and 2017, the EASA agreed on a series of amendments to the main certification specification governing large aircraft (CS-25). It can be shown that the announcement of these amendments tends to be followed by abnormally high demand for shares in companies that supply parts made from composite materials to the aerospace sector. Furthermore, an econometric analysis, following an established event study methodology, was used to estimate the average effect of announcements regarding changes to CS-25 on the share price of eight companies listed on European exchanges and that supply aerospace parts made from composite materials. Finally, following the stock market’s return to steady growth in 2010, EASA’s announcements regarding changes to CS-25 can be associated with about 20% of the growth in these companies’ share price.

Context

The EASA (European Aviation Safety Agency) prescribes airworthiness standards using a series of ‘Certification Specifications’ (CS). The document containing the certification specifications for large commercial aircraft is known as CS-25 and was first published by EASA in 2003. Two elements of this document can be seen as helpful to companies intending to supply aerospace parts made from composite materials: Firstly, the section concerning the suitability and durability of materials used for aerospace parts (CS-25.603)

avoids recommending the use of any particular material. Secondly, CS-25 contains Acceptable Means of Compliance (AMCs 20-29) standards that were specifically intended to address the needs of companies wanting to use composite materials. Hence, EASA signalled its intention to adopt a performance-based approach of assessing the use of materials with the publication of CS-25.

However, since the initial publication of CS-25 in 2003, the document has gone through several iterations; and, so between 2004 and 2016, EASA made 21 amendments to CS-25. As discussed, the initial version of CS-25 included content that was broadly helpful to companies wanting to sell aerospace parts made from composite materials. As it turned out, this iterative process created a document that truly accommodates companies wanting to supply aerospace parts made from composite materials. Experts at Southampton University published a paper in 2017 discussing the modernisation of composite materials regulations. Annex 3.2 of this position paper discusses the approach taken by EASA and says that no other sector has a counterpart document as comprehensive and dovetailed to the generally acceptable regulations as EASA's AMC 20-29 document on materials; this puts applicants in the aerospace sector in a strong position concerning the use of new materials. Hence, it is reasonable to suppose that, amendments to CS-25 would have been welcomed by those investing in the use of composite materials for manufacturing aerospace parts.

The remainder of this study summarises an empirical analysis (event study) that examines the relationship between EASA's announcements about changes to CS-25 and the demand for shares in companies wanting to supply aerospace parts made from composite materials. The economic theory (efficient market hypothesis) underlying the study summarised below is that share prices in the stock market reflect an agent's expectations about the future performance of specific companies and sectors. Investors react to announcements by regulators and other relevant bodies concerning changes to specifications or regulations. That is, regulatory shocks are new information for investors to act upon and according to the efficient market hypothesis, the stock market can be used to measure the commercial effect of regulatory changes. This methodology has a long history of being used to assess regulatory changes in economics and finance[1].

Data

The data used in this study were: (1) the stock market data for companies that supply aerospace parts made from composite materials, as well as, (2) the date of EASA's announcements about proposed/actual amendments to CS-25. An event study methodology was used to look at the effect of amendments to CS-25 on the value of European companies that use composite materials to make parts for aeroplanes.

The study began by identifying eight companies, listed on European stock exchanges, that supply parts made from composite materials to the aerospace sector. The analysis was based on companies that: (1) are listed on a European stock exchange; (2) supply aerospace parts; (3) manufacture goods using composite materials. We found eight companies that met these criteria using information from Google Finance[2]. Using this stock market data, it was possible to generate an index (time series) for the daily share-price of the eight companies using the (unweighted) geometric mean of the eight share prices[3]. The daily return is defined as the percentage change in the value of this index. Lastly, EASA's website systematically archives information regarding announcements about changes to CS-

1 Lamdin, Douglas J. (2000). 'Implementing and interpreting event studies of regulatory changes', Journal of Economic Literature: G14, L51.

2 The eight companies were: GKN PLC; Meggitt PLC; Gurit; Victrex PLC; Morgan Advanced Materials; James Cropper; Solvay; Henkel. The websites of these companies refer to the supply of aerospace parts made from composite materials.

3 Stock market data can be found from the following websites: https://www.investing.com/; and https://uk.finance.yahoo.com/.

25. This study identified 64 regulatory events involving CS-25; which includes both announcements of actual amendments and notices of proposed amendments[4].

The 'event window' was defined as a 15-day period that spans across the day of the event itself and seven days on either side of the event. The estimation window was set at 100 days before the 'event window'. Using a simple linear regression, the 'estimation window' was used to find the relationship (market model) between the return on shares in the eight companies making aerospace parts and the return based on a market index like the FTSE before the event occurred. That is, the daily return for eight companies supplying aerospace parts was regressed against the daily return for the whole stock market, based on data for the 100-day 'estimation window'. As expected, there exists a very strong correlation between changes in the value of this index and changes in the value of an index for the whole stock market (e.g. FTSE). Finally, using the index developed for the eight composites companies, a test was undertaken for abnormal returns during an ‘event’ by subtracting the expected return (as predicted by the market model) from the observed return.

Generally, we observed that the abnormal returns during an event window are positive but without further statistical analysis, one cannot be sure this did not occur by chance. The statistical analysis, recommended by Mackinlay (1997), starts from the assumption that if the ‘regulatory event’ did not affect stock prices, then the returns from the market model should be equivalent to the observed returns[5]. Based on this null hypothesis (of no effect) it is possible to identify the probability that the difference between the abnormal and the expected returns occurred by chance. All 64 events were aggregated to calculate to cumulative average abnormal returns for EASA’s CS-25.

Results

The figure below gives the t-statistic for the average abnormal return t days before/after the event. In the centre of the graph is the day of the event (t = 0); to the left is seven days before the event, and to the right is seven days after the event. The height of the red dotted lines denotes the t-statistic of the average return a given number of days before/after the event. There is a lot of random noise in the stock market and so even if the ‘events’ did not have any effect it’s unrealistic to expect the dots to line-up along the horizontal axis. Rather, one would expect to see the dots randomly occurring slightly above or below the horizontal axis. Assuming the events have no real effect, the red points would remain within the green line (blue line) 10 percent (5 percent). A one-sided test is appropriate given that EASA’s announcements should be good news for companies using composite materials. What stands out from the graph are the high values occurring a few days on either side of the event. And, this suggests that the announcements affect returns three days on either side of the day of EASA’s announcement.

4 In the study, events include notices of a proposed amendment (NPA), as well as, the published amendments themselves. Since 2003, there have been 43 NPAs and 21 final decisions. The dates of announcements and NPAs can be found from material that is systematically archived of EASA’s website.
5 Mackinlay (1997) is a highly cited review of event studies in economics and finance.

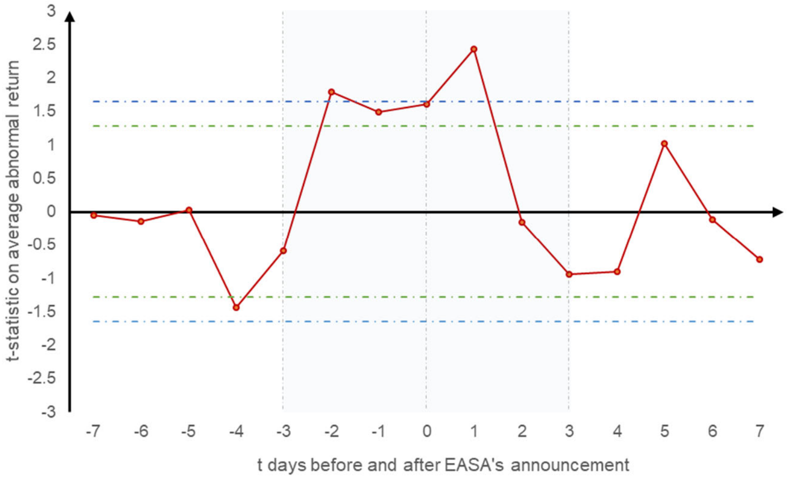

Figure 1: t-statistic for average abnormal return t days before/after the event.

Following Mackinlay (1997), the average cumulative abnormal return (CAR) was found for the seven days between t = -3 and t = 3; which is simply the sum of the seven average abnormal returns for these days. It was found that over this period the average cumulative abnormal return was 0.55% and a standard error of 0.26%, which is very statistically significant.

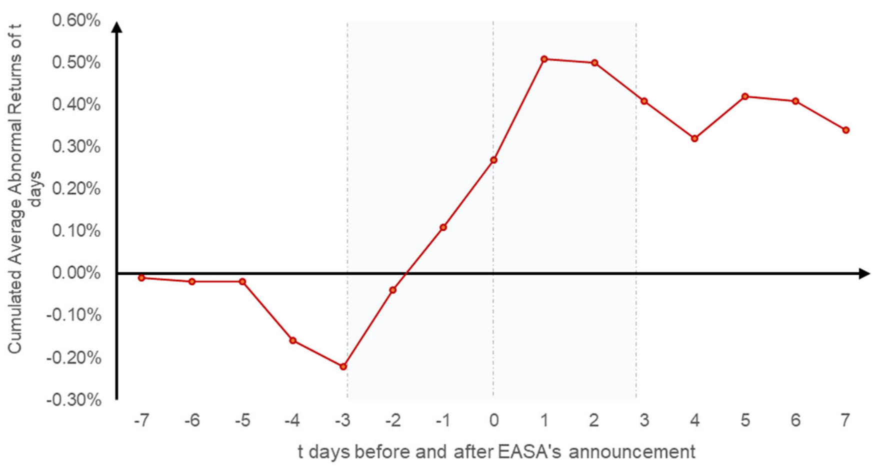

Figure 2: Average cumulative abnormal returns t days before/after the event using a 15-day event window.

An estimate of the relative contribution of these regulatory events to the growth in the share-price index after the 2009 financial crash was made. Since the start of 2010, the average annual return for shares in the eight composites companies was about 14.3%. And, it was estimated that, on average, the cumulative abnormal returns using a seven-day ‘event window’ (three days on either side of an event) is about 0.55%. Since 2010, there have been about 4.1 events per year; which suggests the average annual return would have been about 11.9% without the boost from EASA’s amendments to CS-25. In other words, the regulatory changes are associated with about 20% of the growth in the market capitalisation of the eight composite companies. Using a back-of-the-envelope calculation we estimated that on average investors valued each amendment of EASA at around £8 million for all the companies in our sample and around £1 million for the Uk companies.

This study has demonstrated the value of regulation and standards can be estimated by applying the event study methodology in this context. A possible future study could build on this analysis by identifying which of the 64 amendments/NPAs were strongly related to composite materials. The analysis would then be repeated but this time restricted to just these changes/proposals. It is reasonable to suppose that using a more targeted sample of events might produce even clearer results.

1 INTRODUCTION

Regulations and Standards are necessary for developing products that are “safe to use”, whether the product is a building, an aircraft, or a pressure vessel. In fact, these aspects need each other and interact closely. Regulations define aspects that need to be followed and met to ensure that a product will safely perform its required purpose. These regulations may be European Directives or published by bodies charged with monitoring specific areas, such as the European Aviation Safety Agency (EASA) for commercial aircraft. On the other hand, standards are voluntary specifications that ensure requirements such as safety margins and design principles have been met. These standards do not need to be used, but alternative approaches (i.e. test methods, material specifications) will need to demonstrate the same levels of performance as shown by the standards. Hence it is easier and quicker to use internationally agreed standards, hopefully with precision information covering repeatability (measurements at one place, by one operator at one time) and reproducibility (measurements at different sites, by different operators at different times.

The NPL has made considerable efforts in contributing to standards that would harmonise methods used for determining the properties of composite materials. In the field of polymer composites/fibre reinforced, NPL has directly contributed to drafting 17 ISO standards. For example, a new standard (ISO 20144:2019 - Fibre-reinforced plastic composites — Standard qualification plan (SQP) for composite materials) has recently been published to make it easier and cheaper to qualify materials for the initial preliminary design and material down-selection aspects of product development. The standard started life as a Joint Industry Project, including interlaboratory trials, that was published as an NPL Good Practice Guide. Industry members included CAA – now EASA; small, medium, and large companies, research bodies etc. The document was used as the foundation of ISO 20144, with some updating for the material and process changes highlighted above. Internationally, there was wide support for and strong recognition of the need for this standard.

There has been an increasing demand for composite materials as they are seen to be lighter, stronger, and durable in comparison to traditional materials. Some industries have embraced composite materials e.g. Aerospace, Automobile, while other industries are yet to embrace the use of composite materials. Some composite materials experts have argued that the regulatory processes of these industries are hindering the adoption of composites.

Currently, there are two ways to prove a component is fit for its purpose:

1. The equivalence-based approach entails proving that new components are equivalent to traditional materials, such as steel.
2. The performance-based approach involves proving that the new materials can perform to the required standards in operational conditions.

A study by Southampton University[6] and supported by the CompositesUK Trade Association[7] argue that the equivalence-based approached limits innovation and tends to lock-in the use of traditional materials.

The Southampton University study contained information on the regulatory environment for composite materials in several sectors and went on further to highlight how well the Aerospace sector has adopted composite materials because of the use of “Certificate Specifications” (performance-based regulations) and support from organisations (most especially EASA) dedicated to providing codified standards and guidelines necessary for approval of composite materials.

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6 Southampton University (2017).
7 CompositeUK (2017).

The EASA prescribes airworthiness standards using a series of 'Certification Specifications' (CS). Since about 2003 the EASA, after its creation in 2002, has been developing a performance-based approach to regulating the composition of parts that can be used in aeroplanes because its predecessor JAA (Joint Aviation Authority) made harmonised codes without any legal authority influence.

Consequently, between 2003 and 2017, several amendments have been made to CS-25; which is the main specification for large aeroplanes. We used an event study methodology to look at the effect of amendments to CS-25 on the value of European companies that use composite materials to make parts for aeroplanes. Moreover, this methodology has a long history of being used to assess regulatory changes in economics and finance[8].

The rest of the study is organised as follows: Section 2 contains an overview of regulations and standard in the aerospace industry. In Section 3, the companies and data used for this study are described. The methodology used to estimate the effect of the EASA's amendments to CS25 on the daily share-price of European companies that produce composite materials for large aeroplanes in Section 4. The results of the econometric models are presented and discussed in Section 5. Section 6 concludes.

8 Lamdin, (2000).

2 REGULATIONS & STANDARDS IN AEROSPACE

Composite materials are materials made from the combination of two or more materials and when combined produce a material with characteristics different from the individual materials used. Markets, where composite materials are applicable, include Aerospace, Automotive, Marine, Oil & Gas, Defence, Rail, Renewables and Construction.

Currently, there are two ways to prove a composite component is fit for purpose:

1. The equivalence-based approach entails proving that new components are equivalent to traditional material, such as steel.
2. The performance-based approach involves proving that the new materials can perform to the required standards in operational conditions.

A study by Southampton University called Modernising composite materials regulation and supported by the CompositesUK Trade Association argue that the equivalence-based approached is a subjective assessment of composite materials because the actual performance requirements have developed over many years and can be loosely or poorly defined. It also argues that the performance-based approach is a more objective proof of performance because it relies on codified standards and guidelines.

Another argument for the performance-based approach is that it increases innovation capacity. The concept of innovation capacity[9] measures the level of invention and the potential for innovation in any nation, geographical area, or economic activity. Innovation capacity is the ability to source new ideas/products/methods. As innovation capacity grows the potential to formulate new ideas increase.

The framework of equivalence-based regulations provides little Innovative capacity. Neoclassical economists believe the that innovation capacity of an entity determines the level of innovation in the entity. The framework of a performance-based model increases the innovative capacity of the concerned party in comparison to the more stringent equivalence-based methods. As a result of its flexible nature, regulations can be made to adjust with technological advancements by fostering the integration of these advancements into the ecosystem.

The performance-based approach has general advantages however not all sectors have made effort to apply it. The study goes on further to highlight that the Aerospace sector has introduced performance-based regulation which is supported by an organisation dedicated to providing the codified standards and guidelines necessary for approval. EASA, which has regulatory and executive functions in the field of the safety of civil aviation, has progressively moved towards adopting the performance-based approach.

The EASA regulation structure is divided into three parts;

- Implementing Regulations (‘hard law’)
- Acceptable means of compliance [AMC] (‘soft law’)
- Certification Specifications [CS] (‘soft law’)

The *implementing regulations* are binding legal laws that contain common rules in the field of aviation. The AMCs and CS are quasi-legal instruments that have a weaker legally binding force than the Implementing regulations. The Certificate Specifications (Airworthiness Standards) are CS23, CS25, CS27 and CS29 and contains regulations that cover composite materials.

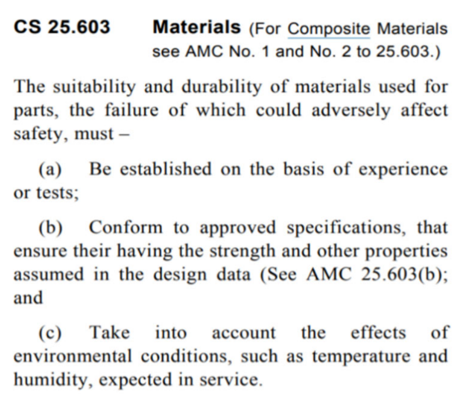
9 Suarez-Villa, (1990).

Figure 3: European Aviation Safety Agency Certification Specifications

The EASA and the Federal Aviation Regulation have a comprehensive rulemaking co-operation programme[10]. This programme aims to: align the rulemaking programmes of the FAA and EASA which would avoid unnecessary divergence and duplication of work, maximize available resources and further harmonisation. The Federal Aviation Administration (FAA) regulations that govern today's aircraft are in Title 14 of the Code of Federal Regulations (14 CFR). The Federal Aviation Regulation have similar Airworthiness Standards to the EASA's certification specification namely Part 23, 25, 27 and 29 which are similar to CS23, 25, 27 and 29 respectively.

We have chosen CS25 for our study because of the accessibility of information. CS25 is the certificate specifications for large aeroplanes. The use of composite materials on passenger aeroplanes has been a huge success which means it would be a good sample to analysis the effect of these regulatory changes.

The extract in Figure 4 is a performance-based regulation. It states the procedures through which assumed materials may be verified, in this illustration, structural integrity under predictable levels of stress (incl. environmental conditions). No exact material type is specified in these general provisions instead materials are verified through their performance credentials



CS 25.603 **Materials** (For Composite Materials see AMC No. 1 and No. 2 to 25.603.)

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must –

(a) Be established on the basis of experience or tests;

(b) Conform to approved specifications, that ensure their having the strength and other properties assumed in the design data (See AMC 25.603(b); and

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

Figure 4: Extracts from CS25

10 Rulemaking co-operation programme document

3 *General*

3.1 This AMC is published to aid the evaluation of certification programmes for composite applications and reflects the current status of composite technology. It is expected that this AMC will be modified periodically to reflect technology advances.

Figure 5: Extracts from the Acceptable Means of Compliance Standards

Figure 5 is an extract from an Acceptable Means of Compliance (AMC). The AMC is a 'soft law' which means that the AMC's legal requisition is weak, however, the companies affected by the regulation are obligated to do it. This is because if they do not, their practices might be outdated in comparison to companies who incorporate the AMC into their process or product.

These extracts from the Initial issue of CS25 shows us that the aerospace sector has recognised the problem with the adoption of composite materials and has identified that the solution would be to move to a performance-based approach. From the initial issue, a total number of 21 decisions to amend CS 25 have been made to improve regulatory practices and standards, with the recent one dated 12 May 2017.

There is an agency rulemaking process for amendments to a Certification Specification[11] that can be narrowed down to three stages:

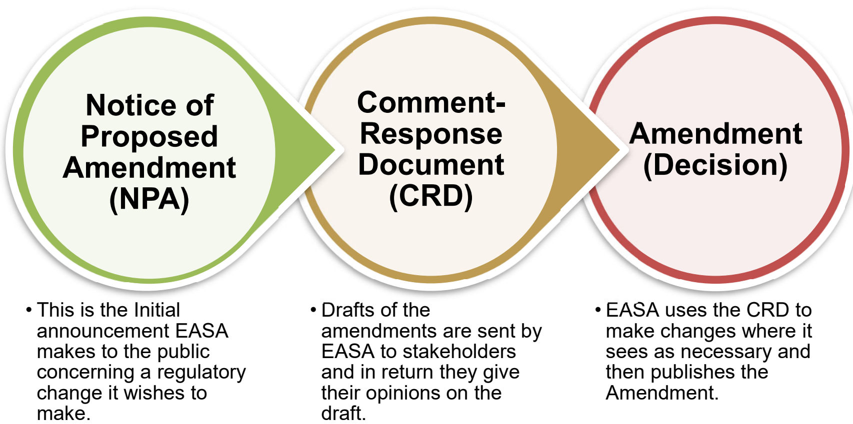


Figure 6: Stages of the rulemaking process

For Certification Specification of Large Aeroplanes (CS25), there have been 43 Notice of Proposed Amendments (NPA) and 21 final decisions for Amendment. We believe that the markets will react to the NPAs, so if we only test the final decisions (Amendments) we are not capturing the full behaviour of the market and the CRDs do not affect stock market prices as there are only comments/reviews of the NPAs. This suggests that to get the full effect of the regulations changes we need to incorporate the NPAs. Figures 7 and 8 show the numbers of Notice of Proposed Amendments and actual amendments from 2004 to 2017.

11 EASA, (n.d.)

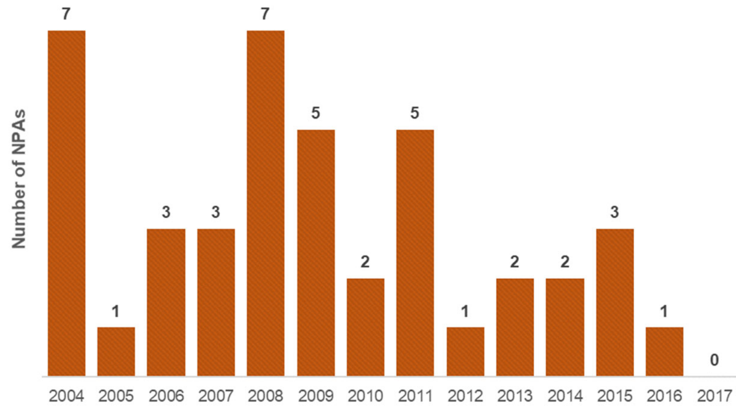


Figure 7: Notice of Proposed Amendment

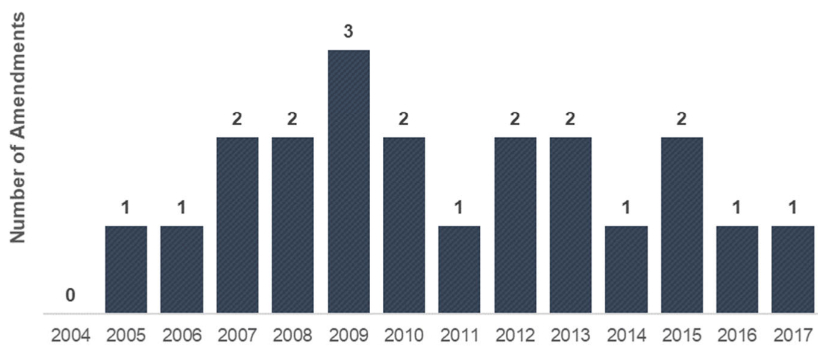


Figure 8: Amendment Decisions

3 COMPANIES AND STOCK MARKETS

For this study decided to only test dates of changes to CS25 by EASA. We have chosen are: (1) are listed on a European stock exchange; (2) supply aerospace parts; (3) manufacture goods using composite materials. We found 8 companies that met these criteria using information from CompositesUK Organisation List[12] as well as Google Finance. The appropriateness of the sample was scrutinized with structured Google searches.

Table 1: Companies

GKN PLC	GKN is a tier 1 supplier that is committed to continuing to develop technologies that maximise the performance benefits of optimised composite architectures whilst also addressing the future requirements of low cost, high rate and automated manufacturing and assembly processes.
MEGGITT PLC	Meggitt has a Polymers & Composites division that make products applied in the aerospace industry such as flexible fuel tanks and so on.
GURIT EU	Gurit is a leading materials supplier to the European aircraft industry and a member of the CompositesUK trade association. They have two ISO 9001 and EN 9100 certified production sites in Switzerland and Germany, dedicated to the manufacture of aerospace materials in Switzerland and Germany.
VICTREX PLC	Victrex is a tier 1 supplier of composite aerospace parts. 15,000+ aircraft rely on Victrex solutions today.
MORGAN ADVANCED MATERIALS	Morgan Advanced Materials produce carbon, graphite and silicon carbide components which are used in the aerospace industry amongst many other products they make.
JAMES CROPPER	James Cropper has a Technical Fibre Products division that makes materials used in the aerospace industry.
SOLVAY EU	Solvay is a member of the CompositesUK trade association. Solvay is an integrated player with a comprehensive portfolio of lightweight materials that make aircraft more fuel-efficient and cost-effective. Among Solvay's aerospace solutions is TEGRACORE™, a structural foam with excellent resistance to fire and water.
HENKEL EU	Henkel is the leader in structural adhesives and surface treatments for the aircraft OEM and MRO industries. The company is listed in over 5.000 aerospace specifications.

Figure 9 shows the revenue generated from the sale of transport (aerospace) parts in these companies[13] and Figure 10 shows the proportion of the company's revenue that comes from the sale of transport parts. This is important because if the aerospace parts division does not generate significant revenue for these firms then changes to CS25 would not affect the stock market prices of our selected companies.

12 CompositesUK Trade Association Organisation List
13 Annual reports of selected firms (Annex)

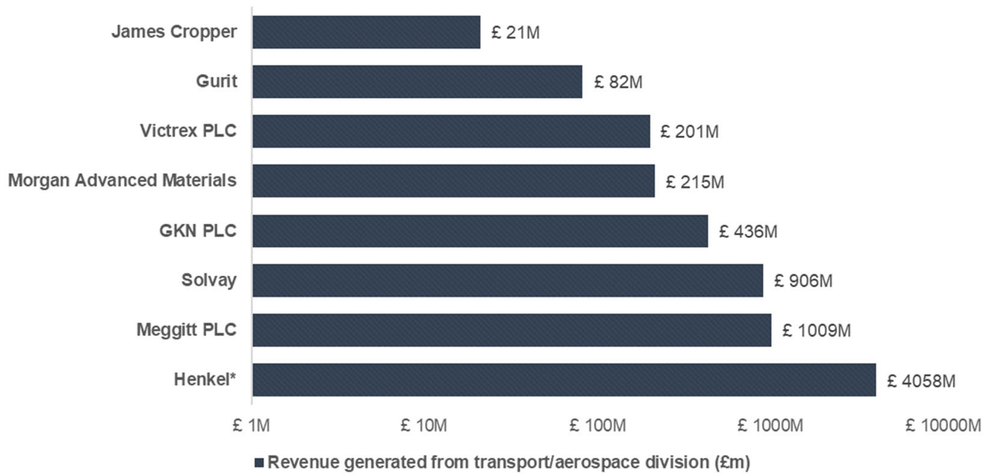


Figure 9: Revenue generated from the transport (aerospace) division

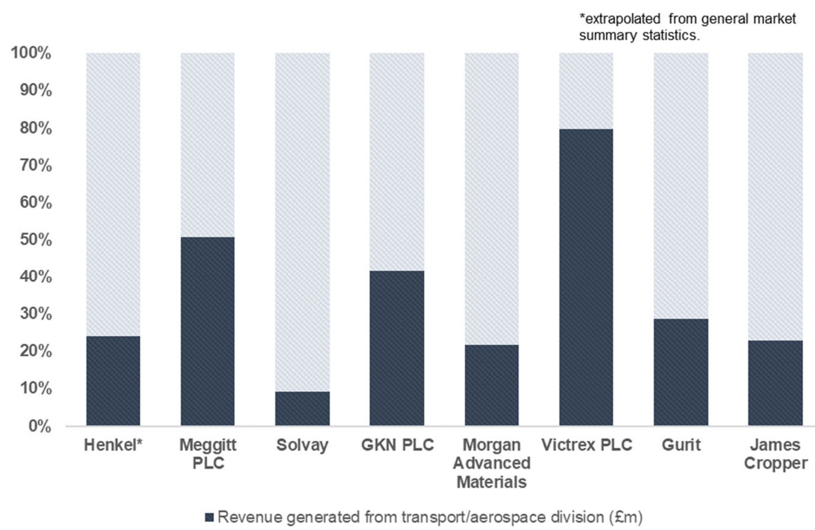


Figure 10: Percentage of transport (aerospace) division revenue of total revenue.

Another method of checking the significance of composites and aerospace to these selected organisations. We have done this by computing search results for articles associated with composite materials, aerospace to the selected companies and comparing the results with the total search results of the selected company. The results of these scrutinized search are shown in Annex 8.1. We find that on average 43% of the web links related to the companies in our sample are associate with aerospace and 19% are associated with composite materials.

4 EVENT STUDY

An event study is an econometric tool used to measure the effectiveness of an economic event using stock market prices. An event study is frequently used in various fields to assess the impact of an event on the value of a firm. In accounting, it has been used to value the effect of company earnings announcements and in law, it has been used to value the effect of a change in the regulatory environment. Other classic examples of regulatory event studies are Prager[14] on the effects of deregulating cable television, Mitchel and Mulherin[15] on finessing the political system: the cigarette advertising ban, Allen and Wilhelm**16** on the impact of the 1980 depository institutions deregulation and monetary control act on market value and risk. The use of these tool dates to 1933 in a paper published by James Dolley.

Event study has also been used for assessing regulatory changes. Lamdin[17] discusses methods for testing the impact of regulatory changes using an event study. He argues that event study has become a standard tool in economics and finance.

Although this tool is powerful, there have been some problems associated with using an event study to assess the impact of regulations. Lamdin highlighted three key issues for concern when using event study to assess regulatory changes:

- The event window
- Political or economic influences
- Post-event window beta calculations

The issue pertinent to our study is the event window. Lamdin highlights that the event window, in the case of a regulatory change, is less concise because a regulation change has several periods i.e. the event encompasses the period when it was initially introduced, debated, and enacted/defeated. This means there could be multiple periods in an event window. If we cannot clearly identify our event periods, our tests are more likely to falsely reject the hypothesis of no regulatory change (null hypothesis) when the alternative hypothesis is indeed true. In econometrics, this is regarded as a False-negative (Type II error). We have been able to resolve this problem by identifying the several event periods in the rulemaking process of our amendments.

5 METHODOLOGY

In an event study, we make some economic assumptions which are features of the efficient market hypothesis:

1. Agents are rational in the market
2. Information is available to the public
3. Agents react to information received and prices adjust accordingly.

Consequently, when new information is available to the public the stock markets reflect the value of the information through a shift in demand causing a change in the stock price of relevant companies. In situ, regulatory shocks are seen as new information and because of these assumptions made above, the stock market can be used to measure the commercial effect of regulation changes.

The structure of the event study varies and Mackinlay[18] outlines several ways of conducting event study and measuring abnormal returns. He argues that the 'market model' is superior to

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14 Prager (1992).
15 Mitchell and Mulherin (1988).
16 Allen and Wilhelm (1988).
17 Lamdin (2000).
18 MacKinlay (1997).

alternative approaches. He also recommends procedures for measuring, analysing, and aggregating abnormal returns.

5.1 MODEL

The 'market model' is a statistical approach that relates the return of any given security to the return of the market portfolio. The market portfolio could be the equivalent of a major stock index such as FTSE, DAX and so on. The model specification of the market model is

$$Y_t = \alpha + \beta(X_t) + \mu_t \tag{1}$$

Where,

α and $\boldsymbol{\beta}$ are fixed parameters to be estimated. $\boldsymbol{\beta}$ represents the propensity of a security to respond to general fluctuations in the market. The beta helps us measure the degree of association of our markets with the companies of interest. $\boldsymbol{\alpha}$ is the autonomous trend rate of growth i.e. the returns our selected companies produce more than the return originally estimated by the CAPM (capital asset pricing model) which describes the relationship between systematic risk and expected return of a stock. **μ** accounts for the residual (disturbance) and it should be independent of previous values. We assume the $Cov(\mu, x) \sim 0$ and $E(\mu) = 0$

$\boldsymbol{Y_t}$ represents the returns of the given security. Our dependent variable would be the returns of the geometric mean of our selected companies. This is done by transforming the historical prices of our companies to log form, finding the average of the data transformed for each period. This is essentially a geometric mean. Afterwards, we difference our current period by the previous period to find the daily return of each period.

$$Y_t = ln\left(\prod_{i=1}^{n} a_i\right)_t^{1/n} - ln\left(\prod_{i=1}^{n} a_i\right)_{t-1}^{1/n} \tag{2}$$

$$where\ a_i\ are\ the\ companies\ and\ n = No\ of\ companies$$

$\boldsymbol{X_t}$ represents the returns of the major stock index. Any associated general stock market index could be our major index. This is because it is perceived as a scale of prosperity for businesses that operate in the country the index belongs to. Accordingly, it can be used to identify market trends. The companies in our sample operate across several market exchanges in Europe, and to make an appropriate market model that tracks these companies better we made an index using major European markets (FTSE, DAX, and CAC40).

$$X_t = ln\left(\prod_{i=1}^{n} a_m\right)_t^{1/n} - ln\left(\prod_{i=1}^{n} a_m\right)_{t-1}^{1/n} \tag{3}$$

The Event Study splits time into three periods. The estimation window, the event window, and the post-event window. The returns would be indexed in event time using τ as our event date.

Some agents in the market know about events before the information is publicly confirmed. On the other hand, some agents react to the information a couple of days after it has been publicly released. Therefore, to capture the market's valuation of the information the event window does not just comprise of the event date, it encompasses days before and after the event. In this study, the event window is recorded as τ ±7 days (7 days on either side of the event date).

The estimation window is a period of normal returns that has not been influenced by the event window. The event window and estimation window do not overlap because this could lead to the event returns having a large influence on the model's parameters. The estimation window in this study is a period of 100 days before the event window. This excludes bank holidays and weekends.

The post estimation window is the period after the event window and is used to analyse the market after the event though it does not apply to our study.

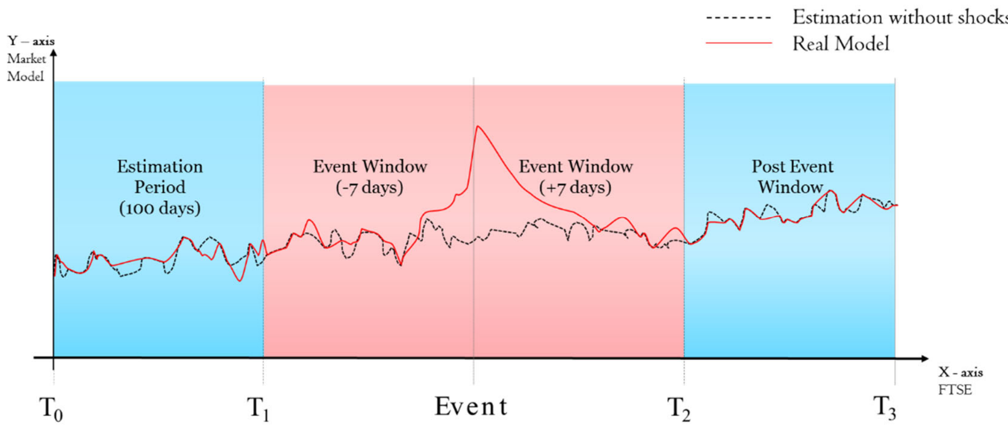

Figure 11: Event study period illustration

The OLS (Ordinary Least Squares) procedure was used to estimate the unknown parameters for our market model. The OLS is a method used to estimate the unknown parameters in a linear regression model. The OLS technique uses the least-squares principle to fit a pre-specified regression through our sample data thus minimising the sum of squares of the differences between our predicted values and the given data.

The OLS gives an estimation of a linear line that gives us the least amount of squared errors.

$$argmin \sum (y - \hat{y})^2 = argmin \sum (\hat{\mu})^2 \qquad (4)$$

y is the real y value from the data, $\hat{y}$ is the estimated value of y using OLS, $\hat{\mu}$ is the residual from differencing the estimated value from the real value.

5.2 ABNORMAL RETURNS

The abnormal return is the deviation between the observed return and the expected return from our market model. It is the disturbance term of the market model calculated on an out of sample basis. The model specification for abnormal returns

$$AR = Y - \mathbb{E}(Y) \qquad (5)$$

$$where\ \mathbb{E}(Y) = \alpha + \beta(X_t)$$

Where **α** and β are the parameters derived from the OLS regression of the market model. The next step is to carry out a statistical hypothesis test on our abnormal returns, to find out if our results are statistically significant by testing the t-statistics. Under the null hypothesis, H_0, the returns of the event have not deviated from the expected behaviour of returns. We use a t-test to compare the size of the abnormal return to its associated error.

$$\mathrm{T_{stat}} = \frac{\mathrm{Y} - \overline{\mathrm{Y}}}{\mathrm{s.e.}(\hat{\beta})} = \frac{\mathrm{AR}}{\mathrm{s.e.}(\hat{\beta})} \qquad (6)$$

$$where\ \mathrm{s.e.}(\hat{\beta})\ is\ the\ standard\ error\ of\ the\ least\ square\ slope$$

Three forms of aggregations can be done.

1. Aggregating the abnormal return of each event window [Form 1].
2. Aggregating the abnormal return of each day in the event window across all events on average [Form 2].
3. Aggregating the abnormal return of an event window across all events on average [Form 3].

The formulae for these forms of aggregation are shown below:

1. **Form 1**: We aggregate the abnormal returns over the event window to draw overall inferences for each event window. The Cumulated Abnormal Returns (CAR) for each event are:

$$CAR_i(\tau_1, \tau_2) = \sum_{\tau=-7}^{7} AR_{i\tau} \tag{7}$$

And the variance of our CAR is

$$\sigma_i^2(\tau_1, \tau_2) = (\tau_2 - \tau_1 + 1)\sigma_{\varepsilon_i}^2 \tag{8}$$

We assume that $AR_{i\tau}$ is normally distributed $AR_{i\tau} \sim N\left(0, \sigma_i^2(AR_{i\tau})\right)$

2. **Form 2**: We can estimate the average aggregate return of each day in the event window of *N* events.

$$\overline{CAR}(\tau_1) = \frac{1}{N}\sum_{i=1}^{N} CAR_i(\tau_1) \tag{9}$$

and the average variance of our CAR is

$$var(\overline{CAR}(\tau_1)) = \frac{1}{N^2}\sum_{i=1}^{N} \sigma_i^2(\tau_1) \tag{10}$$

$$where\ \tau_1\ represents\ the\ event\ day$$

3. **Form 3:** We can also estimate the total effect of our events on average by using

$$\overline{CAR}(\tau_1, \tau_2) = \frac{1}{N}\sum_{i=1}^{N} CAR_i(\tau_1, \tau_2) \tag{11}$$

and the average variance of our average CAR

$$var\left(\overline{CAR}(\tau_1, \tau_2)\right) = \frac{1}{N^2}\sum_{i=1}^{N} \sigma_i^2(\tau_1, \tau_2) \tag{12}$$

The null hypothesis can be tested using

$$\frac{\overline{CAR}(\tau_1, \tau_2)}{var(\overline{CAR}(\tau_1, \tau_2))^{1/2}} \sim N(0,1) \tag{13}$$

The confidence interval which shows the boundary of our estimation lies between is calculated using a 95% confidence interval. This is done by including a margin of error in our estimation of the abnormal returns. The formula is

$$AR \pm (1.96 * \mathrm{s.e.}(\hat{\beta}))$$

5.3 DIAGNOSTICS AND SOLUTIONS

To ensure the validity of our statistical analysis some tests had to be done on the models

- **Robustness Checks** - Here we examine how the regression coefficient estimates changes and affects our results when the model specification is changed. This is to ensure that our results do not rely too heavily on parts of the data. This was done by removing what we believed to be the bigger companies to see if our results would be unaffected. The results were not affected.
- **LINK Test** - The link test shows us if an explanatory variable accurately explains our model. Six of our events failed the link test. From these six events, five of them were during the credit crunch period and we believe there are strong data points (strong movements) during which are affecting our regression analysis. This does not mean our model specification is wrong, it just means our model cannot account for those strong movements.
- **Serial correlation in errors** – This is used to see if the error terms are correlated persistently. We statistically tested this using the Breusch-Godfrey test. Serial correlation occurs when some of the current residual terms are explained by past residual term i.e.

$$u_t = \rho u_{t-1} + e_t \qquad (14)$$

$$t = 1,2,3, \dots, n$$

Where ρ is statistically significant using a 5% significance level.

This test can also be applied to higher orders of serial correlation but in our case testing for first-order serial correlation was sufficient.

Seven of our events tested positive for serial correlation. If serial correlation exists in our model then OLS is no longer BLUE i.e. our standard errors are incorrect, thus making our T-stat wrong. We found some significant serial correlation between our error terms in some events. To correct for serial correlation, we can use an FGLS (Feasible Generalised Least Squares) estimation. The FGLS requires that the regressors in the model are strictly exogenous. A variable is strictly exogenous when it is independent of the states of other variables in the causal model.

In this case, the exogenous variable is our major market index i.e. FTSE, DAX and CAC40. Let us split the factors that can affect these major indices into two parts, macroeconomic factors, and microeconomic factors. Some macroeconomic factors that could affect the major indices are inflation reports, interest rates, exchange rates and BREXIT. Some microeconomic factors that could affect the major indices are earnings report, mergers and so on. In this case, we are concerned about how the Microeconomic factors from our dependent variable can affect our major market index. Any event caused by the components of our dependent variable would not cause a significant shock to our independent variable. This is because FTSE100 is a share index of 100 companies listed on LSE, this means that for a company to significantly affect FTSE they need to have large weightings on the index. Only one of the components (GKN) of our regression belongs to FTSE100 and this component does not have a large enough weighting (0.3% index weight[19]) to significantly affect the FTSE. This means that our market model is strictly exogenous and therefore the FGLS approach can be implemented to correct serial correlation.

To eliminate serial correlation, we transform the model specification by quasi-differencing the data ($|\rho| > 1$) to make the integrated process weakly dependent.

Our initial model is

$$y_t = \beta_0 + \beta_1 x_t + u_t \tag{15}$$

The problem in the serial correlation is from the residual term, remember we were able to identify the proportion of our residual term that is explained by the lagged variable is ρ, so to eliminate the problem we need to difference it from our Initial model by

$$\tilde{y}_t = \hat{\alpha} + \hat{\beta}\tilde{x}_t + e_t \tag{16}$$

$$\tilde{y}_t = y_t - \rho y_{t-1} \; and \; \tilde{x}_t = x_t - \rho x_{t-1}$$

We proceed by regressing $\tilde{y}_t$ on $\tilde{x}_t$ provided we divide the result of the estimated intercept by $(1 - \rho)$ i.e.

$$\hat{\alpha} = \frac{(1-\rho)\beta_0}{(1-\rho)}$$

Although the FGLS approach removes the serial correlation, predictions based on the transformed data does not give you the true value of our abnormal returns. To estimate our abnormal returns, we use our untransformed data but use the coefficients estimated from our GLS approach.

$$Y = \hat{\alpha} + \hat{\beta}X + u_t \tag{17}$$

Therefore, to calculate our abnormal returns we use

$$AR = Y - \left(\hat{\alpha} + \hat{\beta}X\right) \tag{18}$$

The standard errors need to be adjusted to test for abnormal returns, so we write the variance of u_t as

$$\mathrm{Var}(u_t) = \frac{\sigma_\varepsilon^2}{1-\rho^2}$$

N.B Failing these tests does not mean there is something wrong with our model. It is expected to see a couple of serial correlation present and link test failure in such a long time series.

19 FTSE UK 100 Index series

6 RESULTS

Our primary model consists of the eight companies used to make the composite index (dependent variable) and three major European market indices used to make our major market index.

$$Y_{composite} = \beta_0 + \beta_1 x_{market} + u_t \quad (19)$$

In this section, we selected sample events from our study to illustrate how we have used the methods explained in the previous section. The event chosen for illustration was Amendment 12 of CS25. The decision to make the CS-25 / Amendment 12 was on 06/07/2013 and there were three Notice of Proposed Announcements (NPAs) preceding the final amendment namely:

1. NPA 11/2010 – 08/09/2010
2. NPA 14/2011 – 04/07/2011
3. NPA 13/2011 – 22/07/2011

Table 2 shows the regression estimates for each event. All estimates have beta values which show that changes in our composite index closely follows the same pattern as changes in our market index. The alpha values indicate that the companies in our index did not outperform the market in the estimation window, i.e. the risk-adjusted returns from the companies in our index do not differ from the returns observed in the market. The models also show a high R^2 value, indicating that a lot of the variation in the returns of our composite index can be explained by variations in market returns.

Table 2: Regression parameters for each event

Events	α	β	σ	R^2
NPA 11/2010	0.000 (0.001)	0.914 (0.041)	0.007	0.834
NPA 14/2011	0.001 (0.001)	0.826 (0.059)	0.006	0.682
NPA 13/2011	0.001 (0.001)	1.049 (0.071)	0.006	0.700
Amendment 12	0.000 (0.000)	0.927 (0.067)	0.007	0.675

Tables 3, 4, 5 & 6 show the returns for each event, the abnormal returns of each day in the event windows and the t-stat. NPA 11/2010 and NPA 14/2011 showed the most positive returns in their event windows in comparison to the later events leading to CS-25 / Amendment 12. This is probably because earlier events contained information about CS-25 / Amendment 12 that forced investors to act a lot more than information from the later events.

Table 3: Returns from NPA 11/2010

Event days	Date	Y	$E(Y)$	AR	T-stat
-7	30/08/2010	-0.002	-0.004	0.002	0.297
-6	31/08/2010	0.000	0.003	-0.002	-0.310
-5	01/09/2010	0.030	0.028	0.002	0.304
-4	02/09/2010	0.002	0.001	0.001	0.112
-3	03/09/2010	0.009	0.009	-0.001	-0.104
-2	06/09/2010	0.006	0.003	0.003	0.430

-1	07/09/2010	0.003	-0.007	0.010	1.503
0	08/09/2010	0.011	0.006	0.005	0.741
1	09/09/2010	0.021	0.010	0.011	1.630
2	10/09/2010	0.011	0.001	0.011	1.581
3	13/09/2010	0.011	0.009	0.002	0.315
4	14/09/2010	-0.003	0.002	-0.004	-0.639
5	15/09/2010	0.002	-0.003	0.004	0.659
6	16/09/2010	-0.003	-0.003	0.000	0.012
7	17/09/2010	0.002	-0.005	0.006	0.927

Table 4: Results for NPA 14/2011

Event days	Date	Y	$E(Y)$	AR	T-stat
-7	23/06/2011	-0.019	-0.015	-0.004	-0.763
-6	24/06/2011	0.007	0.001	0.006	1.024
-5	27/06/2011	-0.001	0.003	-0.004	-0.711
-4	28/06/2011	0.038	0.010	0.028	5.107
-3	29/06/2011	0.019	0.015	0.004	0.772
-2	30/06/2011	0.012	0.012	0.000	-0.031
-1	01/07/2011	0.008	0.006	0.001	0.252
0	04/07/2011	0.015	0.003	0.012	2.229
1	05/07/2011	0.015	0.000	0.016	2.792
2	06/07/2011	0.001	-0.001	0.002	0.432
3	07/07/2011	0.006	0.006	-0.001	-0.102
4	08/07/2011	-0.007	-0.009	0.002	0.320
5	11/07/2011	-0.015	-0.016	0.000	0.069
6	12/07/2011	-0.011	-0.006	-0.005	-0.809
7	13/07/2011	0.016	0.008	0.008	1.494

Table 5: Results for NPA 13/2011

Event days	Date	Y	$E(Y)$	AR	T-stat
-7	13/07/2011	0.016	0.009	0.007	1.165
-6	14/07/2011	-0.004	-0.007	0.003	0.403
-5	15/07/2011	-0.003	0.000	-0.002	-0.383
-4	18/07/2011	-0.024	-0.013	-0.011	-1.656
-3	19/07/2011	0.002	0.010	-0.008	-1.287
-2	20/07/2011	0.009	0.011	-0.001	-0.175
-1	21/07/2011	0.005	0.011	-0.006	-1.000
0	22/07/2011	0.007	0.007	0.000	0.055
1	25/07/2011	0.005	0.000	0.005	0.785
2	26/07/2011	-0.012	0.000	-0.012	-1.943
3	27/07/2011	-0.005	-0.010	0.005	0.828
4	28/07/2011	-0.008	-0.002	-0.006	-1.010
5	29/07/2011	-0.005	-0.006	0.001	0.147

6	01/08/2011	-0.006	-0.016	0.010	1.545
7	02/08/2011	-0.027	-0.013	-0.014	-2.195

Table 6: Results for Amendment 12

Event days	Date	Y	$E(Y)$	AR	T-stat
-7	27/06/2012	-0.002	0.014	-0.016	-2.118
-6	28/06/2012	-0.006	-0.007	0.001	0.068
-5	29/06/2012	0.031	0.032	-0.001	-0.1
-4	02/07/2012	0.005	0.012	-0.007	-0.946
-3	03/07/2012	0.01	0.01	0	0.058
-2	04/07/2012	0.009	-0.001	0.01	1.33
-1	05/07/2012	-0.012	-0.004	-0.008	-1.058
0	06/07/2012	-0.007	-0.013	0.007	0.873
1	09/07/2012	-0.004	-0.004	0	-0.044
2	10/07/2012	0.008	0.006	0.002	0.228
3	11/07/2012	-0.015	-0.001	-0.014	-1.927
4	12/07/2012	-0.012	-0.007	-0.006	-0.762
5	13/07/2012	0.01	0.014	-0.004	-0.526
6	16/07/2012	0.007	0	0.007	0.932
7	17/07/2012	-0.008	-0.001	-0.006	-0.826

The next step was to aggregate all four events and calculate the average daily return in our event window. Here we would use equations (9) and (10) to calculate the average cumulative abnormal return for each day in the event window and then statistically test them.

Table 7: Aggregated events concerning Amendment 12

Event days	Date	Average Cumulative AR	T-stat
-7	27/06/2012	-0.003	-0.844
-6	28/06/2012	0.002	0.614
-5	29/06/2012	-0.001	-0.384
-4	02/07/2012	0.003	0.844
-3	03/07/2012	-0.001	-0.384
-2	04/07/2012	0.003	0.921
-1	05/07/2012	-0.001	-0.23
0	06/07/2012	0.006	1.842
1	09/07/2012	0.008	2.456
2	10/07/2012	0.001	0.23
3	11/07/2012	-0.002	-0.614
4	12/07/2012	-0.004	-1.075
5	13/07/2012	0	0.077
6	16/07/2012	0.003	0.921
7	17/07/2012	-0.002	-0.461

The standard error of the average cumulative abnormal return is 0.0033, this was used to test the significance of the abnormal returns of each day in the event window.

From the table, we can see the significant event days of CS25 are the event date and the day after, however, the Figures below give a visual representation of the movement during the event window. Figure 12 shows the behaviour of the abnormal returns during the event window in an accumulative form. Figure 11 shows the statistical significance of each day in the event window and from what we can see, the event day and the day after are the significant days in this CS25 amendment on average.

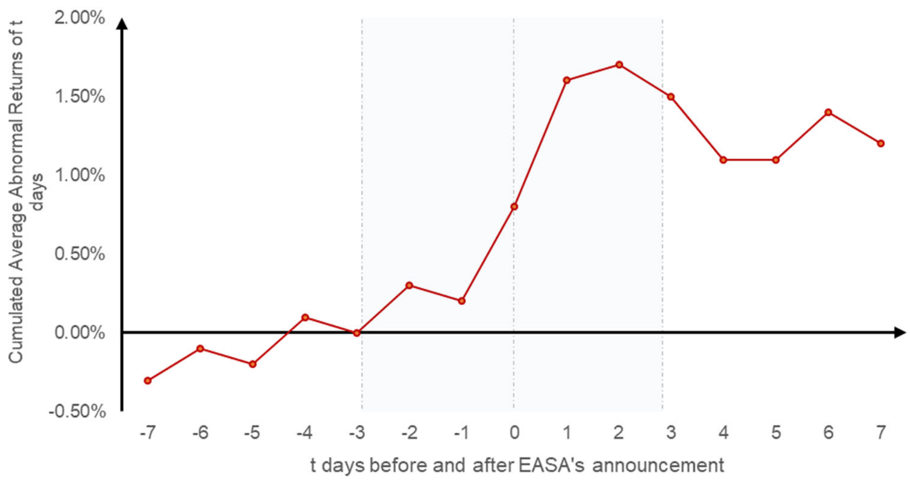

Figure 12: Cumulated Average returns for an event associated with CS25 Amendment 12

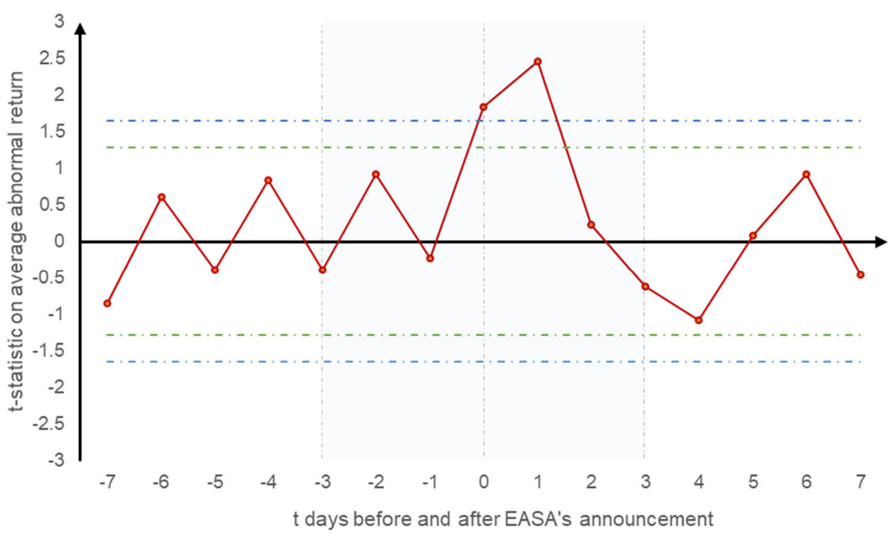

Figure 13: Average cumulative abnormal returns t days before/after the events related to CS25 Amendment 12

6.1 AGGREGATION OF ABNORMAL RETURNS

To understand the full effect of the events we need to aggregate the events we have tested. We first calculate the average daily abnormal returns of the 64 events. This would show us the abnormal return of each day in the event window on average. The figure below gives the t-statistic for the average abnormal return t days before/after the event. In the centre of the graph is the day of the event (t = 0); to the left is the seven days before the event, and to the right is the seven days after the event. The height of the red dotted lines denotes the t-statistic of the average return a given number of days before/after the event. There is a lot of random noise in the stock market and so even if the 'events' did not have any effect it's unrealistic to expect the dots to line-up along the horizontal axis. Rather, one would expect to see the dots randomly occurring slightly above or below the horizontal axis. Assuming the events have no real effect, the red points would remain within the green line (blue line) 10 percent (5 percent). A one-sided test is appropriate given that EASA's announcements should be good news for companies using composite materials. What stands out from the graph is the line of high values occurring a few days on either side of the event. And, this suggests that the announcements affect returns three days on either side of the day of EASA's announcement.

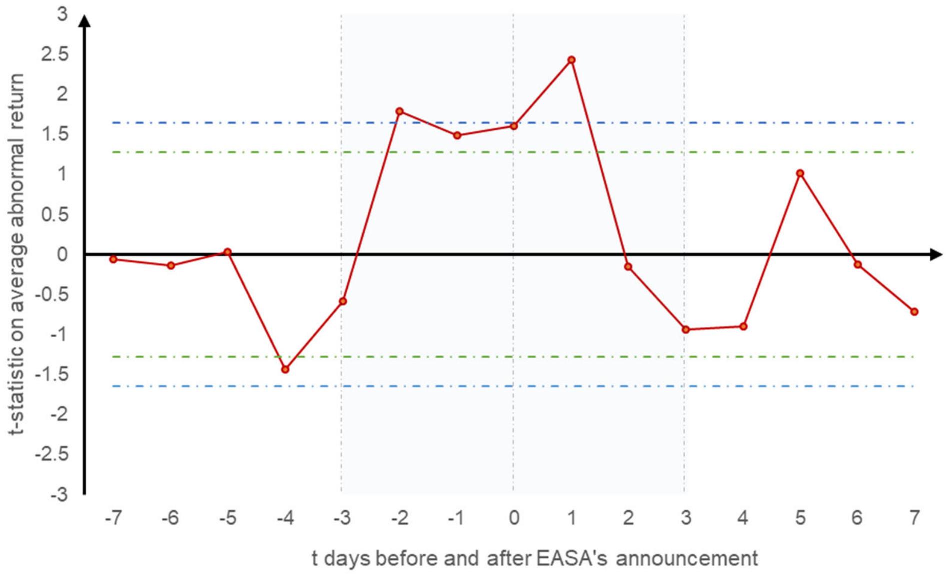

Figure 14: t-statistic for average abnormal return t days before/after all events.

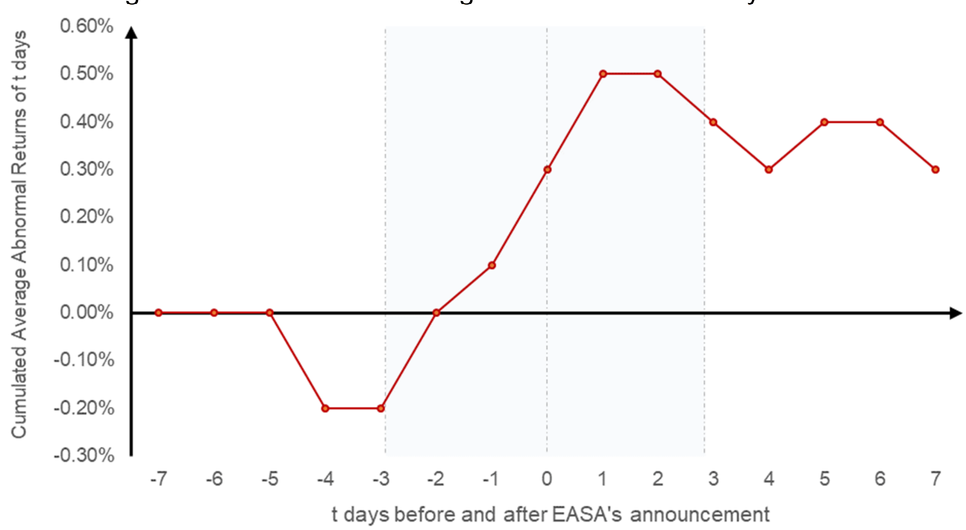

Figure 15: Average cumulative abnormal returns t days before/after all the events

Table 8: Average daily abnormal returns for events in the study.

Event days	Average AR	T-stat	CAR

-7	-0.0001	-0.05	0
-6	-0.0001	-0.14	0
-5	0	0.03	0
-4	-0.0014	-1.43	-0.002
-3	-0.0006	-0.58	-0.002
-2	0.0018	1.79	0
-1	0.0015	1.49	0.001
0	0.0016	1.61	0.003
1	0.0024	2.43	0.005
2	-0.0001	-0.15	0.005
3	-0.0009	-0.94	0.004
4	-0.0009	-0.9	0.003
5	0.001	1.02	0.004
6	-0.0001	-0.12	0.004
7	-0.0007	-0.71	0.003

The Average standard error of an event 0.00098 (0.098%). The formulae can be derived from the variance equation described in equation (10). The T-stat values in Table 8 shows which returns in the event window were significant[20]. The table suggests that the periods with significant changes in the price level of the companies in our study tend to fall in between three to four day if the announcement. Consequently, we have aggregated the abnormal returns of an event on average using different time intervals for our event window. The results are shown in Table 9 below.

Table 9: Aggregated abnormal returns for different window sizes

Event Window	Average Cumulated Abnormal Returns	Standard Error	T-stat	Confidence Interval Upper Boundary	Confidence Interval Lower Boundary
+/- 7 days	0.0033	0.0038	0.86	0.011	-0.0042
+/- 4 days	0.0033	0.0029	1.11	0.009	-0.0025
+/- 3 days	0.0055	0.0026	2.13	0.011	0.0005

We found that over this period the average cumulative abnormal return was 0.55% and a standard error of 0.26%, which is very statistically significant. In Table 9, we can see that the average abnormal returns of the 3-day event window has a larger aggregated abnormal return as well as a lower standard error. This is because, in the larger event windows, the market does not have any information to act. Some events would have had enough information for investors to act on several days before the official announcement. For other events, investors might not have had enough information to take substantial actions. This has caused larger variance abnormal returns when we extend the window to those days.

We estimated the contribution of these regulatory events to the growth in the share-price index after the 2009 financial crash. Since the start of 2010, the average annual return for shares in our eight composites companies was about 14.3%. And, we estimate that, on average, the cumulative abnormal returns using a seven-day 'event window' (three days on

20 One tailed significance level of 10% and 5%.

either side of an event) is about 0.55%. Since 2010, there have been about 4.1 events per year; which suggests the average annual return would have been about 11.9% without the boost from EASA's amendments to CS-25. In other words, the regulatory changes are associated with about 20%[21] of the growth in the market capitalisation of the eight composite companies.

6.2 ALTERNATIVE MODELS

We used two different models to test the validity of our main model.

6.2.1 First Alternative Model

The first alternative model involves replacing the market index with prime companies of the aerospace industry worldwide. The companies used were

1. Airbus
2. Boeing
3. Bombardier
4. Rolls-Royce
5. Rockwell Collins

We used these companies to create an index that replaces the market index. This is because the major market index in the primary model contains information from several industries which could give us weaker results, using an aerospace index would isolate or reduce the noise from the major market index. Consequently, we should get better predictions of the returns in our composite index because the composite index would be more sensitive to changes in the aerospace sector.

The functional form of this alternative model is

$$Y = \alpha + \beta(X) + \mu$$

where Y is the index of companies making aerospace parts made of composite materials, X is the index of major aerospace companies. All the assumptions made for our initial model still holds and the derivation of the indices remain the same.

The results for the first alternative model were

Table 10: Aggregated abnormal returns for different window sizes (First Alternative Model).

Event Window	Average Cumulated Abnormal Returns	Standard Error	T-stat	Confidence Interval Upper Boundary	Confidence Interval Lower Boundary
+/- 7 days	0.0063	0.0047	1.36	0.016	-0.0029
+/- 4 days	0.0062	0.0036	1.7	0.013	-0.0009
+/- 3 days	0.0089	0.0032	2.78	0.015	0.0026

Comparing Table 10 with Table 9, we can highlight that the abnormal returns of the first alternative model are higher than that of our primary model. Also, the event windows are much more significant with the alternative and this is expected for the reasons stated earlier. This comparison can also be seen in Figure 16 below.

21 The percentage increase relative to the counterfactual outcome equals (14.3 – 11.9)/11.9 = 20%.

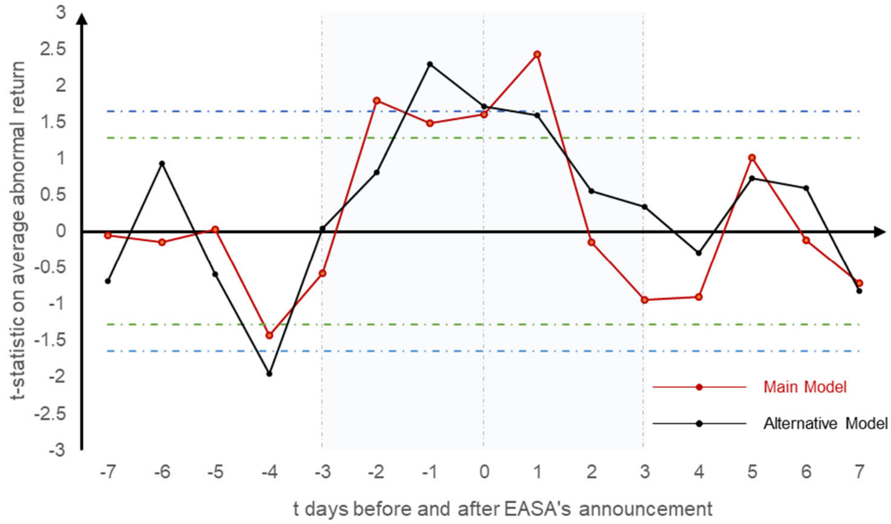

Figure 16: T-stat comparison between the true model and the first alternative model.

6.2.2 Second Alternative Model

Earlier, we claimed that the companies in our composite index are likely to be affected by changes to the CS25 because some of the regulations encouraged the use of composite materials in the aerospace sector. We use another model to test if the changes to CS25 also affected the wider aerospace sector. If the changes did not affect the primes in the aerospace sector, we would have weaker or insignificant abnormal returns and vice versa.

To evaluate the effect of the regulations in the wider aerospace sector, we replace our composite index (dependent variable) with an index for the general aerospace sector.

The functional form of this model is

$$Y = \alpha + \beta(X) + \mu$$

$$where\ Y = The\ Aerospace\ Index$$

$$X = The\ Market\ Index$$

where X is the index of companies making aerospace parts made of composite materials, Y is the index of major European markets. All the assumptions made for our initial model still holds and the derivation of the indices remain the same.

The results of the second alternative model are

Table 11: Aggregated abnormal returns for different window sizes (Second Alternative Model).

Event Window	Average Cumulated Abnormal Returns	Standard Error	T-stat	Confidence Interval Upper Boundary	Confidence Interval Lower Boundary
+/- 7 days	-0.0016	0.0047	-0.34	0.008	-0.0011
+/- 4 days	-0.0016	0.0036	-0.44	0.005	-0.009
+/- 3 days	-0.0022	0.0032	-0.69	0.004	-0.0085

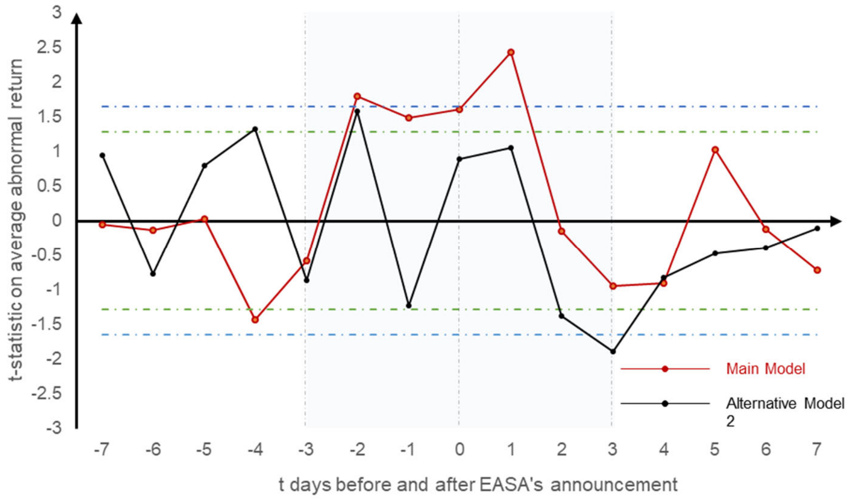

Figure 17: T-stat comparison between the true model and the second alternative model.

From Table 11 we can see that the event windows are statistically insignificant. The t-stat from figure 15 shows the second alternative model significance of the average abnormal return is random and for most of it insignificant. This suggests that when the abnormal returns are aggregated, the announcements to change CS25 did not have any effect on the returns from the aerospace companies in our index.

6.3 VALUATION

Valuation in event study is not 'real' valuation. Real valuation in this sense would be a change in GDP, an increase in turnover, etc. These are real valuations because it is a change in the actual value rather than a change in speculative value. Event study, on the other hand, calculates speculative value i.e. investor valuations of events not the real value of the information.

These investor expectations could come in several forms

- An expected increase in cash flow
- An expected increase in market share
- An expected decrease in cost
- The expected improvement in the supply chain.

The table below shows a comparison between the market capitalisation of FTSE 100 and the UK GDP. This is to illustrate the difference between speculative value (FTSE) and real value (GDP). The FTSE100, which is an index made up of 100 companies, rose by 19.1%. On the other hand, GDP rose by 1.8%. If the FTSE was a real measure of value and not speculative it would mean that these 100 companies outperformed the whole monetary measure of the market value of all final goods and services produced in the United Kingdom that year by a factor of 10.

Table 12: FTSE and GDP value.

FTSE 100 Components Net market Capitalisation (2016)	$2,547,635 (m)
Gross domestic product, current prices (2016)	$2,629,188 (m)
FTSE annual performance (2016)	19.10%
GDP annual growth of the UK (2016)	1.80%

Essentially what we are trying to relay is that event study does not tell you the real impact of the information rather than it tells you what the market (investors) believes the impact of this information would be.

6.3.1 Market Capitalisation

The academic studies do not translate the value of these events in monetary terms because their studies aimed to evaluate the effect of the announcement rather than quantify this effect. We have tried to translate the percentage point we have derived from using event study into an increase in percentage points to monetary value.

This would be done by using market capitalisation to estimate the speculative monetary value of these events.

Market capitalisation is a means of valuating a company through its number of outstanding shares.

$$Market\ Cap.\ (V_t) = Outsanding\ shares(N_t) * share\ price(P_t)$$

Event study essential calculates the deviation from expected normal returns. A deviation from normal return can be seen as a deviation of the normal price.

$$Y_t = Ln(P_t) - Ln(P_{t-1}) \cong {}^{\dot{P}_t}\!/_{P_t} \tag{23}$$

$$Y_t = \alpha + \beta(X_t) + \varepsilon \cong {}^{\dot{P}_t}\!/_{P_t} \tag{24}$$

Market capitalization

$$V_t = P_t * N_t \qquad where\ N_t\ is\ a\ constant$$

$$LnV_t = LnP_t * LnN_t \tag{26}$$

Differentiated to the first order

$$\frac{\dot{V}_t}{V_t} = \frac{\dot{P}_t}{P_t} \tag{27}$$

$$\frac{\dot{V}_t}{V_t} \cong \bar{Y}_t + AR_t$$

Assuming we have an average baseline for our market cap

An increase in market cap would be

$$\bar{V} * \frac{\dot{V}_t}{V_t}$$

Therefore,

$$\bar{V} * \frac{\dot{V}_t}{V_t} = (\bar{V} * \Delta\bar{Y}_t) + (\bar{V} * AR_t)$$

We are interested in the increase in market cap caused by our event, so therefore it would be

$$\bar{V} * \sum_{\tau=\tau_1}^{\tau_2} AR_\tau$$

The calculation of the average baseline method is simply average market capitalisation across all events, this can be calculated using this formula

$$\bar{V} = \frac{1}{t} * \sum_{i=1}^{t} \bar{V}_t$$

$$where\ \bar{V}_t = Average\ Outstanding\ Shares^{22} * Average\ Market\ Price\ of\ the\ event\ window^{23}.$$

Therefore, the market capitalization formulae for the whole events are

$$\bar{V} * \sum_{i=1}^{n} \mathrm{CAR}(\tau_1, \tau_2)$$

6.3.2 Results

Using the procedure explained above we get three different results due to the event windows we are using. Using the 15 days event window (±7 days) we have estimated that the value of the 64 events come up to around £6,530 million. For the 9 days event window (±4 days), the estimated value is almost the same as the 15 days event window. However, for the event window with 7 days (±3 days), the estimated abnormal return is £11,027 million. The message we are trying to convey with these figures is that agents in the stock market have speculatively valued the events of CS25 (NPAs and decisions to amend) to be worth £11bn.

Table 13: Valuation for companies in our study

Firms	Market Cap (£)	± 3 Days (£)
GKN Plc (GKN)	3,093,397,520	1,097,892,763
Gurit (GUR)	221,829,778	78,730,686
James Cropper (CRPR)	19,887,459	7,058,355
Meggitt (MGGT)	2,244,658,535	796,662,681
Morgan Advanced Materials (MGAM)	631,992,266	224,303,450
Victrex (VCTX)	830,315,231	294,691,218
Solvay (SOLB)	6,521,488,017	2,314,573,040
Henkel	17,506,611,969	6,213,356,825

22 Annual Reports of the selected companies from the years 2004-2016
23 Yahoo Finance

(HNK_p)	
Total	11,027,269,019

Given that we know the average increase in price due to the regulatory changes, we can estimate the relationship between price fluctuation and profits. The price-earnings ratio is a valuation metric that estimates the ratio between the earnings per share of a company and the market value per share. The price-earnings ratio is represented as

$$P/_{E} = \frac{P_t}{E_t}$$

Where P_t is the price per share of an organisation a time t and the E_t is the earnings per share of an organisation at time t. The Earnings per share is the net profit generated per outstanding share of stock. If we assume that agents are rational and adjustments in price are equivalent reflection of the adjustments in earnings, i.e. a relative increase in the price of a stock leads to an equivalent increase the expected profits of an organisation, we can estimate the expected profits from abnormal price changes that occur due to the EASA regulatory changes. We realise that the price earnings ratio may fluctuate from year to year because of transitory factors, therefore, we try to estimate the expected price-earnings ratio for a given company. To calculate the expected price-earnings ratio of a firm we take an harmonic mean of the reported price earnings ratio at different years between 2010 and 2020. This can be represented as

$$H(P/E) = \frac{1}{t} \cdot \left(\sum_{i=1}^{t} \left(\frac{P_t}{E_t} \right)^{-1} \right)$$

Where t represents the time period analysed, which could range from 2010 to 2020. $\mathrm{H(P/E)}$ is the harmonic mean of the price-earnings ratio of a company. Given the expected price-earning ratio, we can calculate the in expected change in profits from a change in the perceived market value of the organisation. This can be calculated using

$$\Delta Earnings = \Delta V * \ [H(P/E)]^{-1}$$

Where V is the market capitalisation (i.e. Price of a share * number of all outstanding shares) and the inverse of the price-earnings ratio is how much earnings an investor is willing to accept if the stock was priced £1 per share.

We calculated the expected price earnings ratio for all 8 companies in our study and used this to calculate the expected earnings from the announcements of the 64 amendments. Using these figures, we estimated that on average each amendment of EASA CS25 was valued at around £8 million by investors in the all markets. For companies in the UK, the estimated value of each amendment of EASA CS25 was £1 million. This is expected because the non-UK companies are much larger than the UK companies.

Ticker	Price Earnings Ratio	Inverse Price Earnings Ratio	∆Market Cap (m)	Expected Earnings (m)
GKN Plc	15.97	0.0626	£ 1,097.9 m	£ 68.7 m
Gurit	16.02	0.0624	£ 78.7 m	£ 4.9 m
James Cropper	2758.95	0.0004	£ 7.1 m	£ 0.0026 m
Meggitt Plc	1659.82	0.0006	£ 796.7 m	£ 0.5m
Morgan Advanced Materials	1356.64	0.0007	£ 224.3 m	£ 0.2 m
Victrex	2932.29	0.0003	£ 294.7 m	£ 0.1 m
Solvay	16.45	0.0608	£ 2,314.6 m	£ 140.7 m
Henkel	19.78	0.0506	£ 6,213.4 m	£ 314.1 m

7 ANNEX

7.1 GOOGLE AEROSPACE RELEVANCE SEARCH

	Articles associated with Aerospace in the text	Articles associated with Composite materials in the text	Combination of both searches	Total searches affiliated with the company
GKN PLC	479000	176000	14900	685000
Meggitt PLC	213000	99800	6180	468000
Gurit	136000	142000	4160	368000
Victrex PLC	193000	119000	9180	281000
Morgan Advanced Materials	124000	9910	2370	151000
James Cropper	2500	338	213	48600
Solvay	234000	146000	35200	790000
Henkel	890000	240000	16400	26200000

7.2 AMENDMENT LIST

Date	Title
12/12/2005	CS25 - Amendment 1
25/09/2006	CS25 - Amendment 2
12/09/2007	CS25 - Amendment 3
20/12/2007	CS25 - Amendment 4
29/08/2008	CS25 - Amendment 5
18/12/2008	CS25
26/06/2009	CS25 - Amendment 6
14/10/2009	CS25 - Amendment 7
11/12/2009	CS25 - Amendment 8
05/08/2010	CS25 - Amendment 9
16/12/2010	CS25 - Amendment 10

Date	Title
27/06/2011	CS25 - Amendment 11
27/01/2012	CS25
06/07/2012	CS25 - Amendment 12
17/06/2013	CS25 - Amendment 13
19/12/2013	CS25 - Amendment 14
22/07/2014	CS25 - Amendment 15
12/03/2015	CS25 - Amendment 16
16/07/2015	CS25 - Amendment 17
23/06/2016	CS25 - Amendment 18
15/05/2017	CS25 - Amendment 19

7.3 NPA LIST

The list shows the NPAs in every amendment.

Amendment	NPA	Dates
CS-25 Amendment 1	Notice of Proposed Amendment NPA No 08/2004	19.10.2004
	Notice of Proposed Amendment NPA No 11/2004	10.11.2004
	Notice of Proposed Amendment NPA No 10/2004	10.11.2004
	Notice of Proposed Amendment NPA No 13/2004	18.11.2004
	Notice of Proposed Amendment NPA No 02/2005	02.02.2005
CS-25 Amendment 2	Notice of Proposed Amendment NPA No 14/2004	15.11.2004
CS-25 Amendment 3	Notice of Proposed Amendment NPA No 15/2004	22.11.2004
	Notice of Proposed Amendment NPA No 16/2004	14.12.2004

	Notice of Proposed Amendment NPA No 21/2005	12.01.2006
	Notice of Proposed Amendment NPA No 04/2006	25.04.2006
CS-25 Amendment 4	Notice of Proposed Amendment NPA No 02/2006	10.03.2006
	Notice of Proposed Amendment NPA No 18/2006	08.01.2007
CS-25 Amendment 5	Notice of Proposed Amendment NPA No 18/2007	07.12.2007
CS-25	Notice of Proposed Amendment NPA No 14/2008	13.06.2008
CS-25 Amendment 6	Notice of Proposed Amendment NPA No 05/2008	10.04.2008
	Notice of Proposed Amendment NPA No 13/2008	20.05.2008
	Notice of Proposed Amendment NPA No 19/2008	17.07.2008
CS-25 Amendment 7	Notice of Proposed Amendment NPA No 08/2009	31.08.2009
CS-25 Amendment 8	Notice of Proposed Amendment NPA No 10/2008	07.05.2008
	Notice of Proposed Amendment NPA No 15/2007	24.10.2007
CS-25 Amendment 9	Notice of Proposed Amendment NPA No 04/2008	10.04.2008
	Notice of Proposed Amendment NPA No 06/2009	10.07.2009
	Notice of Proposed Amendment NPA No 07/2009	14.07.2009
CS-25 Amendment 10	Notice of Proposed Amendment NPA No 01/2008	01.03.2008
	Notice of Proposed Amendment NPA No 13/2010	23.11.2010
CS-25 Amendment 11	Notice of Proposed Amendment NPA No 12/2009	30.11.2009
CS-25	A Notice of Proposed Amendment NPA No 10/2009	28.09.2009
CS-25 Amendment 12	A Notice of Proposed Amendment NPA No 11/2010	8.09.2010
	A Notice of Proposed Amendment NPA No 13/2011	22.07.2011
	A Notice of Proposed Amendment NPA No 14/2011	04.07.2011
CS-25 Amendment 13	A Notice of Proposed Amendment NPA No 09/2011	28.05.2011
	A Notice of Proposed Amendment NPA No 17/2011	23.09.2011
CS-25 Amendment 14	A Notice of Proposed Amendment NPA No 02/2013	22.01.2013
CS-25 Amendment 15	A Notice of Proposed Amendment NPA No 06/2014	27.03.2014
CS-25 Amendment 16	A Notice of Proposed Amendment NPA No 03/2011	21.03.2011
	A Notice of Proposed Amendment NPA No 22/2012	27.11.2012
CS-25 Amendment 17	A Notice of Proposed Amendment NPA No 11/2013	10.07.2013
	A Notice of Proposed Amendment NPA No 16/2014	25.06.2014
CS-25 Amendment 18	A Notice of Proposed Amendment NPA No 07/2015	12.06.2015
	A Notice of Proposed Amendment NPA No 11/2015	13.08.2015
CS-25 Amendment 19	A Notice of Proposed Amendment NPA No 07/2013	23.04.2013
	A Notice of Proposed Amendment NPA No 19/2015	17.12.2015
	A Notice of Proposed Amendment NPA No 07/2016	26.07.2015

7.4 ANNUAL REPORT ARCHIVES FOR COMPANIES

Companies	Links
GKN	https://www.gkn.com/en/investors/results-centre/annual-reports/annual-reports-archive/
Meggitt PLC	http://www.meggittinvestors.com/results-archive
Gurit	http://www.gurit.com/Investors/Reports/Archive
Henkel	https://www.henkel.com/investors-and-analysts/financial-reports
Solvay	https://www.solvay.com/en/investors/publications/reports/index.html
James Cropper	http://www.cropper.com/financial/annual-report/previous-annual-reports-1.php
Victrex	http://www.victrexplc.com/news-and-presentations/reports-and-presentations
Morgan Advanced Materials	http://www.morganadvancedmaterials.com/en-gb/investors/reports/

7.5 INDEX CALCULATION BREAKDOWN

$$Y_t = ln\left(\prod_{i=1}^{n} a_i\right)_t^{1/n} - ln\left(\prod_{i=1}^{n} a_i\right)_{t-1}^{1/n}$$

The expression:

$$ln\left(\prod_{i=1}^{n} a_i\right)_t^{1/n}$$

Can be broken down as:

$$= \ln\left[\sqrt[n]{(a_1 * a_2 * a_3 \dots \dots a_n)}\,\right]$$

$$= \ln\,(a_1 * a_2 * a_3 \dots \dots a_n)^{1/n}$$

$$= \frac{1}{n} * \ln\,(a_1 * a_2 * a_3 \dots \dots a_n)$$

$$= \frac{1}{n} * (\,lna_1 + lna_2 + lna_3 \dots \dots + lna_n)$$

$$= (1/n) \sum_{i=1}^{n} lna_i$$

$$where\ a_i\ are\ the\ companies, n = Number\ of\ companies$$

7.6 SERIAL CORRELATION REMOVAL

The problem in the serial correlation is from the residual term, remember we were able to identify the proportion of our residual term that is explained by the lagged variable is ρ, so to eliminate the problem we need to difference it from our initial model by:

$$y_t = \beta_0 + \beta_1 x_t + u_t \dots (1)$$

$$y_{t-1} = \beta_0 + \beta_1 x_{t-1} + u_{t-1} \dots (2)$$

$$\rho(y_{t-1} = \beta_0 + \beta_1 x_{t-1} + u_{t-1}) \dots (3)$$

$$(3) - (1)$$

$$y_t - \rho y_{t-1} = (1-\rho)\beta_0 + \beta_1(x_t - \rho x_{t-1}) + e_t$$

$$\tilde{y}_t = (1-\rho)\beta_0 + \beta_1\tilde{x}_t + e_t \dots \dots . (4)$$

$$\tilde{y}_t = \hat{\alpha} + \hat{\beta}\tilde{x}_t + e_t \dots \dots \dots (19)$$

$$\tilde{y}_t = y_t - \rho y_{t-1} \; and \; \tilde{x}_t = x_t - \rho x_{t-1}$$

We proceed by regressing $\tilde{y}_t$ on $\tilde{x}_t$ provided we divide the result of the estimated intercept by $(1-\rho)$ i.e.

$$\hat{\alpha} = \frac{(1-\rho)\beta_0}{(1-\rho)}$$

7.7 AVERAGE ABNORMAL RETURNS OF ALTERNATIVE MODELS
First Model

$$Y_{composite} = \beta_0 + \beta_1 x_{aerospace} + u_t$$

Second Model

$$Y_{aerospace} = \beta_0 + \beta_1 x_{market} + u_t$$

First Model

Event days	Average Abnormal Returns	t-stat
-7	-0.0008	-0.6915
-6	0.0011	0.9282
-5	-0.0007	-0.5887
-4	-0.0024	-1.9588
-3	0.0000	0.0366
-2	0.0010	0.8110
-1	0.0028	2.3001
0	0.0021	1.7182
1	0.0019	1.5984
2	0.0007	0.5563
3	0.0004	0.3435
4	-0.0004	-0.2953
5	0.0009	0.7270
6	0.0007	0.5951
7	-0.0010	-0.8148

Second Model

Event days	Average Abnormal Returns	t-stat
-7	0.0011	0.9432
-6	-0.0009	-0.7712
-5	0.0010	0.7929
-4	0.0016	1.3282
-3	-0.0011	-0.8670
-2	0.0019	1.5790
-1	-0.0015	-1.2283
0	0.0011	0.8843
1	0.0013	1.0553
2	-0.0017	-1.3734
3	-0.0023	-1.8826
4	-0.0010	-0.8238
5	-0.0006	-0.4735
6	-0.0005	-0.3846
7	-0.0001	-0.1031

7.8 MARKET CAPITALISATION VALUATION RESULTS FOR ALL EVENT WINDOWS

Firms	Average Shares Outstanding from 2004-2016	Average Stock Price	Market Cap (£)	± 3 Days (£)	± 4 Days (£)	± 7 Days (£)
GKN PLC (GKN)	1330206250	£233	£3,093,397,520	£1,097,892,763	£645,625,422	£650,156,456
Gurit (GUR)	467967.8125	£474	£221,829,778	£78,730,686	£46,298,267	£46,623,191
James Cropper (CRPR)	8654659	£230	£19,887,459	£7,058,355	£4,150,727	£4,179,857
Meggitt (MGGT)	707419884	£317	£2,244,658,535	£796,662,681	£468,484,443	£471,772,292
Morgan Advanced Materials (MGAM)	280433642	£225	£631,992,266	£224,303,450	£131,903,602	£132,829,308
Victrex (VCTX)	83166018	£998	£830,315,231	£294,691,218	£173,295,743	£174,511,942
Solvay (SOLB)	87977359	£74	£6,521,488,017	£2,314,573,040	£1,361,104,879	£1,370,657,185
Henkel (HNK_p)	433813657	£45	£17,506,611,969	£6,213,356,825	£3,653,818,714	£3,679,461,407
Total	**2932139437**			**£11,027,269,019**	**£6,484,681,797**	**£6,530,191,638**