Innovation Failure and CEO Compensation Packages[1]

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Abstract

Innovations have always been a crucial factor in a firm's long-term success. The declared purpose of innovation is to develop new products or process enhancements that have not yet been developed. As a result, there is a growing need to understand the consequences of corporate innovation activities with a more comprehensive view. In contrast to the existing research on corporate innovation, this paper uses "novel data" from the U.S. Patent and Trademark Office (USPTO) over the last 20 years to document a "failure gap in corporate innovation" and examines its effect on the chief executive officers (CEOs) compensation packages. We find that there is a significant negative correlation between CEO's changes in short-term incentives (jointly and separately) and non-granted patents (NGPs). We also find a significant negative correlation between the CEO's subsequent long-term incentives, "stock-based compensation", and NGPs. However, we do not observe a negative correlation between a CEO's changes in long-term incentives, "option-based compensation", and NGPs. To conclude, the results from using the USPTO data support our suggestion that NGPs have a negative association with CEO compensation packages in the following year and, more importantly, help in understanding the consequences associated with failure in innovation by providing new information on U.S. corporations.

Note that this is not a call for U.S firms to avoid innovation activity; rather, it is a recommendation to consider the implications of failures in innovation.

JEL: G11, G30, G32, G34, O31

Keywords: Corporate finance, Innovation failure, CEO compensation, Incentives, CEO turnover.

1. Introduction:

This paper studies the correlation between failure in innovation and CEOs compensation packages in the last two decades. Innovation is vital for a country's economic growth (Romer, 1986) as well as a firm's long-term competitive advantage (see Porter, 1992; Solow et al., 1957 respectively). The focus of innovation is on generating, accepting, and implementing new ideas, processes, products, or services (Thompson, 1965) as a foundation for generating wealth from an invention (Gao et al., 2018; Gomez-Mejia et al., 2010). Economists have estimated that 85% of a nation's economic growth is attributable to technological innovation (He, J. J et al., 2018). Given that the firm is the central mechanism for converting innovation into economic action, comprehending the nature, process, and outcome of innovation requires understanding at the level of the firm (Dodgson et al., 2013). Therefore, exploring the effects of corporate innovation has become an increasingly important topic that has attracted tremendous attention and research effort from academic researchers in all kinds of disciplines including economics, finance, management, and so on. This is particularly true in the last decade, mostly because of the availability of granted patent data that measure countries and firms' innovation output. In addition to patent counts, the number of citations is frequently used to measure the impact of innovation as well as to adjust for patent quality. The availability of the two above factors—granted patents and number of citations—which are powerful tools for understanding innovative activity (Lerner et al., 2022), is mainly due to open innovation and social efficiency (Kim et al, 2019). Yet, scholars have not devoted sufficient attention to the dark and unexpected side of patents that have not been granted and whether such applications impact CEO compensation packages, as well as other firms' activities in the short and long term.

To be granted, however, applicants must go through a series of sequential and selective steps, such as the examination process and early fees before obtaining the final decision from the patent office. In 1975, the United States Patent and Trademark Office (USPTO) started keeping track of patent information in a digital format, considerably enhancing academics' access to this information. Nevertheless, it must be emphasized that prior to the reform on November 29, 2000—which in fact began publishing patent applications in 2001 under the 18 months publication provisions of the American Inventors Protection Act of 1999 (AIPA) (P.L. 106-113)[2]—was not possible to gather and classify non-granted patents (NGPs) from the USPTO database. This is the main reason why, in the literature of economics, finance, and management, the vast majority of studies on corporate innovation focus on success in innovation activities, which measured by R&D and later patents granted and their citations, while only a few studies look at the phenomenon of failure in innovation and mostly rely on the databases from European Patent Office EPO. We are more interested in failure than success in innovation, especially at the "firm level".

Moreover, the USPTO database has been instrumental in creating a patent system for various levels, including firm-level databases. Yet, acceptance of the difficulty of accessing and classifying patent applications that the USPTO rejected has meant that this logic is rarely challenged. In particular, prior research analyzing unsuccessful patents using the USPTO database have been very limited. For instance, (Sampat et al., 2019) collect both successful and unsuccessful patents submitted to the USPTO, but they only look at patents that are held by "individuals" in the period of 2001-2010. With special access to internal USPTO databases, (Farre-Mensa et al., 2020) have recently examined successful and unsuccessful applications. Their study, however, is limited to startups that filed their first-time patent application to USPTO between 2001 and 2013. In addition, we know from the existing literature that CEO compensation is often linked to innovation, with studies suggesting that short-term CEO compensation is related to metrics like patent counts and R&D spending—discussed in detail in Section 2.2.1. High compensation aims to mitigate the conflict of interest between the CEO and those of shareholders, potentially encouraging greater risk-taking in R&D, which could result in more patents (Balkin et al., 2000). What remains unclear, however, is whether firms tolerate/adjust CEO compensation when innovation efforts fall short such as when there is a lack of successful patents. This is a significant knowledge gap given the growing problems surrounding innovation activity. Exploring this relationship could offer insights into the effectiveness of the board, CEO entrenchment, and the overall quality of corporate innovation/governance. Thus, the objective of this paper is to close this gap by answering the following research questions:

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[2] See 35 USC 102 "Conditions for patentability; Novelty; Prior Art https://www.uspto.gov/web/offices/pac/mpep/s2152.html and the USPTO Protection Act of 1999 (AIPA)(P.L. 106-113) https://www.uspto.gov/patents/laws/american-inventors-protection-act-1999/helpful-hints-regarding

Does failure in innovation, represented by NGPs, have an effect on the compensation package of a CEO in both the short and long term? If so, do NGPs influence other firm's characteristics, and - if this is the case - do these characteristics play a significant role in the corporate innovation process? These are the substantive questions that we intend to investigate and to provide an analysis of the failure in innovation and its potential consequences on firm activities.

Furthermore, due to the lack of systematic data about NGPs, we initially decided to use the Derwent database World Patents Index DWPI (formerly known as Thomson Innovation) because it contained extensive data on innovations. Unfortunately, data on NGPs for US firms is not readily accessible in the Derwent database, making it unreliable for our research purposes. Even today, with data much more accessible of patent activity, the available data on NGPs is still quite limited. Showing that NGP is a reliable measure of failure in innovation activity is an interesting accomplishment on its own merit. Likewise, using the USPTO data to understand what can be explored with NGPs is a valuable resource for scholars addressing finance and innovation-related subjects. Therefore, to investigate the consequences of failure in corporate inventive activity, we extract the number of NGPs using utility applications from the USPTO Patent Examination Research Dataset PatEx (formerly referred to as Public PAIR data), which contains data on NGPs for the past two decades. We use the latest and most recent version of USPTO-PatEx data (updated in 2022) for US patent applications filed between 2001 and 2022. The sample of this study, however, stops in 2020 because the average time lag between the patent application date and the grant date is three to five years. Our final collection of data for the period 2001-2020 covers 723 firm-year observations and consists of 2,003 applications of unsuccessful patents for 256 firms. More importantly, although we faced enormous obstacles in collecting and categorizing NGPs, using of USPTO data provides us with deep insight into what is happening in various domains of related literature, as well as in more detail than is possible to observe from other patenting data. Plus, we had the opportunity to engage in deep discussion with internal USPTO experts, enabling us to accurately interpret and efficiently present our findings.

More specifically, the study explores whether firms tolerate innovation failures. To measure firms' failure in innovation, we apply NGPs because at any given point, innovation firms have granted patents (indicating success in innovation), NGPs (indicating failure in innovation), and pending applications (with hope to be awarded). NGP measure captures innovation firms' response toward failure by gauging their tolerance for their CEOs' compensation packages, as well as their willingness to continue investing in innovation activity despite past poor performance (i.e., obtaining NGPs) before they "pull the plug" (i.e., stop investing). We follow the definitions provided by (Farre-Mensa et al., 2020; Sampat et al., 2019) defining failure in innovation as "patent applications that are submitted to the USPTO and ultimately rejected by USPTO examiners."[3] We investigate whether firms tolerate such innovation outcomes.

Accordingly, we do not deal with applications that are still pending, as they may have potential value in the future (i.e., granted and cited). Nor do we use granted patent due to the numerous studies that have been conducted in this area. Firms in our data, hence, did not receive granted patents from the USPTO during the time frame in which their applications were rejected. In other words, they only had failed patents during those periods. So, in this paper we show why we think NGPs are "exclusively" interesting despite all the difficulties that arise in their availability and interpretation. To do so, we will first describe the nature of patents (granted and non-granted) and their process. We will next review some of the prior work on patenting activity, the types of data employed by researchers, as well as some of the current issues in the corporate innovation literature that are related to our research paper. Then we will cover the previous assessments linking CEO compensation to innovation activities. We will not be able, however, to do all the prior work justice, as there are other good studies examined unsuccessful patents from a different perspective, but we hope to provide an important addition to the relevant literature. Finally, we will discuss the hypotheses, methods, and results of the current study.

To conduct this study, we use a two-stage analysis on our selected sample. First, we empirically investigate the entire data collection, which consists of 723 firm year-observations for all variables spanning the year prior to, during, and following the occurrence of the NGPs, to analyze the correlation between NGPs and CEO compensation packages. Or put it differently, we examine whether CEO compensation packages reduce in the post-NGPs year. With that data, and consistent with our hypotheses, we find that NGPs have a significant negative effect on all short-term incentives (i.e., salary, bonus, and total cash compensation, which is the sum of both) in the year following NGPs. Similarly, stock-based compensation, in terms of long-term incentives (i.e.,

[3] Strictly speaking, the USPTO never officially rejects patent applications; rather, they are abandoned by applicants who still have the option to appeal them (see the discussion in Lemley et al., 2008). These scholars have collected 2,724 rejected patents. For the sake of clarity, we follow (Sampat et al., 2019; Farre-Mensa et al., 2020) and refer to such abandoned applications as rejected.

options, stocks, and other long-term incentives plans), is significantly and strongly negatively impacted by NGPs in the year after NGPs.

Moreover, prior work uses research and development R&D expenditures to measure innovation output, and others rely on granted patents for the same purpose. However, they disregard the fact that R&D expenditures, which is the primary input into the innovation process, do not offer any details on the “success of the innovation” (Kleinknecht et al., 2002). NGPs, on the other hand, provide information on the firm's “unsuccess of the innovation”. Hence, to explore the relationship between our primary variable to measure failures in innovation, NGPs, and R&D activities, we examine the impact of NGPs, innovative outputs in our study, on firms' investment in R&D, innovative inputs, in the year following the appearance of NGPs. We find that NGPs have a strong and significant negative effect on R&D investments in the subsequent year for the U.S firms. We use the ordinary least squares (OLS) technique to run all these models.

In addition, we observed that in our entire dataset, almost 24% of all CEOs (i.e., 95 out of 401) were departed the year following the occurrence of NGPs. Consequently, we investigate the correlation between firm’s failures in innovation and the departures of the CEOs. Our analysis, using a binary variable and logistic model, shows that the NGPs do not influence the departure of CEOs. We intend, however, to dig into this outcome further by gathering the motives for the departure of CEOs, as the databases we rely on do not encompass all the relevant information on CEOs' departures. The logic behind this collection is to identify a direct link, if any, between the effect of NGPs and the reasons of a CEO's departure so that we can suggest some directions for future research and theory building. We find that “resignation” was the main cause of departure for 70% of CEOs who left their positions (i.e., 67/95) in the year following NGPs (Section 3.3 provides more details). Our conclusions suggest that innovation failure could be a contributing factor—considering the long tenure of these CEOs and their high number of NGPs— but it is obviously not the primary reason for CEOs turnover. Therefore, if more innovation firms, especially those with a high number of NGPs, exhibit a tendency to replace their CEOs in the year subsequent NGPs, our hypothesis of CEO departure may be accepted. More importantly, the findings would open up a new area of future research about the role of failure in innovation and its impact on firms' board of directors' decision-making process.

Second, as a further robustness check, we tighten our data by considering only the CEOs who had their tenures extended after the occurrence of the NGPs and excluding those who left, resulting a total of 628 firm year-observations consists of 306 CEOs and 1,823 cases of NGPs. Then, we run the exact models in the first stage in order to examine the consequences of NGPs on CEO compensation packages, as well as firm's R&D investments. In this stage, however, we are unable to analyze the relationship between NGPs and the departure of the CEOs, as we do in the first stage, due to limitations in our dataset in this level, which only includes CEOs who were in the position at least one year before, during, and after the NGPs occurred. These CEOs represent 87% of our total data on CEOs. We argue that CEOs who have been reappointed bear full responsibility for the firm's patent applications from the time they start the filing process until the firm receives the final decision from the USPTO examiner. In specific, since these CEOs remain in their positions for at least three years and show failure in innovation, by obtaining NGPs, such result could have a negative effect on their short-and long-term incentives in the subsequent year. As a result, the observable characteristic of firm innovation, R&D investment, may also reduce in the year following the NGPs. The effect on the latter variable is particularly relevant as it is the only input into the innovation process that is "entirely under managerial control". In other words, if CEO compensation packages decrease post-failure in innovation, their motivation to invest in R&D is most likely to decrease.

We confirm from an OLS regression that the empirical results we obtain in the second stage support the findings of the first stage across all models. Particularly, failure in innovation, in the form of NGPs, is associated with a decrease in 1) the CEO's short-term incentives, 2) the CEO's long-term incentives "stock-based compensation," and 3) the firm's investment in R&D, all in the post-NGP year. Moreover, these results indicate a significant negative impact of NGPs on all components of CEO short-term incentives. With CEO long-term incentives, the findings show that stock-based incentives in the year after NGPs are less effective than stock-based incentives in the year before NGPs. Likewise, the outcomes show that NGPs have a significant negative impact on a firm's investments in R&D in the post-NGPs year. Overall, all these empirical models from the "two-stages" demonstrate that firm's failure in innovation have a significant impact on various aspects of firm operations. The results, therefore, suggest hitherto unexplored effects of the USPTO-NGPs on U.S firms. As far as we know, the current study is the first to link "exclusively" the innovation failures of U.S firms with compensation packages of CEOs, as well as their R&D

investments. Some may argue that this exclusive focus on NGPs is exaggerated and that other types of patents, such as those that are pending, are of equal if not greater importance. Nevertheless, our study attests to the principle of robust results (this is the second level) that NGPs demonstrate.

This study makes several contributions to the literature. First, while it has been known the effects of success in innovation on many different aspects of firm activities, we are the first to shed new light on the failure in innovation using our analysis on the USPTO-PatEx database and provide strong evidence for the empirically underexplored conjecture that the adjustments in the CEOs compensation packages and firm's R&D investments are related to the failure in firms' innovation. These findings are relevant to all areas of finance and innovation literature. Second, we propose a useful proxy variable to measure firms' failure in innovation, which strictly represents patents that received a final decision with rejection from USPTO examiners. We named our measure non-granted patents (NGPs). Third, empirical research, in general, uses R&D investment and latter patents granted and citations to investigate firms' innovative activities. Yet, the effect of NGPs, within the context of innovative activities, is still ambiguous. Therefore, this study contributes to the existing body of literature by linking the failure in innovation —particularly the role of NGPs— with CEOs' remuneration packages, as well as their R&D investments.

Fourth, our study also contributes to the literature on the causal effect of innovation outputs. Existing literature (e.g., Mao et al., 2018; Baranchuk et al., 2014; Lerner et al., 2007; Makri et al., 2006) has focused on patents granted and R&D investments. We take advantage of NGPs to explore their causal effect on all short-and long-term CEO compensations. Fifth, in contrast to previous research, we provide robust evidence that NGPs, as a negative result of investment in innovation, have an impact on CEO's compensation and R&D investment at the firm level, thereby contributing to the literature on the corporate outcomes of innovation investment. Sixth, our sample period of 2001–2020 is long enough to capture the effects of NGPs that could appear in both the short and long run. In doing so, we not only integrate new knowledge with prior studies, but we also go one step further and address a set of interesting characteristics of firms and management that reflect the impact of NGPs on corporate innovation activity. Finally, this study, in general, contributes to the body of research on the "dark side" of corporate innovation—why scholars only look at success in innovation when studying patenting activity and ignore the role of unsuccess in innovation, which seems to have a significant impact on many firms' activities —by determining the scope of patent activity, classifying the NGPs recognized by the USPTO, and showing the direct effects of NGPs.

We conclude that, despite being relatively inconsequential for most of the US firms, we initially predicted that NGPs might only affect compensation of CEOs in the "long-term." Interestingly, our study shows surprising outcomes on the two stages of analysis, indicating that, except for stock-based compensation, the effects of NGPs are actually significant for the "short-term." From managerial perspectives, these results can therefore be valuable to firm administrators in determining whether these patents require more attention. Plus, they suggest that firms ought to carefully consider the importance and potential economic value of NGPs in the long run, especially if the firm seeks re-evaluation and the USPTO examiner approves to review and, eventually, grant them in the future. They also offer guidelines for policy makers regarding the implications of strategic decision-making in innovation.

Two limitations should be acknowledged at the outset. First, previous research on failure in innovation using USPTO data has been limited, which leaves a lack of knowledge that requires further exploration. The prior studies note the difficulties associated with gathering patent applications that have not been granted from the USPTO database, due to the access issues, differences in definitions of such patents, and variations in their types. We spent over two years to the effort of collecting and purifying our data and related details to ensure their validity and reliability for our research investigation. Yet, our sample collection and analysis of the USPTO database is limited to 2,003 patent applications for 256 firms, due to almost the same obstacles and limitations in earlier research. Even though we present robust evidence of the consequences of NGPs, There is no reason, however, that this methodology could not be extended to a longer USPTO data set, which would allow for a more precise identification of the effects of innovation failure. Second, since we exclude pending patents from this study due to their unresolved status and, more importantly, may or may not be awarded in the future, further research could accumulate more observations of unsuccessful USPTO patent applications, particularly given the current high volume of pending patents. Because the literature on innovation failure is still quite unexplored, with a relative lack of meaningful empirical measures, a simpler approach seemed desirable. The intention is that this research study will encourage more empirical and theoretical work on how the firms' failure in innovation affects CEOs' compensation packages. We finally confirm that our sample, analysis, and findings are still reliable and valid despite all these limitations.

The remaining of the study is organized as follows: Section 2 discusses the background and related literature of innovation and CEO compensations. It additionally describes the classifications of NGPs and the interaction between patent applicants and examiners of the USPTO. Sections 3 summarizes our expectations. According to the literature, when patents are granted, they frequently result in positive effects on various aspects of firms' operations. In contrast, we hypothesize that NGPs will have negative impacts on CEO remuneration, including some other potential negative effects on firm innovation activities, like lower the investment in R&D. Section 4 describes data and methodology, including sample, measures, models, and data analysis. Section 5 presents the empirical results and robustness. Through our analysis we find support for our primary hypotheses related to impacts of NGPs. Our analysis, however, does not find effect on all components of long-term incentives for CEOs. Section 6 concludes the study.

2. Literature Review:

When the topics of innovation failure and success are discussed together, failure is frequently conceptualized in terms of success. (Godin et al., 2017) argue that the little scholarly attention paid to innovation failure is a manifestation of the pro-innovation bias that dominates the research literature. We support this argument given that our current study is the first to shed light on the consequences of failure in innovation and its effects on a firm's various activities. We also argue that academic research concentrates on the work of innovation success, and this has resulted in a dominant representation of outcomes of innovation as the only way to investigate a firm's innovation activity. Therefore, we suggest an alternative approach sidelined by this dominant representation to study corporate innovation outcomes—i.e., innovation failure.

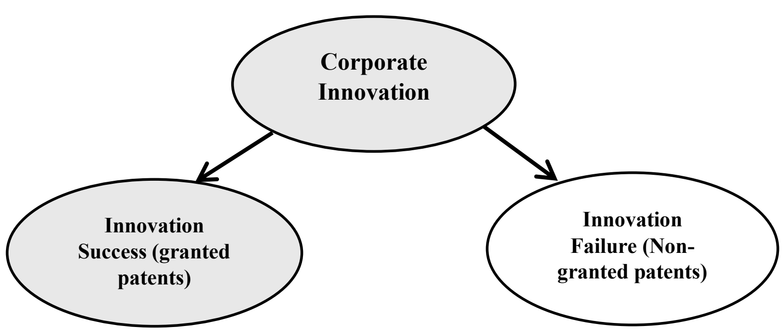

Fig. 1. Visual representation of the focus of this paper is on the right side (innovation failure), while the box on the left side represents most of the existing literature.

To use the USPTO data effectively, particularly our main independent variable, NGPs, it is necessary to understand a little about the prior studies conducted on both granted and NGPs in the related literature. Most of these studies have relied on R&D investments, granted patents, and citation patents to represent corporate innovative performance. This part, however, reviews current research on the interaction of corporate innovation with CEO compensation packages.

*2.1 Innovation Activity**:** Patents examinations, Granted Patents, and Non-Granted Patents*

2.1.1 Patents examinations:

A patent is a legal document, issued by recognized governmental agencies, granting the right to exclude anyone else from the production or use of a particular new device, apparatus, or process for a stated number of years (Griliches, 1990, 1998). The main objective of the patent system is to promote innovation and technological development by allowing the inventor a temporary monopoly for the inventor and requiring early disclosure of the information necessary for the production of this product or the operation of the new process. The inventor of the device or process receives the grant after an evaluation that considers both the uniqueness of the claimed item and its potential value. The applicants, however, must go through a series of sequential and selective steps, such as the examination process and early fees, before obtaining the final decision from the patent office, which, at best, can last three years (Schettino et al., 2009). Failing to meet the obligations in due time, however, the patent is considered to be withdrawn.

Furthermore, the USPTO examiner is a public officer who is legally required to grant a patent if the inventor met the criteria for patentability established by the US Congress and federal courts. The USPTO uses five criteria to determine whether to grant a patent application: patent eligibility, novelty, non-obviousness, utility, and the text of the application satisfying the disclosure requirement. More precisely, the USPTO sends the applications to the "art unit", a group of patent examiners, for review. The examiner, with relevant expertise, makes an initial assessment of patentability based on the five aforementioned criteria. Most often, this assessment is just the first in a series of revisions carried out in collaboration with the applicant. Notably, there are only two participants: the examiner and the applicant. In other words, there is no possibility for other interested parties to submit evidence during the initial review that could influence the decision to grant the patent. After the initial review, which is estimated to take an average of eighteen hours for a patent examiner to decide on each application (Burk et al., 2002), the applicant receives an official letter detailing the examiner's initial decision. At this point, the applicant can revise the claims to meet the demands of the examiner, and another round of the same revisions may follow. If the patent reaches an advanced stage —most likely to be in pending —there is a substantial chance to be issued. Otherwise, the applicant will receive a final rejection. We find most applications are either initially rejected or in the pending stage at any given time prior to the final decision; and we were only able to obtain 2,003 applications with "final rejection" between 2001 and 2020. Moreover, three months following the final rejection, however, the USPTO applicant has the right to respond and decide on one of the three options: request a *re-examination* with compelling justifications for why the applicant persists in believing their application should be accepted; *appeal* against the final decision if the applicant perceives that the examiner may have missed a crucial component of the application during the patent examination process; or *abandon* the application when there is little chance to issue the patent if the applicant proceeds.

We argue that the term "final rejection" seems inappropriate at this point because the applicant should not take any further action following such a determination. We contend that the USPTO ought to consider the disparity between these phrases to avoid any misunderstanding when researchers try to employ them. The final accept/refuse decision task takes approximately 3 years on average. However, the delay in the granting process may be substantially longer due to the rise in patent applications, which can be largely associated with applicants' increasing use of strategic patenting (Hall et al., 2009). Half of the US patents granted in 1996 spent about 20 months in pendency, while, in sharp contrast, half of the patents granted in 2011 spent more than 36 months in pendency (Zahringer et al., 2018).

2.1.2 Granted Patents:

The likelihood of securing a patent varies significantly across countries. (Boubakri, et al., 2021) indicate that countries with a tolerance-oriented culture tend to have more corporate innovation. (Griliches, 1990), for instance, shows that the success rates of obtaining patent protection were 90% in France, 80% in the UK, 35% in Germany, and 65% in the U.S during the 1970s (approximately two out of three applications in the U.S are ultimately granted) and 73% in the 1980s. (Cohen et al., 2000), document that the total number of U.S patent grants has increased 78% between 1983 and 1995. Since then, the patenting activity has grown substantially in the U.S.

(Schuster et al., 2020) recently reported that, out of over 3.9 million applications using U.S. data, 68.8% resulted in patent issuance between May 22, 2001, and March 22, 2016. Other studies (see, e.g., Carley et al., 2015), however, argue that the U.S grants patents easily, and many such patents granted hinder, rather than promote, the U.S. innovation system. This disparity is mostly due to the differences in the economic conditions, procedures, and resources used by various patent offices, resulting in variations in the quality of a granted patent between countries and periods. These findings suggest that the likelihood of reducing the failure risk increases with experience in the patenting process.

In the past two decades, patenting has been frequently used as an alternative proxy to capture corporate innovation (He, J. J., et al., 2018). Several studies in the field of finance have looked at the intersection of firms' granted patents with mergers and acquisitions (Bena et al., 2014), bankruptcy (Bai et al., 2020; Acharya et al., 2009), banking deregulation (Hombert et al., 2017; Cornaggia et al., 2015; Amore et al., 2013; Chava et al., 2013), going public (Bernstein, 2015), and stock volatility (Bartram et al., 2012). Others have examined the relation between litigation (Choi et al., 2017; Haslem, 2005), unions (Bradley et al., 2017), and other factors with firms' patents. (Farre-Mensa et al., 2020), for example, demonstrate that obtaining a patent not only boosts the number of subsequent patents granted to the firm, but also improves the quality of these patents (the average number of citations per subsequent patent). In contrast, (e.g., Crosby, 2000) show a negative relationship between patents granted and innovation activities. Whether or not the patents granted reflect true innovation, it is still of interest to assess the factors that contribute to successful patenting. Given their importance to the firms that obtain them, granted patents are used as a main variable in all of these studies to measure corporate innovation. There is no study, however, in the empirical literature of patents that captures "perfectly" innovation.

2.1.3 Non-Granted Patents:

The prior empirical literature in this area is relatively sparse, perhaps due to the difficulty and limited resources of comprehensive data. Until recently, publicly available data sets, such as National Bureau of Economic Research (NBER) or Harvard Business School, only covered patents granted (Fang et al., 2017; Lerner J, 2002). Even today, public disclosure of patents that have not yet been granted is insufficient. Therefore, we conducted this study, as no previous work "exclusively" used NGPs to capture firms' innovation failure over the period 2001-2020. This section addresses the potential causes of the firms' NGPs that have been reported in the relevant literature as well as the various consequences they may have. We divided them into three groups based on their common reasons: lack of technological merit, examination decision differences, and market value estimation.

One of the reasons why firms' patent applications might be rejected is a lack of technological merit. As per US patent regulations, technology may be deemed to lack novelty if it is either obvious, thereby lacking technological merit, or made publicly available more than a year prior to the application being filed. (Carley et al, 2015), for example, use USPTO's databases from 1996 to 2005, which include granted and rejected applications, and show that applications in the high technology fields such as drugs and medical, computers, and communication are least likely to be successful, with a sharp decline at 55.8%. This result is consistent with a previous study (Frietsch et al., 2013) use the EPO database and reveals that patents rejected are more in the high-tech industries, such as electrical engineering and chemistry, than those in the medium- or low-tech industries, like mechanical engineering. In a similar spirit, (Basmann et al., 2007) study the impact of patents on technical change in the U.S. from 1947 to 1981, using various types of U.S. patent activity variables, including unsuccessful patent applications, as instruments for the technology changer. The idea is that technical change can be seen in how readily one input can be substituted for another as the technology evolves. The results indicate that 38% of patent applications are unsuccessful, and, while they matter, they are less effective than granted patents (domestic or foreign) in terms of their effect on input substitution. These outcomes together support the argument that firms use patent applications for strategic reasons, such as blocking other firms, improving the reputation of the company, improving position in negotiations with other firms, creating incentives for their R&D employees, and measuring firm performance.

Another reason patents are denied is because of differences in the decisions made during patent examination (see e.g., Graham et al., 2018; Cockburn et al., 2002). In practice, the examiners make their decision by comparing the patent application with certain criteria, which include the state of existing knowledge, the patent application’s novelty, the nonobvious of the patent, etc. If the application does not match the criteria, the examiner issues an "office action," rejecting the application as not patentable and explaining the reasons for that rejection. Hence, the decision to grant or non-grant the application should be the same across offices for the same patent.

(Palangkaraya et al., 2011) use granted and refused patents to investigate the misclassification in patent examination decisions made at the EPO, USPTO, NBER, the Japanese Patent Office (JPO), and the Triadic Patent Family (TPF) between 1990 and 2004. The results display a 6.1% probability of refusing a true grant application and a 9.8% probability of granting a true refusal application. In a similar vein, (e.g., Batabyal et al., 2008) find that examiners in the USPTO make too many errors in the process of evaluating the strengths of individual patent applications. These errors can result in rejecting a deserving patent application or accepting an undeserving patent application. These findings suggest that differences in examiner skills, staffing levels, office procedures, and country-specific legal texts may explain differences in decisions, but they should not serve as justification. Because both applicants and examiners participate in the patent examination process, it is important to comprehend how applicants behave strategically.

Others argue that the market value estimation—i.e., the market-perceived value of patents—plays a significant role in determining patent failure through decreasing their value. Some finance and economic studies in this area of literature have regarded the U.S. context (e.g., Farre-Mensa et al., 2020; Lanjouw et al., 2004), and demonstrating significant effects of market value on granted patents than NGPs. Others show similar results for the European firms (e.g., Hall et al., 2007; Toivanen et al., 2002). Two decades earlier, (Guellec et al., 2000) use two factors related to the technological value and legal rights conferred to the patentee and demonstrate that the patents granted have a higher private value than the ones that are withdrawn or refused. Other researchers have confirmed the patents granted–market value link in other contexts. For example, (Kogan et al., 2017) use a novel measure of the economic value of new innovations that is based on stock market reactions to the U.S. patents granted between 1926 and 2010. Specifically, they estimate the private value of the patent by exploiting movements in stock prices following the days patents are issued to the firm. Their findings reveal a higher volatility in returns on patent grant days compared to days without any patent grant announcement, which indicate the release of valuable information to the market. In contrast, (Yang et al., 2019; Fang et al., 2014) show that market value has a significant negative influence on the patenting activities of emerging countries. Similarly, (Walsh, J.P et al., 2016) use information from US patents and show that 30% of non-use patents (including failed patents) are due to the market environment reducing the value of the invention. These results highlight two important points: First, the misleading values of the patents may lead to wrong conclusions if they are not properly addressed. Second, the low-value granted patents could influence the future potential value of patents with initial rejection (if they issued later) for the same invention. Overall, these issues of lacking technological merit, examination decision differences, and market value estimation are determinants of patents' success or failure and have often received considerable critical attention from researchers. In this study, however, we are interested in establishing facts about the effects of NGPs on CEO compensation packages.

2.2 CEO Compensation Packages:

CEOs are the most important decision-makers for firms (Faleye et al., 2014), responsible for allocating corporate resources (Coles et al., 2006), designing corporate strategies (McDonald et al., 2008), and ultimately generating profits and financial returns (He, J. J., et al., 2018). In a modern firm where ownership and control are separate, providing compensation to managers mitigates misalignment between managers' and shareholders' interests and motivates them to invest in innovations (e.g., Roe, 2013; Koo et al., 2019). Thus, firms wishing to pursue innovation would provide their CEOs with more compensation. However, CEOs are risk-averse and favor short-term earnings, especially when it comes to innovation, partially due to the high failure rate (Biggerstaff et al., 2019; Edmans et al., 2017), as well as the risk of being fired (Aghion et al., 2013). We know little about how failure in innovation, in the form of NGPs, affects a firm's CEO's incentives. The current study addresses these two issues: the CEO's failure to innovate and the CEO's departure.

Our compensation sample is formed from US firms with CEO compensation data available on BoardEx. The BoardEx database's structure indicates that a CEO's compensation package consists of two main components: First, short-term incentives (STIs) are the total cash compensations—the sum of salary and bonus. Second, the total equity at risk—the sum of the stocks, options, and the long-term incentive payment (LTIP)—indicates long-term incentives (LTIs). We focus on these two main compensation measures, as well as each of their components separately. Prior studies, which we discussed below, have mostly linked one or two components of CEO compensation to innovation activity. In our study, however, we intend to link all of the short- and long-term components to corporate innovation, both jointly and separately. The literature on CEO compensation packages consists of two sections. The first section reviews the literature that links short-term CEO compensation and innovation activities. We discuss studies that explore how successful innovation, in the form of granted patents, influences the CEO's total cash incentives, salary, and bonus. The second section covers studies examining the relationship between long-term CEO compensation (stock, options, etc.) and innovation activities. We will also discuss the relationship between these two main compensations and the innovation failure.

2.2.1 Prior research linking short-term CEO compensation to corporate innovation.

Given the high rate of innovation failures, CEOs may avoid innovation investment decisions and devote attention instead to other firm strategies that enhance their personal career objectives. In this case, most firms intervene by adjusting compensation packages to encourage CEOs to engage more in innovative activities and generate more granted patents, as well as to affect the riskiness of their decision-making (Graffin et al., 2020). However, in practice, other CEO incentives, such as stock and options, are not always achievable. The shareholders, thus, can only offer the CEO a short-term compensation, even though the cost of short-term incentive is higher than the cost of long-term incentive (Manso 2011). Such short-term compensation is most likely to be linked to profitability (Incentive-based performance). Moreover, One of the most widely cited papers that investigate CEO short-term schemes is (Healy, 1985). The author describes different forms of compensation, including both salary payment and bonus plans, and indicates that bonus schemes depend on earnings. Many subsequent researchers have pointed to Healy's study as evidence that CEOs' bonuses are associated with profitability. For example, (Makri et al., 2006) use a sample of 206 firms from 12 US manufacturing industries to explore the relationship between innovation activities and CEO incentives in technology firms. The findings indicate a stronger correlation between bonuses and financial results. They further suggest that R&D-intensive firms should reward CEOs for financial results with annual bonuses. Therefore, rewarding a CEO with annual bonuses linked to earnings reinforces their focus on continuous innovation.

Prior literature presents mixed results concerning the relationship between innovation activity and CEO short-term incentives. For instance, (Brick et al., 2006) use a sample of 1441 firms over the period 1992–2001 to examine, besides other investigations, the association between the CEO's cash compensation and R&D. The authors document a strong positive correlation between the CEO's cash compensation and R&D after controlling for monitoring proxies. Using sample data between 1992 and 2004, (Sheikh, 2012) examines whether the structure and design of CEO compensation has any effect on firm innovation. In particular, the author empirically examines how incentives from compensation contracts affect two observable characteristics of firm innovation: R&D expenditures and patents and citations to patents. The results indicate that the CEO's cash compensation is positively related to investment in R&D, number of patents, and citations.

In a similar spirit, (Shen et al., 2013) focus on both short-term incentives and equity-based compensation to study which CEO compensation can influence corporate investment efficiency and hence impact shareholder wealth. They use a sample of 843 cases in which firms increased their R&D investments by an economically significant amount during 1995–2006. They also point out that increases in R&D investment tend to increase investor opinion divergence, resulting in greater stock return volatility. They find a positive and strong correlation between CEOs with higher cash compensation and increased R&D investments. This finding is consistent with prior work (e.g., Guay, 1999), which discussed that a CEO's risk aversion is related to how much of that CEO's personal income is earned within the firm. In other words, increasing the CEO's cash compensation would be a motivation to invest more in R&D projects, which, in turn, would generate more patents and vice versa.

In an empirical study on the duration of CEOs' compensation, (Gopalan et al., 2014) develop a measure of pay duration that directly captures the mix of short-term and long-term compensation. More precisely, their measure explicitly considers the length of the vesting schedule for each component of the CEO's compensation, of which there are often many during a given compensation year. Since cash compensation can produce incentives for a CEO to take high risks, R&D investment (Roe, 2013), the authors indicate that, based on their data, 30% of CEOs compensation consists of salary and bonus, which vest immediately (we know that the non-cash components, long-term incentives, typically vest within five years if a CEO remains in the position). That is because most of these CEOs have longer-duration pay contracts, in which most of their compensation comes from equity-based incentives. They show overall a positive correlation between CEO cash compensation (salary and bonus) and R&D investment. In particular, CEOs with long pay durations have significantly higher salary compensation but lower bonus compensation. These results support the literature that indicates a positive relationship between both short- and long-term contracts with innovation.

In contrast, (Cheng, 2004) examine the relationship between innovation, in the form of R&D, and CEO compensation. Based on the data from 160 Forbes 500 firms in R&D-intensive industries over the period 1984–1997, the main hypothesis suggests a positive correlation between changes in R&D and changes in CEO compensation. In contrast to changes in long-term incentives, the results show that changes in cash compensation (salary and bonus) are significantly negatively associated with changes in R&D. In other words, when the firm faces a small earnings reduction or small loss, its R&D is likely to be sharply reduced or cut in the subsequent year (Hayes et al., 2012). The decline in the firm's earnings will negatively affect the CEO's cash incentives. As the firm forms strong long-term incentives for its CEO to prevent any reduction in such incentives, the correlation between the decline in the firm's earnings and long-term incentives is positive, especially when the CEO approaches retirement.

Likewise, (Mao et al., 2018) use a sample consisting of 15,741 firm-year observations between 1992 and 2008 to explore how the risk-taking incentive derived from CEO compensation affects firm innovation. They apply compensation changes made by the FAS 123R accounting regulation in 2005, which mandated stock option expensing at fair values. Based on their baseline ordinary least squares (OLS) results, there is a significant positive relationship between CEOs' risk-taking incentive (i.e., vega) and innovation output (patents granted and citations). Further, they examine the relationship between the CEO's short-term incentives (salary and bonus) and innovation activities in an OLS regression framework. The findings demonstrate a negative relationship between the CEO's short-term incentives and innovation following the implementation of FAS 123R. This negative result indicates that firms use pay-for-performance-based compensation when they use the FAS 123R law. In a similar spirit,.

In short, salary and bonus (total cash compensation) are part of CEO total compensation packages, and both are contingent upon the year-on-year performance of a firm and are agreed upon ex-ante. Bonuses, for example, reward CEOs with additional payments on top of a base salary when they show good performance (e.g., generating more patents). In other words, short-term incentives motivate CEOs to shift attention to the short term and focus only on less risky investments that have sufficient potential to guarantee meeting the objectives tied to their short-term compensation. Yet, when a firm fails to obtain patents, such failures might influence its CEO's subsequent bonuses and, consequently, the CEO's entire short-term incentives. Overall, prior studies have mainly focused on the positive role that successful innovation plays in the CEO's short-term incentives, and they neglected the potential negative consequences of innovation failure, which may directly affect the CEO's future compensation from salary, bonus, and total cash incentives. Hence, this study seeks to fill this gap.

2.2.2 Prior research linking long-term CEO compensation to corporate innovation.

We now review the literature on how corporate innovation affects a CEO's long-term incentives (i.e., stock, options, LTIP). Scholars (e.g., Manso, 2011; Holmstrom, 1989) argue that incentive contracts should provide a long-term commitment and protection from failure to motivate managers to invest in the exploration of new ideas rather than exploiting existing ones. Recently, there has been a call from academics and commentators for a more comprehensive empirical investigation into the relationship between CEOs' long-term compensation and corporate innovation (e.g., Mazouz et al., 2019; Shen et al., 2018; Laux, 2015; Baranchuk et al., 2014; Shen et al., 2013; Manso, 2011; Ryan et al., 2002). These studies summarize the results of this line of research by stating that successful innovation, which is mostly measured by granted patents, has a positive relationship with the CEO's long-term incentives. (Francis et al., 2010), for example, use a sample of 1,106 firms during 1992–2005 to explore the relationship between the long-term compensation and innovation activity, as measured by the number of patents filed and citations. The findings indicate a positive relationship between the CEO's long-term incentives (options and stock) and the firm's innovative activities. Their results provide evidence consistent with the theory that contracts that offer a high tolerance for failure motivate CEOs to invest more in innovation.

Since R&D has assumed a greater importance in corporate innovation and the efficiency of R&D projects has more significant influence on firms' future performance, several recent papers have therefore explored the potential impact of R&D investments on CEO compensation. In this context, (Shen et al., 2013) focus on R&D investments in corporate innovation and investigate whether the sensitivity of the CEO long-term compensation affects the propensity for, and especially the efficiency of, R&D investment. They use a sample of 843 cases in which firms increased their R&D investments by an economically significant amount during 1995–2006. The results prove that firms with higher sensitivity of CEO long-term compensation value to stock volatility (i.e., vega) are more likely to have large increases in R&D investments. They further suggest that shareholders should frequently monitor the level of CEO risk incentives and decrease CEO compensation vega that is excessively high to prevent the potential overinvestment problem associated with excessively high vega. Likewise, (Lin et al., 2011) examine the roles of managerial incentives and CEO characteristics in a firm's innovation activities, as measured by R&D investments. The data they use includes 1088 manufacturing firms in 18 Chinese cities. They highlight that weak manger incentive schemes and restricted decision-making power plague China's firms with agency problems. This is what motivated the researchers to explore the impact of these factors on corporate innovation activities in China. They find that firms that provide CEOs with significant shareholding and performance-based compensations are more likely to invest in R&D and tend to invest more in R&D. These findings demonstrate that CEOs with high compensations would have stronger incentives to engage in long R&D investments, which are tangible in cost but intangible in benefits.

Additional evidence is constructed by (Gonzalez-Uribe, 2017) who study the relationship between the long-term incentive and innovation quality as measured by, respectively, CEO contract horizon and granted patents citations. Using a sample of 1,262 firms headed by 1,346 CEOs during the 1993–2008 period, they find that firms with longer CEO horizons produce more important patents. In a related paper, (Nguyen, 2018) uses a sample of 1,900 firms between 1992 and 2006 to find out whether the CEO's long-term incentive plan LTIP (restricted stock and unvested option) is higher in firms that work in industries and product markets where innovations are more urgent. Building on (Manso, 2011), he further investigates whether, in specific, unvested options-based incentives spur corporate innovation. Regarding the first question, the author documents that long-term incentives are significantly higher among firms in innovative industries as well as among firms facing strong product market competition. In regard to the second question, the results from the baseline specification indicate that the higher level of CEO long-term incentives is associated with not only a higher number of patents but also a higher impact of patents generated in the subsequent year.

Another paper that examines the innovative-related incentives of CEOs is (Mazouz et al., 2019) who study whether takeover protection affects the ability of CEOs long-term incentives (equity-based compensation) to spur innovation. When both incentives and protection are considered, the latter may hinder the ability of the former to motivate innovation. Using a large sample of US firms over the period 1996–2014, they find that long-term incentives have a stronger influence on innovation when combined with takeover threats. That is because risk-averse CEOs tend not to engage in innovation when a takeover threat is imminent due to the high level of uncertainty about the expected payoff. Therefore, without appropriate protection, equity-based compensation may not provide CEOs with sufficient incentives to engage in high-risk investment. Finally, they suggest that the discipline of takeover markets is crucial for CEOs who receive high long-term incentives to perform as intended.

Given that innovation is a long-term, unpredictable, idiosyncratic, and risky process, it requires effort not only from a firm’s CEO but also from its non-CEO executives. Therefore, several studies have investigated how the incentives of non-CEO executives impact firms' innovative activities. For instance, (Chang et al, 2015) examine the effect of non-CEO executive stock option on corporate innovation. The findings indicate a positive effect of non-executive stock options on patents and citations. They also argue that the main channel through which these compensations encourage innovation is their positive effect on the risk-taking incentive (i.e., vega) rather than on the performance-based incentive (i.e., delta). Furthermore, they argue that the main way in which these compensations promote innovation is their positive influence on the risk-taking incentive (i.e., vega) rather than on the performance-based incentive (i.e., delta).

Upon delving deeper into the long-term compensation of CEOs, other streams of research reached opposing conclusions. For example, (Biggerstaff et al., 2019) use the implementation of FAS 123R as a quasi-natural experiment to investigate the relationship between option-based compensation and corporate innovation. Although they find a decline in CEO's long-term compensation, such a decline does not impact the level of patent applications around FAS 123R. These findings suggest that long-term incentives (i.e., option-based compensation) do not drive corporate innovation. In a similar spirit, (Koo et al., 2019) use a sample of 3281 granted patents and their citations over the period 1996–2005 to investigate whether lucky grants to CEOs impact firm innovations. The ‘lucky grant’ is a term used by (Bebchuk et al., 2010) to describe how CEOs leverage the opportunistic timing of stock option grants to increase their compensation—or stock options issued to CEOs when the price is low. They find that if CEOs receive lucky grants in the previous year, firm innovation decreases. Finally, the authors suggest that lucky grants may reduce the incentive for CEOs to engage in risky projects and negatively affect firm innovation.

Overall, the evidence on how long-term incentives negatively impact innovative firm activities remains surprisingly scant in the corporate finance literature. We conjecture that our main independent variable (NGPs) might have an effect on the CEO's long-term incentives, especially stock-based compensation, because it is more sensitive to risk (failures in our study) than other long-term incentive types, such as option-based compensation. If so, our result will then be consistent with the literature that argues that long-term incentives hinder corporate innovation. In sum, theory suggests that CEO compensation contracts suited for innovation should include two key features: they should provide a long-term commitment to the CEOs, and they should offer protection from failure. The above discussions mostly reveal a positive association between a CEO's long-term incentives and successful innovation. To date, however, relatively less attention has been devoted to understanding how innovation failures could impact the CEO's subsequent long-term incentives. To fill this void, we use a sample of 2,003 cases of NGPs from the USPTO for 256 US firms over the period 2001–2020 to investigate the correlation between failure in innovation and the CEO's subsequent long-term incentives (i.e., options, stock, and LTIP).

3. Hypotheses Development:

As demonstrated in the introduction section, failures in a firm innovation, measured by NGPs, might reduce the CEO's compensation package and, thus, the firm's R&D spending. In the following sections, we first introduce the dependent variable with our key independent variable—NGPs—for each hypothesis. We then propose our hypotheses in light of the relevant arguments in the literature.

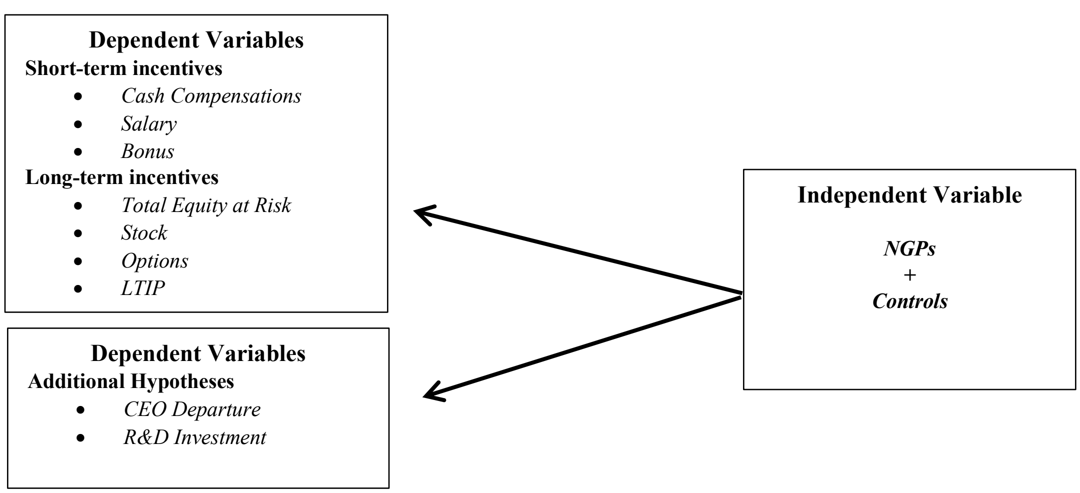

Fig. 2. The Impact of the Key Independent Variable on Two Groups of Dependent Variables.

3.1 CEOs Compensation Packages and Firm's Failure in Innovation

CEO compensation is directly under a firm's control and, hence, is critical in directing CEO behavior, particularly with regards to innovation activity. In fact, the CEO's compensation package is most closely linked with performance, and the future compensation of a CEO is also tied to this relationship. Prior studies have focused on the effects of successful innovation on CEO compensation while ignoring the potential impacts of failures in innovation. This omission is critical if differences in the results of innovation help to determine the future CEO's compensation package. A long tradition of empirical studies has established only one side of this fact, the effects of success in innovation. In the current study, we are more interested in failures than success in innovation, especially at the "firm level".

Based on the structure of the BoardEx database, the compensation package of a CEO is composed of two main parts: First, short-term incentives (STIs) are the total cash compensations—the sum of salary and bonus. Second, the total equity at risk—the sum of the stocks, options, and the long-term incentive payment (LTIP)—indicates long-term incentives (LTIs). We focus on these two main measures of compensation and each of their components separately. We further compute other dependent variables, including the total stock and option (the sum of stock and options), long-and short-term incentives (the sum of bonus and LTIP), and CEO total remunerations (the sum of cash compensation and equity at risk). The Appendix B-Level 1 and 2 includes all of the hypotheses, models, and regression results for the last three variables that we calculated.

3.1.1 CEO Short-Term Incentives and Non-Granted Patents NGPs

In this section, we discuss the potential effects of NGPs on the subsequent changes of the CEO's cash compensation. We will also discuss how NGPs may directly affect changes in the other components of the CEO's cash compensation. In general, CEOs consider the advantages and disadvantages of innovative activity. Hence, they involve in such activity only when they expect the personal profits will be mora than the losses. Their expected losses of innovation include failure and its potential negative impact on their future short-term compensations and, thus, the CEO total remuneration. The potential negative impact of innovation failure on the CEO short-term compensations is due to the fact that, according to (Cheng, 2004), CEOs consider R&D

investment, which is the key factor to firm's innovation, as less favorable compared to other investments, in terms of the influence of investments on short-term compensations. As a result, R&D investment may not fully reflect the "current benefits" of CEO's cash compensations. Therefore, CEOs concerned with a decline in their cash compensations may reduce the firm's R&D investment, which is entirely under their control, to increase investments with benefits fully reflected in their current cash compensations. Moreover, CEOs may prefer not to engage in risky and potentially disruptive R&D projects that have a negative short-term effect on their compensation (Faleye et al., 2014; Coles et al., 2006). This preference from CEOs is seemingly consistent with empirical results that R&D investment may not necessarily represent its potential outcome (Atanassov, 2013). In a similar vein, (Jensen, 1993) suggests that increased R&D can simply reflect managerial spending on domestic and/or more ordinary projects rather than significant investments in corporate innovation. Because risky R&D investments can negatively impact CEOs short-term compensations, CEOs with this preference are likely to less invest in R&D in order to avoid any potential reduction in their "future benefits". However, this could ultimately lead to failures in firms' innovation, as success innovation requires a high R&D investment.

In addition, salary is an important portion of CEO's cash compensation and represents the fixed and relatively riskless portion of CEO's total remuneration (Cohen et al., 2013; Healy, 1985). According to (Murphy, 1999), the CEO's compensation often includes a guaranteed minimum increase in base salary over a five-year period. Similarly, the annual bonus is a significant component of a CEO's compensation (Holthausen et al., 1995). In fact, firms reward their CEOs with annual bonuses to maintain their focus on financial outcomes under extreme time pressures. R&D-intensive firms, for example, are more likely than others to use higher bonus-to-base pay ratios to direct CEOs attention toward the innovation outcome (Makri et al., 2006). Therefore, from a BoDs perspective, using innovation outcomes to prompt bonuses for a CEO may be a better option in the short term than other monitoring factors, since bonuses are less ambiguous and more controllable by BoDs. Following the method of previous studies (Gormley et al., 2013; Manso, 2011; Brick et al., 2006; Guay, 1999) we focus on changes in cash compensation variable and its components (i.e., salary and bonus) to examine their potential negative correlations with NGPs. While these prior studies aggregate salary and bonus into one category, we test salary and bonus separately.

In sum, prior studies have recognized the importance of successful innovation and its impact on determining the CEO’s short-term incentives, but they have neglected the potential effects of failure in innovation. We have collected data on firm-level of 2,003 cases of unsuccessful patents for 256 firms, which makes it possible to examine the potential impact of firm's failure in innovation on the CEO’s compensation packages. More precise, our hypotheses of compensations are based on the following argument: if the CEO's compensation package is determined based on the expected profits of the firm's innovation success (i.e., outcome-based compensation), where firms are active in innovative activity, then failures in innovation could have a negative effect on the CEO's short-term compensation. In other words, a negative correlation between NGPs and changes in CEO’s cash compensation may result in a reduction in all other components of short-term incentives, which, in turn, may discourage CEO to innovate. Therefore, the above argument leads to the first set of hypotheses:

H1: *The firm's failure to innovate in the form of NGPs at time (t) is negatively related to the change that occurred in the CEO’s total cash compensation, CEO’s salary, and CEO’s bonus all at time (t+1).*

3.1.2 CEO Long-Term Incentives and Non-Granted Patents NGPs

In this section, we turn our attention to address the CEO's long-term incentives (i.e., total equity at risk) based on how BoardEx, the database we use, has structured them. In specific, we follow the method of (Borisova et al., 2018) to examine the association between changes in the CEO's total equity at risk and NGPs. For the purpose of this study, we test each component of the total equity at risk separately (i.e., stock, options, and LTIP). We expect that each incentive component, which is a portion of the CEO’s total remuneration, will show a negative correlation with NGPs, specifically, stock compensation. According to (Core et al., 2003) and others, CEO's incentives come almost entirely from changes in the CEO's stocks and options. From a CEO perspective, however, obtaining these incentives requires a long-term contract. (Manso, 2011; Holmstrom, 1989) suggests that to encourage CEOs to invest in the exploration of new ideas rather than exploiting existing ones, incentive contracts should assure a long-term commitment (that is a three- to five-year contract) and protection from failure. Investing in R&D for innovation, for example, does not necessarily imply that CEOs have invested in a novel idea or that the investment will result in a successful innovation. Therefore, as innovation is long-term, unpredictable, idiosyncratic, and involves a high probability of failure, the CEOs may pass up innovative ideas for less risky projects to maximize their own benefits.

Nevertheless, (Manson, 2011) further argue that incentive contracts that encourage CEOs to innovate should have a high tolerance for failure. That is because if a CEO is penalized for innovation failure, he/she faces consequences that extend beyond the short-term incentives to include the long-term incentives. They might also lose motivation to engage in future innovation endeavors. Building on Manso, we intend to explore this relationship between firms' innovation failures and the changes in their CEOs' long-term incentives. Several studies (e.g., Mazouz et al., 2019; Shen et al., 2018; Laux, 2015; Gopalan et al., 2014; Yanadori et al., 2006), however, have noted the positive relationship between firms success in innovation (patents granted and citations) and the long-term incentive-based compensation. For instance, (Lerner et al., 2007) indicate that more long-term incentives are associated with more patent awards and more heavily cited patents. (Francis et al., 2010) show a positive relationship between the CEO long-term incentives and firm innovative activities (R&D, patents granted, etc.). In a similar spirit, (Manso, 2011) argues that the use of stock-based compensation provides CEOs with the necessary incentives to invest in innovation. (Chang et al, 2015) corroborate these findings from empirical study by examining the relation between option incentives, as a crucial component of long-term compensation, and patents granted. They find that patents activity drives by option-based compensation.

However, we argue that this only applies to a CEO who receives full protection from failures. In other words, a CEO with a long-term incentive-based compensation and a high level of protection would likely be less concerned with being fired—and, hence, less concerned about failures. In this context, (Baranchuk et al, 2014; Ederer et al., 2013) examine whether the combination of tolerance for failure and rewards for long-term success prompts the CEO to adopt more innovative paths for the firm. They suggest that firms wishing to pursue innovation and obtain patents should offer their CEOs more incentive compensation and more protection from early termination. The idea that "tolerance for failure" boosts firm innovation activities is also supported by the evidence in (Tian et al., 2014). Taken together, these outcomes seem to suggest that such combination enhances CEOs to exert more effort for firm innovation over the long run. Missing from our study, though, is any consideration that these characteristics of the long-term incentives may play complementary roles in motivating CEOs to pursue innovative activities. This is because complementarity is critical when it comes to the CEO's long-term incentives.

In short, in the previous section (3.1.1), we predict that a negative correlation between NGPs and changes in the CEO's cash compensation may result in a reduction in all other components of short-term incentives. That is based on the argument: if the CEO's compensation package is determined based on the expected profits of the firm's innovation success (i.e., outcome-based compensation), where firms are active in innovative activity, then failures in innovation could have a negative effect on the CEO's short-term compensation. Consistent with this argument, CEOs may receive lower equity-based compensation in the year following NGPs than the year before. To clarify, a negative correlation between NGPs and changes in the total equity at risk may lead to a decrease in all other components of long-term incentives (i.e., stock, options, and LTIP). The same arguments also hold for changes in CEO total remuneration, total stocks and options, and short-and-long-term incentives (which we do not present here for brevity). Based on our testable argument and relevant literature, we can hypothesize:

H2: *The firm's failure to innovate in the form of NGPs at time (t) is negatively related to the CEO's total equity at risk change, CEO's stock-based compensation change, CEO's option-based compensation change, and CEO's long-term incentive plan LTIP change that occurred at time (t+1).*

3.2 CEO Departure and Firm's Failure in Innovation:

Our data indicates that almost 24% of all firms' CEOs (i.e., 95 out of 401) departed after the year of NGPs, while 76% (i.e., 306 out of 401) were renewed their positions. Such observation was interesting and motivated us to examine whether the CEO's departure is correlated with the firm's failure in innovation. We also dug into this observation further by looking at the reasons for the CEOs departures. Since the databases we use do not include all the relevant details on CEOs' departures, we manually collected the missing information using annual reports, proxy statements, and SEC Form 10-K for US companies, as well as corporate websites. The logic behind this collection is to identify a direct link, if any, between the effect of NGPs and the reasons of a CEO's departure so that we can suggest some directions for future research and theory building. We observe that *resignation* was the main reason for 70% of CEOs who left their positions in the year after NGPs (i.e., 67/95); 27% went for retirement (i.e., 26/95); and 2 died.

Moreover, based on our data set, three additional observations are worth mentioning regarding to the above two main reasons for the CEOs' departures. First, in the event of the CEO's retirement, mainly due to aging or stumbling, the successor typically offered a long-term contract—that is, a three-year contract, and the retried CEO is expected to notify the board of directors (BoDs) of his decision to retire a year or two years earlier. Previous studies (e.g., Dechow et al., 1991) show a negative relationship between CEOs close to retirement and firm's innovation activity, measured by R&D expenditures. (Xu et al., 2014) proves this finding by examine the impact of CEO retirement on corporate innovation, measured by patents and citations. They show that firms obtain a few granted patents at the end of CEO tenures, and these patents obtain fewer subsequent citations. Moreover, the newly hired CEO to "succeed the retired CEO", in most cases, is from outside the firm. Such replacement often does not have a significant impact on the firm's innovation activity in the long run, as the firm has sufficient time to appoint the most qualified successor before the CEO departs (Dechow et al., 1991). Under this process, decision-making authority is progressively passed to the successor in the years before the CEO changes. The retired CEO, then, has less power to alter the firm's innovation strategy since the succeeding CEO shares many of the decision-making rights and has motives to control the retired CEO's decisions.

Second, in the event of the CEO's resignation, the BoDs typically appoints an interim CEO with a short-term contract—that is, a one-year contract or less. That interim successor CEO is most likely an internal member of the BoDs, and their tenure as CEO might be extended if they show good performance. This is especially true because, from an overall perspective, hiring an external CEO is more costly than appointing an internal CEO who is also a member of the BoDs, is expected to be aware of the firm's innovation strategy, and strives to avoid prior failures. In an empirical study, (Balsmeier et al., 2015) compare the innovative behavior of CEOs hired from inside and outside the firm. They report that inside CEOs are associated with significant higher innovative activity compared with their outside hired colleagues. (Cummings et al., 2018) also asserted that a firm's innovation decays under external CEOs relative to that of internal CEOs. Conversely, research by (Wong et al., 2018) shows that, because of their diverse backgrounds and networks, external CEOs in family firms have more innovative value than the internal. (Atallah et al., 2021) show that firms have a higher innovative activity with outside CEOs. It is somewhat surprising that we could not find many studies on the impact of external CEOs on firm's innovation. Nevertheless, in most cases, our data indicates that the BoDs hire new external CEOs on a long-term contract—that is, a three-year contract, rather than internal CEOs. This observation upheld the result of (Murphy et al., 2007), who find that more than one third of all CEOs are hired from outside the firm in the US.

Third, our data also indicates that there are some cases where firms hire CEOs with long-term contracts to replace their interim internal CEOs, even when they show good firm performance during their tenure. In fact, these interim internal CEOs often replace the CEOs with poor performance and their contracts basically on short-term. Yet, with considering the success of the interim CEOs with short tenure, such replacement could impact firm's innovation activity. Prior work (e.g., Lee et al., 2020; Ahuja et al., 2008;) document that previous CEOs are better managers of innovation than new CEOs and suggest that such a CEO replacement may have significant negative ramifications on firms' innovation performance. In the same vein, (e.g., Wu et al., 2005) examine the relationship between a CEO's time in office and firm inventive activities. They find that shorter tenured CEOs are more innovative than longer tenured CEOs. In contrast, (González-Uribe, 2017; Barker et al., 2002) report that longer tenured CEOs increase firm's innovation. (Cho et al., 2017) use data from 681 US firms and assert that CEOs with short tenures tend to produce fewer breakthrough innovations. In their empirical study, (Zona et al., 2016) examine the impact of CEOs tenures in different stages on firm's innovation and demonstrate that CEOs at the later stage decrease firm's innovation while CEOs at the early stage increase firm's innovation. Overall, two main debates are raised when comparing the innovative firm activities of internal CEOs with short-term contracts versus external CEOs with long-term contracts. From the BoDs point of view, the external CEOs with three-year contracts are more likely to bring new vital ideas and alter firm innovation strategy due to their presumably broader outside experiences. In contrast to internal CEOs, external CEOs might not have the critical firm-specific knowledge and skills required to manage the firm's innovation process, which could lead to a decrease in the firm's innovative activities. These arguments suggest there are complex trade-offs in selecting a CEO successor, as both have support in the literature. Therefore, it is not surprising that the empirical results on the comparison between internal and external CEOs are inconsistent.

In spite of that, we observe that resignation was the primary reason for the CEOs who departed their positions in the post-NGPs year. We build interpretations, that is, as a way to account for our observations. Therefore, the word "*resignation*" can be interpreted as firing or pursuing other interests. We interpret resignation as firing due to poor performance—since we try to analyze the effects of failures in innovation. However, we argue that this interpretation is limited to the unsuccessful outcomes (resignation following the innovation failures). With this in mind, we also argue that when the CEO of a firm is reluctant to engage in innovation activity or invests less than what would otherwise be, this may result in a high probability of failure in innovation. Such failures, consequently, may eventually lead the firm to replace its CEO, especially those with a high number of NGPs. Therefore, ceteris paribus, we formulate the following testable hypothesis:

H3: *The firm's number of NGPs has a negative impact on the CEO departures in the following year.*

3.3 Innovative Input, Output, and Failure in Innovation:

The existing literature on the input (i.e., R&D investments) and output (i.e., granted patents) of innovation can be divided into two streams. First, several studies investigate the effect of innovative input or output separately on different aspects of firm operations. On the innovative input side, R&D investment is one of the major sources of innovation (Zona et al., 2016; Hall et al., 2010) that drives a firm's long-term viability (Yu et al., 2016) and provides a significant contribution to firm's innovation (Dodgson et al 2008). At the same time, the innovation success of firms is mainly based on the level of investing in R&D, hence forcing them to invest heavily in R&D. From this point of view, R&D is always expected to have a positive impact on firms operations as validated by many studies (e.g., Rodríguez et al., 2016; Ehie et al., 2010; Kerr et al., 2008; Del Monte et al., 2003). For example. (Morbey, 1988) indicates a strong correlation between firm's R&D and performance after analysis of 800 US firms. Similarity (Eberhart et al., 2004, 2008) report significantly positive operating performance following substantial R&D raises. These studies suggest that R&D drives innovative firms as it allows them to establish efficient processes, cultivates new knowledge, create new products, and obtain more patents, which in return encourage firms to increase their future investment in R&D. Others (e.g., Cruz et al., 2013; Zhang et al., 2010) reveal that R&D expenditure includes the employment cost of R&D employees, such as salary, bonuses, and other allowances. More precise, R&D spending improves, indirectly, such payments in the long run, especially when firms obtain patents (Mao et al., 2018; Lerner et al., 2007; Makri et al., 2006). Therefore, R&D investment has always been at the center of debate among scholars in an attempt to boost innovation efforts. On the innovative output side, patents granted are typically found to have a positive effect on firm operations as they represent successful innovation that is protected from the possibility of being misappropriation (e.g., Maresch et al., 2016; Helmers et al., 2011; Czarnitzki et al., 2010; Kafouros et al., 2008; Mann et al., 2007; Bloom et al., 2002) . For example, (Helmers et al., 2010) find evidence of the positive impact of patenting on firm performance. (Ernst et al., 2001) examines the relationship between patent applications and subsequent changes of firm performance. He finds that patent applications positively affect firm sales for the period of 1984 to 1992. In the same vein, (Pandit et al., 2011) indicate that patents granted are positively related to the firm's operating performance. In addition, (Zhang et al., 2019) report a positive and significant relationship between granted patents and firm performance.

Second, there is yet another important research stream in the innovation literature (e.g., Hegde et al., 2023; Hunt, 2006) examine the relationship between innovative input and innovative output, and suggest that both are expected to have a positive impact on one another. For instance, (Faleye et al., 2014) show that firms invest more in R&D receive more and higher quality patents. Similarity (Farre-Mensa et al., 2020) show that successful applications (i.e., granted patents) foster firm's investment in R&D. Others investigate how firms expand their R&D abroad and whether this has an effect on the firms' number of patent. In fact, many firms internationalize their R&D activities to obtain new knowledge and capabilities available in other countries. In light of this, (Si et al., 2021; Penner et al., 2005) examine the international R&D activities and patent output and find that, only when firms have domestic R&D investments, foreign R&D has a positive impact on the firms' innovative output. Likewise, (Bertrand et al., 2013) study the differences between internal and offshore R&D (i.e., external R&D) and their impact on firm's innovation outputs. They find that absorptive capacity from internal R&D allows for more offshore R&D and leads to more positive innovative outputs. These studies also suggest that success in innovation, as measured by granted patents and citations, enhances firm's future investment in R&D. Accordingly, R&D appears to always have a positive effect on a firm's patents, since it is the most significant factor of innovation. However, not all innovations are eventually patented as no one can guarantee that a firm's investments in R&D will automatically result in successful innovation. This suggest that some of firm's R&D could turn to sunk costs. It is important to understand that the R&D experience of a firm is enriched by trial and error. Thus, R&D that generates failures in innovation should also have a positive impact on firm's patents because, in the long run, the firm will learn from its failures, gain more experience with the patent system, and become more innovative.

In short, it is typically that these two innovation activities are complementary—firms that conduct a lot of R&D tend to patent more. And ordinarily, reducing the investment in R&D will hinder more patents. Yet, if firms are active in their R&D, failures in obtaining patents may result in less R&D in the future. Overall, even though prior research reveals that R&D activities have a positive impact on firm's innovation success and vice versa, it is still ambiguous whether innovation failures (i.e., NGPs) affect firms to boost their R&D investment in the future. In other words, do firms strive to enrich their R&D experience, even when they face failures in innovative output, in order to become more familiar with the patent process and more creative in the future? We find no evidence in the relevant literature suggesting such link between failures in innovation at time *t* and R&D investments at time *t+1*. Moreover, we expect it to matter not just whether the firms attempt to innovate—and not just whether they generate more innovative output, but whether they are able to constantly invest in innovation while experiencing a decline in the number of granted patents. On this basis, firms engaging in R&D activities have to decide whether to pursue their R&D experience, depending on the availability of resources and capabilities, of course. This does not imply the elimination of R&D investments, due to firms' innovation failures, but rather "less R&D investments than would otherwise occur". These arguments lead us to propose the following hypothesis:

H4: *The firm's number of NGPs at time (t) is negatively related to the change that occurred in the firm's research and development R&D at time (t+1).*

4. Data Sources and Methodology:

The data set we established for our study is determined by the joint availability of data on the United States Patent and Trademark Office USPTO, the BoardEx database, and the North American Compustat database for the period of 2000-2020. Table 1 reports the sample size, sources, and other details on NGPs at the stage 1.

4.1.1 USPTO-PatEx – Non-Granted Patents NGPs

We start our sample selection procedure by focusing on NGPs based on the records of the US Patent and Trademark Office, Patent Examination Research Dataset (USPTO-PatEx).[4] PatEx data

[4] Available at https://www.uspto.gov/ip-policy/economic-research/research-datasets/patent-examination-research-dataset-public-pair

is formerly referred to as Public Patent Application Information Retrieval—Public PAIR data, which is a data source established by USPTO following the US Congress passing the American Inventors Protection Act (AIPA), 1999. AIPA does, however, have some implications that may affect PatEx users. In particular, the legislation dramatically increased the share of prior unpublished patent applications that became accessible after 2001 but also included "an opt-out provision", which means, in order to properly use this data, researchers need to be aware of the selectivity issues that this data contains. PatEx data was created by the USPTO in 2014 to provide information on US patents, patent applications, and their examination process, dating from the 1910 to present. Even though the USPTO updates and makes the PatEx data available, some categories of patents and patent applications—such as those that have not been awarded—were only released from 2001. In this study, we employ the latest version of PatEx (the 2022 release) which includes details that have not been disclosed in prior updates (that is in 2014 and 2019), including data on patent inventors (particularly for NGP applications).

We take a novel approach to collect our data on patents that have not been granted. However, it is not a simple matter to determine which patent is rejected, as thousands of patent applications are filed and issued annually by the USPTO. As (Lemley et al., 2008) mentioned that we cannot know exactly how many patents have been rejected by the USPTO in the past two decades. But knowing the process of the USPTO and what applicants are actually doing is a prerequisite to inform debate on this issue. By scrutinizing how patent applications are assigned to an examiner group in the USPTO and, eventually, assigned to individual patent examiners for search and examination, we first observe an ambiguity in both the examination process of patents and the applicants responses. We also observe duplicates in some definitions and descriptions in the PatEx file related to patent classifications, especially those that have not been granted. Therefore, we engaged in an intensive conversation with experts managing the USPTO-PatEx file, discussing all these issues. Further, we provide some suggestions regarding the initial and final decisions made by USPTO examiners, and recommend considering our suggestions in the future update of PatEx file, allowing researchers interested in collecting and analysis such data.

Rather than looking at all filings patents to gather the NGPs, we first establish a group of patent applications, which we then pursue through the process. In particular, as in the prior studies on innovation, our research concentrates only on utility patent applications, at the firm-level, which consist of approximately 90% of USPTO patent documents in recent years. We exclude patents from the other two types of USPTO data, plant and design applications, as well as patents applications owned by non-profit organizations, governments, and individuals. We also omit firms incorporated outside of the United States and firms with no stock price data. Next, disambiguation of firm names presents a major challenge, since patent documents are not required to contain the assignees (owners) of the patents. Prior work (e.g., Kline et al., 2019) indicate that approximately 50% of patent applications in USPTO are missing assignee names. We worked with the USPTO available data to fill in assignee names (i.e., owners/firms), not inventions, for our sample data of NGPs. We also follow the literature (e.g., Kline et al., 2019; Balsmeier, B et al., 2017; He, J.et al., 2013), and eventually assign a patent application to the *location* and *year* it was applied for. Following disambiguation, we only left with applications titled pending, abandoned, rejected, or withdrawn.

After that, we eliminate patents that are pending because they are being processed and may eventually be granted. We also ignore withdrawn patents that their applicants withdraw before receiving the first action from the examiner. Rejected patents that have not been abandoned (i.e., repeat application) by their owners will return to pendency, because USPTO applicants always have the right to appeal and claim that the examiners should re-evaluate their patent applications. Of course, the request must be approved by the examiner, and the applicant is required to pay an examination fee for each application filed, whether initial or repeat. If the examiner refuses the appeal, however, the final decision will be implemented. Such patents are also excluded from our final NGP sample (additional information is provided in the measure section). Then, we gathered patents that have gone through the examination process, abandoned by their owners, and received a final decision of rejection from the USPTO examiner between January 2001 and December 2020. Our final collected data, thus, contains 723 firm-year observations, with a total of 2,003 NGPs for 256 firms. Finally, the NGPs we collected are matched with other databases: ExecuComp, BoardEx and North American Compustat.

4.1.2 CEO Compensation Packages

Rather than using the ExecuComp database to collect information on the US CEO compensation package, we use the BoardEx database—compiled by Management Diagnostics Limited, which is a private research company specializing in gathering and disseminating information on company officials of public and private companies in many countries, including the US—for two reasons. First, BoardEx indicates more observations than ExecuComp when we separately merge them with the USPTO data (the merge section below provides more details). Second, we find that the BoardEx approach is more useful than ExecuComp for collecting and classifying the missing data. In unreported results with the first match between USPTO and compensation data from the two databases, we find that measuring compensation for US CEOs using BoardEx rather than ExecuComp supports the main findings of our study. More importantly, BoardEx includes detailed data on various components of CEO compensation—including salary, bonus, cash compensation, option, stock, and other long-term payments. BoardEx not only contains data on CEO compensation but also provides comprehensive biographic information on CEOs and other executives for many countries, even those without obligatory regulations for disclosing CEO compensation. BoardEx started collecting data in 1999 and began gathering information on US companies in 2003. In 2005, however, BoardEx's sample of US firms dramatically increased to cover US public companies prior to 2003 and add new companies. Currently, BoardEx database contains information on US companies for more than 20 years. As mentioned earlier, however, when we merged our USPTO data with BoardEx, we missed many observations on the compensation packages of US companies (more details below in the merge section). To supplement the BoardEx data, we manually collect the missing data using annual reports, proxy statements, and SEC Form 10-K for US companies, as well as corporate websites. As shown in Table 1, Panel A, 512 firm-year observations with manually gathered data are included in our final sample, which consists of 723 firm-year observations on 256 firms for the period 2000–2020.

4.1.3 Firm Characteristics

We obtain firm-level financial data from COMPUSTAT database, which is the primary source of accounting data on American corporations. Yet, some firms in our main NGPs data from the USPTO-PatEx file lack financial information from the Compustat database, such as R&D, age, sale, and other firm-specific variables. To complete the financial data, we gather it manually using annual reports, proxy statements, and SEC Form 10-K for US companies, as well as corporate websites. Our unique hand-collected dataset on U.S firms enables us to investigate the potential effect of NGPs on CEO compensation. Table 1, Panel A provides information on the missing and collecting financial variables.

4.1.4 Merging Data

To merge our final sample of 723 firm-year observations of USPTO data with the compensation and financial databases, we use a method of matching the GVKEY and CUSIP codes, as well as company names. We manually review these identifiers to verify the accuracy of the match. We also conduct online searches when the names are not exactly the same, and we only include the observation if we are confident that the names match. Following this procedure, we first merge the NGPs data we collect from the USPTO-PatEx with the CEO compensation data from the ExecuComp database. We, initially, consider the match of eight components that cover the short- and long-term compensation package: salary, bonus, cash compensation (salary + bonus), option, stock, other long-term incentives LTIP, and total equity at risk (option, stock, LTIP), as well as the total CEO remuneration. We later compute other dependent variables, including total stock and option (TST&TOP) and long-and short-term incentives (LT&ST), as well as other incentives for CEOs.

This method obtains a sample of 169 firm-year observations, of which 554 firm-year observations are missing in ExecuComp. Then, we apply the BoardEx database to improve the CEO compensation data. Although we could not match all the firm-year observations of our USPTO data, BoardEx shows slightly better match results than ExecuComp. The result increases the sample of CEO compensations to include 211 firm-year observations and decreases the number of missing data to 512. After a manual review of the observations we obtained from the two databases, we find that the BoardEx outcomes cover almost all of the observations from the ExecuComp. We further look at the Bloomberg database, but the variables we need to investigate are not classified as BoardEx databases. Therefore, we rely on BoardEx and its approach for obtaining the missing data of compensation packages consistent with the prior research (see, for example, Borisova et al., 2018; Fernandes et al., 2013; Fracassi et al., 2012). After that we merge the above sample of USPTO unsuccessful patents and BoardEx compensation packages with the financial data from COMPUSTAT for the control variables. This results in a total sample of 407 firm-year observations, of which 316 firm-year observations being missing. Finally, we manually collect the missing observations on both compensation package and financial data, such as salary, bonus, cash compensations, options, stocks, total compensation, R&D expenditure, total assets, and other related variables. We use annual reports, proxy statements, and SEC Form 10-K for the firms with missing information. However, we face difficulties in extracting certain information about CEO’s compensation package of many companies, including the restricted and unrestricted stocks and exercisable and unexercisable options, as they do not disclose such information. Thus, the option and stock variables we consider in our sample are the annual totals. Our final sample represents only firm-year observations where data for all variables included in the analysis are available between 2001 and 2020. In Panel B of Table 1, we present the yearly distribution of our final sample. We also follow the extant literature to include a number of control variables—such as firm size, R&D, firm age, market value, CEO age, and others—that may interact with data quality and affect the study’s outcomes.

In summary, due to the fact that USPTO database does not provide information on patents that have not been awarded prior to 2001 and the time lag before applicants receive a final decision on whether or not their patents grant (3–5 years), this results in significantly truncated data for NGPs. We recognize, thus, that our sample from USPTO between 2001 and 2020 may not cover the most cases of NGPs at the firm level. This is actually in line with prior studies (see, for example, Hegde et al., 2018) on the required disclosure of inventions to the public, whether or not been granted. Likewise, ExecuComp and BoardEx do not include data on all US public firms between 2000 and 2020, leading to a lack of information on many CEOs compensation packages in our sample of firms with NGPs. ExecuComp, for instance, only covers firms that are listed on Standard & Poor's (S&P) 1500, which comprises firms listed on the S&P 500, S&P 400 Mid-Cap, and S&P 600 Small-Cap. Nevertheless, after the manual collection, our final sample seems to be reasonably comprehensive.

Table 1: Sample and Distribution

Panel A: Sample Distribution by Year, Observation, and number of NGP
This table displays all firm year-observations in our sample (including the missing variables of compensation packages and financial data) and USPTO NGPs per year using period from 2000 to 2020.

Year	Observations	Percentage %	N	Percentage %	Databases
2000	20	0.0276	90	0.0449	USPTO + BoardEx + Compustat
2001	33	0.0456	137	0.0683	USPTO + BoardEx + Compustat
2002	33	0.0456	174	0.0868	USPTO + BoardEx + Compustat
2003	30	0.0414	159	0.0793	USPTO + BoardEx + Compustat
2004	45	0.0622	152	0.0758	USPTO + BoardEx + Compustat
2005	52	0.0719	140	0.0698	USPTO + BoardEx + Compustat
2006	44	0.0608	119	0.0594	USPTO + BoardEx + Compustat
2007	54	0.0746	135	0.0673	USPTO + BoardEx + Compustat
2008	37	0.0511	125	0.0624	USPTO + BoardEx + Compustat
2009	35	0.0484	100	0.0499	USPTO + BoardEx + Compustat
2010	31	0.0428	87	0.0434	USPTO + BoardEx + Compustat
2011	36	0.0497	94	0.0469	USPTO + BoardEx + Compustat
2012	39	0.0539	81	0.0404	USPTO + BoardEx + Compustat
2013	30	0.0414	57	0.0284	USPTO + BoardEx + Compustat
2014	26	0.0359	56	0.0279	USPTO + BoardEx + Compustat
2015	31	0.0428	63	0.0314	USPTO + BoardEx + Compustat
2016	29	0.0401	46	0.0229	USPTO + BoardEx + Compustat
2017	32	0.0442	62	0.0309	USPTO + BoardEx + Compustat
2018	26	0.0359	32	0.0159	USPTO + BoardEx + Compustat
2019	41	0.0567	61	0.0304	USPTO + BoardEx + Compustat
2020	19	0.0262	33	0.0164	USPTO + BoardEx + Compustat
Total	**723**	**100%**	**2,003**	**100%**	USPTO + BoardEx + Compustat

Note: The highest number of observations occurred when the financial crisis hit in the winter of 2007 and continued in 2008. However, comparing the three years prior to and following the 2007 financial crisis, we observe that the number of observations was reduced. Additionally, the number of NGPs was also mitigated in the subsequent years of 2007. Some prior studies on unsuccessful patents end their samples in 2006 to avoid having their results affected by the financial crisis. Our results, however, remain unaffected when we include the years subsequent to 2007. Likewise, the lowest number of both observations and NGPs (19 and 33) happened during the COVID-19 pandemic, which began in late 2019 and early 2020. Taken together, we reveal an interesting twofold reason for such a reduction "when crises occur": (1) USPTO's examiners may accelerate the level of the patenting process; and (2), more importantly, grant more patents at the firm level in order to boost innovation activities and, eventually, revive the economy.

Panel B: Frequency Distribution of NGPs Sequence Number with Year Observations

The table shows the serial number of NGPs, firm year-observations, total number of NGPs for firm year-observations, and its percentage of the 2,003 total in our sample. The most frequent number of NGPs in our sample is 1, which has 480 firm year-observations and 480 unsuccessful patents that have received a final decision from the USPTO's examiners. This number constitutes 24% of the 2,003 NGPs total. Number 2 is next, with 106 firm year-observations and 212 NGPs, which accounts for almost 11% of the 2,003 NGPs. Firms with 11 NGPs, in contrast, have the lowest NGP total—only one firm year-observation and 0.5% of the total 2,003 NGPs; followed by firms with 12 NGPs, which have one firm year-observation and 0.6% of the total 2,003 NGPs.

Serial Number of NGPs	Firm Year-Obs	N	Percentage %
1	480	480	0.2396
2	106	212	0.1058
3	29	87	0.0434
4	30	120	0.0599
5	22	110	0.0549
6	5	30	0.0149
7	12	84	0.0419
8	8	64	0.0319
9	8	72	0.0359
10	2	20	0.0099
11	1	11	0.0054
12	1	12	0.0059
13	2	26	0.0129
14	1	14	0.0069
15	1	15	0.0074
16	1	16	0.0079
17	1	17	0.0084
18	1	18	0.0089
19	1	19	0.0094
21	1	21	0.0104
22	1	22	0.0109
27	1	27	0.0134
30	1	30	0.0149
34	1	34	0.0169
36	1	36	0.0179
57	1	57	0.0284
65	1	65	0.0324
73	1	73	0.0364
101	1	101	0.0504
110	1	110	0.0549
Total	**723**	**2,003**	**100%**

Descriptions of variables

Table 2: This table describes some variables with short names. All variables are in logarithms except for CEO Dep. Appendix A includes all variables definition.

Variable	Description	Database
NGPs	Non-granted patents from the USPTO-PatEx	USPTO
Cash.Comp	Total cash compensation (salary + bonus)	BoardEx
TotAtRisk	Total compensation at risk (stock, option, and long-term incentive pay)	BoardEx
LTIP	Long-term incentive payment (restricted stocks + unvested option)	BoardEx
STIP	Short-term incentive payment (bonuses)	BoardEx
TST&TOP	Total stock and option	BoardEx
LT&ST	Long-term and short-term compensation	BoardEx
CEO Total.Rem	Total CEO remuneration (cash compensation + total at risk)	BoardEx
CEO Dep	CEO departures (i.e., CEO with a renewed position after the NGP event)	BoardEx
R&D	Firm investments in Research and development	Compustat
ROA	Return on asset	Compustat
ROE	Return on stock	Compustat
ROI	Return on investment	Compustat
MV	Market value	Compustat

Table 1, Panel A displays all the firm year observations, databases, and the number of NGPs from the USPTO along with their yearly percentages from 2000 to 2020. Some observations of pay packages and financial data are missing. As we demonstrated in Section 4.1, we start with the USPTO-PatEx database to gather NGPs from 2000 to 2020. Then, we merge it with Execucomp and BoardEx for connection data. The BoardEx data provides more observations of CEO compensation than Execucomp. After that, we merge USPTO and BoardEx with Compustat for the control variables. Next, we manually collect the missing observation variables from annual reports, proxy statements, and SEC Form 10-K, following the BoardEx database structure. Finally, our final sample contains 723 firm-year observations for NGPs, CEO compensation, and financial data from 2000 to 2020.

Table 2 lists the names, data sources, and a brief description of some of the variables we used in the study. Each variable is represented on a logarithmic scale to solve the skewed problem. We provided further detail on these variables in the hypotheses development section. We also include three variables, which we computed specifically for the CEO compensation model, in the Appendix, as they do not provide evidence to support our hypotheses. These variables are the total CEO's stock and option, long-term and short-term compensation, and the total CEO's remuneration.

4.2 Measures:

4.2.1 Dependent variables: CEO Compensation Packages:

Our sample consists of 256 US publicly traded firms, provided by the USPTO database, with CEO compensation data tracked in BoardEx. In the two stages of analysis, we follow the prior work (e.g., Hung et al., 2019; Borisova et al., 2018; Fernandes et al., 2013) to investigate the change in the two main variables of CEO total remuneration package (CEO TotRem) in BoardEx: first, the short-term compensation, including base salary and bonus, which is measured by ΔCEO cash compensation. This measure represents the change in the CEO's cash compensation in the year following the NGPs. Then, we split the short-term compensation to look at the changes in salary and bonus, as both together constitute the overall cash compensation. Second, the long-term incentive (i.e., stocks, options, and the long-term incentive plan LTIP) is measured by ΔCEO total equity at risk, which represents the change in the CEO's long-term incentives subsequent to the occurrence of NGPs. Further, separate tests are conducted on each of the three components that form this variable. We also calculate the CEO total remuneration (CEO Total.Rem) by adding the CEO's annual short- and long-term income (cash compensation + total at risk). Each of these components in the two main variables is a ratio of the CEO total remuneration. In addition, we calculate and run three other variables besides the above eight components of compensation: the total stock and option TST&TOP and the long- and short-term incentives LT&ST (total remuneration - salary), as well as other payments for CEOs, as indicated in each of the sample firm's annual reports (Appendix A presents the definitions of all these variables, while Appendix B—Levels 1 and 2—contains the results of the last four variables: CEO Total.Rem, TST&TOP, LT&ST, and others, which are not reported for brevity). We employ the logarithmic transformation in the CEO compensations to mitigate the impact of outliers and use the first change as our dependent variable in both short- and long-term CEO compensation, each as a ratio of the total CEO remuneration package (Δl-r-compensations).

4.2.2 Independent variables: Innovation Failures:

The core of our data set is patents that have eventuality not been granted, obtained from PatEx file in the USPTO database. As we stated earlier that determining which patent is rejected in order to measure failure in innovative activity at firm-level is not a simple matter. In fact, the applicant always has the option to go back and request the USPTO examiner reconsider her patent application; if the examiner approves, the application becomes pending rather than refused. Therefore, it can be difficult to distinguish between pending patents, whether initial or repeat, and patents that are finally rejected. We managed to determine not pending patents but rejected patents in order to construct a key measure for failure in innovation, which we named NGPs—that is, the total number of patents that are "ultimately denied" and abandoned by their owners (i.e., firms in our sample). In other word, this measure captures the quantity of "unsuccessful innovation output" of a firm *i* in year *t*, and is based on the update of PatEx database that consists detailed information of all USPTO-NGPs. In the current research, we employ the 2022 version, which is the most recent PatEx update. Since the distribution of NGPs is skewed, we also use the natural logarithm to reduce the skewness in our regressions (l-NGPs).

A few issues about our measure of failure in innovation, NGPs, deserve further reminder. First, using USPTO data to measure firm innovation activities, particularly patents that have not been granted, has been adopted in some previous studies (e.g., Farre-Mensa et al., 2020; Kline et al., 2019; Balsmeier, B et al., 2017; He, J. J., et al., 2013; Lemley et al., 2008; Basmann et al., 2007). Under the territorial principle in US patent laws, individuals who seek to claim exclusive rights over their inventions must file US patent applications. Following earlier studies (e.g., Hsu et al., 2014), we assume that all important inventions have been filed to and evaluated by the USPTO, as the US has been the world's largest market for technology consumption in recent decades. Second, we do not include individuals, governments, or non-profit organizations, rather, we only focus on firm-level data because it is more valuable than other types of data.

Third, all pending patents—initial or repeat—are not included in our sample. The vast majority of repeat applications, for which their applicants decided to restart the examination process, have already received a final decision, yet their owners (i.e., firms) have not abandoned them, so they remain eligible for future grants. They fall into one of two categories: requests for continued examination (RCEs), which are essentially extensions of the same application, and continuation applications, considered a new application. Prior work (e.g., Sampat et al., 2010) emphasize that RCEs are useful in pursuing arguments with an examiner who is hesitant to approve a patent, and find that 57% of repeat applications were RCEs. Others (Frakes et al., 2015) show that 63% of repeat applications are filed with RCEs. Both groups, however, used for the same purpose:

restarting the examination process of a "refused patent application". Finally, we assign NGPs to their owners (i.e., firms) instead of inventors because our goal is to measure the failure in innovative activities for US firms. Doing so eliminates any potential sampling bias because some firms in the USPTO own a larger pool of patent applications, whether awarded, rejected, or pending, than others..

4.2.3 Control variables:

Following the prior literature (Balsmeier et al., 2017; Kung et al., 2015; Fang et al., 2014; Atanassov, 2013; Welch et al., 2011; Makri et al., 2006), we control for several firm and CEO characteristics that could confound the relationship between a firm's innovative unsuccess and its performance and CEO compensation packages. We compute all variables for firm *i* over its fiscal year *t*. In particular, we include *firm size* (log of a firm's book total assets), *research and development* (ratio of firms' R&D to total book assets), and *leverage* (total debt to total assets). We also control for *firm age* (the number of years since the initial public offering IPO date), as older firms may look in older technological areas, and *market value* (the annual close price x the total number of outstanding shares). Moreover, firm performance, as proxied by returns on assets *ROA*, returns on equities *ROE*, and returns on investments *ROI*, enters a few regressions (e.g., the regressions of CEO departures and R&D) to control for differences in profitability. In the finance literature on innovative activities, these performance variables are frequently used as controls. We employ a logarithmic transformation for the above control variables to account for the skewness of the distribution.

In addition to firm-specific variables, three variables are used to capture CEO-specific characteristics. Specifically, following (Islam et al., 2020; Cao et al., 2019; Mao et al., 2018), we control for *CEO age*, *CEO tenure*, and *CEO's gender* (male or female sex scaled by percentage) because these variables can potentially impact our regression results. Finally, various other controls have sometimes been used in our study. We find, however, that such controls are not statistically significant and have little impact on our results, thus, we do not include them for brevity.

Table 3: Descriptive Statistics – Level 1. This table displays summary statistics for the key variables for a sample of all 256 US firms from 2000 to 2020 consist of 723 firm-year observations. For each variable, the mean, median, standard deviation, and number of year-observations are also displayed in the table. The CEO compensation-related variables are reported in US dollars (000s). The description of all variables is given under the table and in Appendix A. Data source: Own calculation based on BoardEx database.

Variables	Number	Mean	Median	Standard Deviation
Panel A: **Failure in Innovative**				
NGPs	723 Y-Obs	0.445	1.000	0.778
Panel B: **CEO Compensation Package**				
Sohrt-Term Components: **($ thousands)**				
Δ Cash.Comp	723 Y-Obs	-1.351	-1.252	1.790
Δ Salary	723 Y-Obs	-1.540	-1.456	1.792
Δ Bonus	723 Y-Obs	-2.306	-2.853	2.081
Long-Term Components: **($ thousands)**				
Δ TotAtRisk	723 Y-Obs	-0.420	-0.360	1.711
Δ Stock	723 Y-Obs	-11.141	-11.453	3.216
Δ Option	723 Y-Obs	-1.292	-1.336	2.094
Δ LTIPs	705 Y-Obs	-1.303	-1.357	2.027
Panel C: **Firm Characteristics**				
Δ ROA	723 Y-Obs	0.773	0.013	8.605
Δ ROE	723 Y-Obs	-3.449	-3.279	3.055
Δ ROI	723 Y-Obs	8.678	9.435	1.659
Panel D: **CEO Characteristics**				
CEO age	723 Y-Obs	52.733	53.000	8.203
CEO stays one year after NGPs – binary	723 Y-Obs	0.869	1.000	0.338
Panel E: **Controls**				
Δ R&D	723 Y-Obs	3.942	4.205	2.889
Leverage	723 Y-Obs	- 4.338	- 4.258	3.034
Size	723 Y-Obs	6.324	6.369	3.193
Firm Age	723 Y-Obs	2.533	2.708	0.959
MV	723 Y-Obs	13.347	13.726	3.667
R&D	723 Y-Obs	3.916	4.130	2.869

Note: Variable Definitions: *NGPs* = patent applications that are submitted to the USPTO and ultimately rejected by USPTO examiners. *Cash.Comp$* = natural logarithm for the sum of CEO's salary and bonus. *Salary$*= natural logarithm for the CEO's salary. *Bonus* = natural logarithm for CEO's *bonus$*. *TotAtRisk$* = natural logarithm of the CEO's total compensation at risk (i.e., the sum of stock, option, and LTIP). *Stock$* = natural logarithm of the CEO's stock-based compensation. *Option$* = natural logarithm of the CEO's option-based compensation. *LTIPs$* = natural logarithm of the CEO's long-term incentive payment (i.e., restricted stocks + unvested option). *ROA* = natural logarithm of the return on assets divided by total assets. *ROE* = natural logarithm of the return on equities divided by total equities. *ROI* = natural logarithm of the return on investments divided by total invested capital x 100. *CEO age* = the age of the CEO of a firm. *CEO tenure* = the number of years the CEOs have been in the chief executive position at the current firm. *CEO gender* = male or female sex scaled by percentage. *R&D* = natural logarithm of the change in research and development. *Leverage* = natural logarithm of the total debt to total assets. *Size* = natural logarithm of a firm's book total assets. Firm age = natural logarithm of the number of years since the IPO date. *MV* = the annual close price x the total number of outstanding shares. R&D = natural logarithm in research and development at time *t*. Results using total stock and option, long-and-short-term incentives, other payments, and total CEO remuneration as dependent variables indicate a positive or insignificant correlation with NGPs. These results are not reported for brevity. We also separately computed total stock and option (TST+TOP), long and short incentives (LT+ST), and other CEO's compensations as dependent variables. NGPs, however, have insignificant effects on each of these variables.

Table 4: CEO sample for two-stages

Panel A: Period of observations

Table 4 presents firm year-observations for CEOs who remain and those who departed when NGPs occurred, as well as other CEO's characteristics between 2000 and 2020.

Three-Year Contract	Status	Data
Firm-Year Observation	723	USPTO + BoardEx + Compustat
Total CEOs	401	USPTO + BoardEx + Compustat
CEOs left after NGP	95	USPTO + BoardEx + Compustat
CEOs stay after NGP	306	USPTO + BoardEx + Compustat
CEO average age	52	USPTO + BoardEx + Compustat
CEO male %	100%	USPTO + BoardEx + Compustat
CEO nationality	U.S.A	USPTO + BoardEx + Compustat

Note: First, we run all of our models using the whole dataset, which consists of 723 firm year-observations, including all of the CEOs in our sample. Then, we exclude those who departed after the occurrence of the NGPs, and run the models with 628 firm year-observations.

Table 3 provides a breakdown of the summary statistics for failure in innovation, CEO compensation package, firm performance, CEO characteristics, firm characteristics, and other variables from the final sample. Panel A shows that, on average, the firm has one NGP. As previously mentioned in the introduction section, we have gathered 2,003 instances of NGPs from 256 US firms. All these firms have faced failures in innovation, and some have not received any patents at all. Turning to Panel B, the changes on CEO's short-term incentives (i.e., cash compensation, salary, and bonus) are, respectfully, \$1.351, \$1.540, and \$2.306. The panel also shows the changes in the second main part of CEO compensation, the long-term incentives (i.e., stock, option, LTIP, and their total). We observe a significant change in the stock-based compensation, with an average value of 11.144. The compensation from stock shows a significant negative correlation with NGP. As shown in panel C of table 3, return on equities shows the highest change among the form performance measures with approximately USD 3.449, and the mean return on equities is 3.279. Panel D of table 3 indicates that the average age of the CEOs is 53, and, on average, the chance for a CEO to renew his position is almost 87%. We show in detail that among 401 CEOs, almost 24% (i.e., 95) left their position motivated by different reasons (resignation, retirement, etc.). Panel E in table 3 indicates that the mean firm's change in R&D is \$3.942, which reveals a significant negative association with our main independent variable, NGP. The median firm has \$13.7 market value, 2.5 age, and 3.9 R&D. Furthermore, the median firm's size, which is scaled by total assets, is 6.369.

Table 4 reports the CEO sample. We manually gathered most of this information after merging three different databases (USPTO, BoardEx, and Compustat). All our regression analyses in Level 2, as shown in the robustness section, use 628 firm-year observations. This sample includes 306 US CEOs, representing 76% (306/401) of the CEOs who have remained in their positions for at least three years, including the year following the NGPs. Table 4 also reports a total of 95 US CEOs who departed after NGP occurred (as demonstrated in the introduction, these CEOs account for 24% of all the CEOs in our data). For each fiscal year in the sample period, we cover demographic details on each CEO of US companies, including age, gender, and tenure. We observe that all of the CEOs are men, all from the U.S.

4.3 Empirical Models:

This section presents the main empirical models we created to investigate their correlation with our main variable, NGPs. Specifically, these models test the changes of several dependent variables in the subsequent year of NGPs. We begin by considering whether CEO compensations packages reduce in the year following NGPs. To do so, based on a number of firm characteristics that have been demonstrated to be determinants of CEO compensations, we specify an empirical model, includes our primary factor and controls, that better deals with the level of changes in CEO compensation. Further, we identify two additional empirical models: the first investigates whether firm's R&D investments reduce following the NGPs year; the second examines the relationship between NGPs and CEO departures, since many CEOs left their positions after the occurrence of NGPs.

4.3.1 CEO Compensation Model

To test hypotheses on whether CEO short-term incentive packages reduce in the post-NGPs year, we use the following regression model:

Test of H1

$$\Delta\text{log-Cash.Comp}_{i,\,t+1} = \beta_0 + \beta_1\, \textit{Innovation Failures}_{i,\,t} \{NGPs_{(i,\,t-3)}\} + \beta_2\, \textit{F-Size}_{i,\,t} + \beta_3\, R\&D_{i,\,t} + \beta_4\, \textit{F-Age}_{i,\,t} + \beta_5\, \textit{Leverage}_{i,\,t} + \beta_6\, \textit{CEO-age}_{i,\,t} + \beta_7\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad (1)$$

Test of H1(*a*)

$$\Delta\text{log-Salary}_{i,\,t+1} = \beta_0 + \beta_1\, \textit{Innovation Failures}_{i,\,t}\, \{NGPs_{(i,\,t-3)}\} + \beta_2\, F\text{-}Size_{i,\,t} + \beta_3\, R\&D_{i,\,t} + \beta_4\, F\text{-}Age_{i,\,t} + \beta_5\, Leverage_{i,\,t} + \beta_6\, CEO\text{-}age_{i,\,t} + \beta_7\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad (2)$$

Test of H1(*b*)

$$\Delta\text{log-Bonus}_{i,\,t+1} = \beta_0 + \beta_1\, \textit{Innovation Failures}_{i,\,t}\, \{NGPs_{(i,\,t-3)}\} + \beta_2\, F\text{-}Size_{i,\,t} + \beta_3\, R\&D_{i,\,t} + \beta_4\, F\text{-}Age_{i,\,t} + \beta_5\, Leverage_{i,\,t} + \beta_6\, CEO\text{-}age_{i,\,t} + \beta_7\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad (3)$$

where $Cash.Comp_{\,i,\,t+1}$, $Salary_{\,i,\,t+1}$, and $Bonus_{\,i,\,t+1}$ are the natural log of CEO short-term incentives for firm *i* at year *t+1 minus – t*. *NGPs* is the failure in innovation for firm *i* at year *t* but started from *t-3*, the average time lag of patents. Prior studies (e.g., Hung et al., 2019; Borisova et al., 2018; Huson et al., 2012) on CEO compensations use a change model to capture differences in the compensations that firms pay from year *t* to year *t+1* or year *t-1*. Thus, we employ a change regression to test all the hypotheses in our study using (OLS) except for the CEO departure hypothesis, as we use a different regression method. In particular, we measure the change for each dependent variable we use in the regression analyses from *t* to *t+1*. We provide a complete set of data for US firms over 2 years (*t and t+1*) during our sample period of 2001–2020 to analyze changes in all dependent variables. We expect that NGPs, our key independent variable, will have a negative impact on cash compensation, salary, and bonus at year *t +1*. In addition, we use controls that represent a set of variables known to influence particular compensation. We also expect to find a significant correlation between the changes in short-term compensations at year *t+1* and the two primary controls in the literature—the firm's research and development (R&D) and firm size (F-Size)—. In keeping with the prior work (e.g., Islam et al., 2020; Atanassov, 2013; Welch et al., 2011; Frydman et al., 2010; Zaheer et al., 2005), along with R&D and firm size, we include additional control variables—firm age (*F-Age*), debt (*Leverage*), market value (*MV*), CEO-specific characteristics (*CEO-age*), and *ε* as a random error term—to mitigate the possibility that the impact we expect to find on the short-term compensations is in fact driven by these variables.

We then use the following four regressions for the same model to test hypothesis 2 regarding whether CEO long-term incentives decrease in the year following NGPs:

Test of H2

$$\Delta\text{log-TotAtRisk}_{i,\,t+1} = \beta_0 + \beta_1\, Innovation\ Failures_{i,\,t}\, \{NGPs_{\,(i,\,t-3)}\} + \beta_2\, F\text{-}Size_{i,\,t} + \beta_3\, R\&D_{i,\,t} + \beta_4\, F\text{-}Age_{i,\,t} + \beta_5\, Leverage_{i,\,t} + \beta_6\, CEO\text{-}age_{i,\,t} + \beta_7\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad (4)$$

Test of H2 (*a*)

$$\Delta\text{log-Stock}_{i,\,t+1} = \beta_0 + \beta_1\, Innovation\ Failures_{i,\,t}\, \{NGPs_{\,(i,\,t-3)}\} + \beta_2\, F\text{-}Size_{i,\,t} + \beta_3\, R\&D_{i,\,t} + \beta_4\, F\text{-}Age_{i,\,t} + \beta_5\, Leverage_{i,\,t} + \beta_6\, CEO\text{-}age_{i,\,t} + \beta_7\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad (5)$$

Test of H2 (*b)*

$$\Delta\text{log-Option}_{i,\,t+1} = \beta_0 + \beta_1\, Innovation\ Failures_{i,\,t}\, \{NGPs_{\,(i,\,t-3)}\} + \beta_2\, F\text{-}Size_{i,\,t} + \beta_3\, R\&D_{i,\,t} + \beta_4\, F\text{-}Age_{i,\,t} + \beta_5\, Leverage_{i,\,t} + \beta_6\, CEO\text{-}age_{i,\,t} + \beta_7\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad (6)$$

Test of H2 (*c*)

$$\Delta\text{log-LTIP}_{i,\,t+1} = \beta_0 + \beta_1\, Innovation\ Failures_{i,\,t}\, \{NGPs_{\,(i,\,t-3)}\} + \beta_2\, F\text{-}Size_{i,\,t} + \beta_3\, R\&D_{i,\,t} + \beta_4\, F\text{-}Age_{i,\,t} + \beta_5\, Leverage_{i,\,t} + \beta_6\, CEO\text{-}age_{i,\,t} + \beta_7\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad (7)$$

where $TotAtRisk_{i,\,t+1}$, $Stocks_{i,\,t+1}$, $Options_{i,\,t+1}$, and $LTIP_{i,\,t+1}$ are the natural log of CEO long-term incentives for firm *i* at year *t+1 minus – t*. BoardEx defines CEO long-term incentives as total equity at risk or total equity proportion of total compensations, which is the sum of stock, options, and long-term incentive plan (LTIP) awarded during the period, divided by total CEO remunerations (TotAtRisk/Total CEO remunerations). Following the previous research (e.g., Borisova et al., 2018; Manso, 2011; Frydman et al., 2010) we test and analyze total equity at risk. In addition, we conduct separate tests on each of the three components (i.e., stocks, options, and LTIP). According to BoardEx, while stocks include restricted and unrestricted stocks, options consist of both exercised and unexercised options. LTIP component represents the sum of cash, equity, and equity matched and option-based LTIPs and its value is calculated using the closing stock price of the selected annual report date. We do not expect that NGPs will have a significant effect on the CEO's total equity at risk at year *1 + t*. Rather, we expect that NGPs will have a negative impact on stock-based compensation, in particular, because previous research (e.g., Mao et al., 2018) often shows a positive relationship between innovation activity at the firm level and the other two components of CEO total equity at risk, especially option-based compensation. In addition, it is widely known in the literature that stock-based compensation is more sensitive to risk (NGPs in our case) than option-based compensation. For controls, we apply the same control variables in short-term regression model. However, we do not expect a significant association between changes in CEO total equity at risk at year *t+1* and both firm's R&D and firm size. Overall, we focus our analysis on the levels of CEO total short-term incentives —in the form of cash compensation—and CEO total long-term incentives—in the form of equity at risk—and their components because these two main measurements cover the potential broad consequences of most CEO remuneration packages. By using these compensation models, we expect the effect of failures in innovation—in the form of NGPs—will be stronger on the CEO's short-term incentives than long-term incentives.

4.3.2 Additional Models

4.3.2.1 CEO Departure Model:

We also examine whether the CEOs who run the firm for at least a year or two prior to the NGPs will remain in their position the following year.

Test of H3

$$CEO\text{-}Dep_{i,\,t+1} = \beta_0 + \beta_1\, Innovation\ Failures_{i,\,t}\{NGPs_{(i,\,t-3)}\} + \beta_2\, F\text{-}Size_{i,\,t} + \beta_3\, R\&D_{i,\,t} + \beta_4\, ROA_{i,\,t} + \beta_5\, ROE_{i,\,t} + \beta_6 F\text{-}Age_{i,\,t} + \beta_7 Leverage_{i,\,t} + \beta_8\, CEO\text{-}age_{i,\,t} + \beta_9\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad \textbf{(10)}$$

where $CEO\text{-}Dep_{i,\,t+1}$ is a binary variable taking value 1 if the firm renews its CEO contract the following year of NGPs, rather than replace the CEO, and 0 otherwise for firm *i* at year *t+1*. We observe that almost 24% of all firms' CEOs (i.e., 95 out of 401) left their positions the year following NGPs in our data set. Such observation is what motivated us to examine whether the CEO's departure is correlated with the firm's failure in innovation. As we previously stated, resignation was the main reason for 70% of CEOs who departed in the year after NGPs (i.e., 67/95), followed by retirement with 27% (i.e., 26/95), and 2 died. The purpose of this model is to determine whether there is a correlation between firms' innovation failures and the departures of their CEOs in order to provide new insight into this relationship and, more importantly, open a new area of future research about the role of failures in innovation and its effects on the decision-making process of a firm's board of directors. We argue that when the CEO of a firm is reluctant to engage in innovation activity or invests less than what would otherwise be, this often results in failures in innovation. Such failures, consequently, may eventually lead the firm to replace the

CEO, especially those with a high number of NGPs. Therefore, we expect that NGPs could impact the firms' CEOs' departures.

4.3.2.2 Firm's R&D Investments Model:

Finally, we test hypothesis 4 about whether firms' R&D reduces in the post-NGPs year, as shown below:

Test of H4

$$\Delta \text{log-R\&D}_{i,\,t+1} = \beta_0 + \beta_1\, \textit{Innovation Failures}_{i,\,t}\{NGPs_{(i,\,t-3)}\} + \beta_2\, Cash.Comp_{i,\,t} + \beta_3\, TotAtRisk_{i,\,t} + \beta_4\, ROI_{i,\,t} + \beta_5 F\text{-}Age_{i,\,t} + \beta_6\, Leverage_{i,\,t} + \beta_7\, CEO\text{-}age_{i,\,t} + \beta_8\, MV_{i,\,t} + \varepsilon_{i,\,t} \quad \textbf{(11)}$$

Our dependent variable, $R\&D_{i,\,t+1}$ is the natural log of firm's research and development, in which *i* represents a given firm at year *t+1 minus – t*. The independent variables include the failure in innovation *(NGPs)* for firm *i* at year *t* but began from *t–3,* which is the average time lag of patents, total cash compensation (*Cash.Comp*), which is the sum of salary and bonus for firm *i* at year *t*, total equity at risk (*TotAtRisk*), which is the sum of stock, option, and long-term incentive plans for firm *i* at year *t*, return on investments (*ROI*), firm age (*F-Age*), debt (*Leverage*), CEO-specific characteristics (*CEO-age*), market value (*MV*), and *ε* as a random error term. As we demonstrated earlier (in Section 3.4), prior studies (e.g., Bertrand et al., 2013; Hunt, 2006) that illustrate the relationship between firms' innovative input (i.e., R&D investments) and innovative output (i.e., patents granted) indicated strong positive results. They further suggest that R&D—the main sources of innovation—drives innovative firms as it enables them to establish efficient processes, create new products, and obtain more patents, which in return spurs firms to increase their future investment in R&D. Moreover, R&D investment not only increases the output of innovation but also improves the quality of patents. It is typically that these two innovation activities are complementary—firms that conduct a lot of R&D tend to patent more. And ordinarily, reducing the investment in R&D will hinder more patents. Unlike much of the previous research, we find it important to test on whether "failures in innovation" at time *t* discourage firms from reinvesting in R&D at time *t+1* (Section 5.2.3 provides details), since there is no empirical evidence of such a relationship in the literature.

4.3.3 Model Analysis

We analyzed our collected data using ordinary least squares regression (OLS). To examine the impact of the key variables and control variables, we build four models. In model 1, we separately model several CEO compensation components with a set of controls. In model 2, we model the CEOs departures with additional control variables and use a logistic regression model, as OLS is not appropriate for such types of regressions. In model 3, we model the firms' R&D investments by modifying models 1 and 2. We examined all our models for clarity issues, and we conclude that there is no significant concern with our models.

5. Main Results:

5.1 Correlations

5.1.1 The Impact of NGPs on CEO Compensation, R&D Investments, and CEO Departure

In Panel A of Table 5, we present Pearson correlations between the variables that we use in the short- and long-term compensation model. Consistent with our expectations for the CEO's short-term incentives, we find a negative and statistically significant correlation between NGPs and *ΔCash.Comp* (-0.096*, *p* = 0.010), *Δsalary* (-0.123***, *p* = <.001), and *Δbonus* (-0.126***, *p* = <.001). For the long-term incentives, we also find a negative and statistically significant correlation between NGPs and *Δstock-based compensation* (-0.128***, *p* = <.001). However, we do not find any correlation between NGPs and the rest of the long-term compensation (i.e., *ΔTotAtRisk*, *ΔOptions*, and *ΔLTIP*).

In Panels B and C, we present additional tests for the correlation between NGPs and *CEO departure*, for which we use a binary variable = 1 if the CEO remains in the position in the year following the NGP event and 0 otherwise, and *ΔR&D*. The former result with NGPs is the opposite of our expectations and reveals no correlation between firm failure in innovation and CEO departures (0.068, *p* = 0.068). However, the later demonstrates a negative and statistically significant correlation with NGPs (-0.123***, *p* = <.001), which is consistent with our projections.

Table 5: Correlation for all variables used in the four models

Panel A: Pearson and P-value Correlations for the Variables Used in the CEO Compensation Model.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) NGPs	1													
(2) ΔCash.Comp		1												
Pearson's r	-0.096*													
P-value	0.010													
(3) ΔSalary			1											
Pearson's r	-0.123***	0.987***												
P-value	<.001	<.001												
(4) ΔBonus				1										
Pearson's r	-0.126***	0.527***	0.534***											
P-value	<.001	<.001	<.001											
(5) ΔTotAtRisk					1									
Pearson's r	-0.072	0.676***	0.664***	0.534***										
P-value	0.053	<.001	<.001	<.001										
(6) ΔStock						1								
Pearson's r	-0.128***	0.546***	0.526***	0.534***	0.775***									
P-value	<.001	<.001	<.001	<.001	<.001									
(7) ΔOptions							1							
Pearson's r	-0.053	0.569***	0.545***	0.473***	0.855***	0.703***								
P-value	0.157	<.001	<.001	<.001	<.001	<.001								
(8) ΔLTIP								1						
Pearson's r	0.006	0.636***	0.618***	0.499***	0.861***	0.753***	0.796***							
P-value	0.872	<.001	<.001	<.001	<.001	<.001	<.001							
(9) MV									1					
Pearson's r	-0.088*	-0.102**	-0.117**	0.104**	0.042	0.213***	0.142***	0.078*						
P-value	0.019	0.006	0.002	0.005	0.256	<.001	<.001	0.039						
(10) Leverage										1				
Pearson's r	-0.128***	-0.099**	-0.116**	0.164***	0.055	0.130***	0.137***	0.064	0.671***					
P-value	<.001	0.008	0.002	<.001	0.137	<.001	<.001	0.089	<.001					
(11) R&D											1			
Pearson's r	0.676***	-0.031	0.042	0.055	-0.031	0.092*	0.058	0.009	0.045	-0.075*				
P-value	<.001	0.405	0.256	0.137	0.405	0.013	0.121	0.804	0.231	0.043				
(12) Firm Size												1		
Pearson's r	-0.135***	-0.111**	-0.134***	0.142***	0.045	0.165***	0.135***	0.070	0.724***	0.880***	0.786***			
P-value	<.001	0.003	<.001	<.001	0.231	<.001	<.001	0.062	<.001	<.001	<.001			
(13) Firm age													1	
Pearson's r	-0.020	-0.108**	-0.094*	0.139***	-0.075*	-0.061	-0.021	0.002	0.121***	0.221***	0.177***	0.171***		
P-value	0.585	0.004	0.012	<.001	0.043	0.100	0.572	0.959	0.001	<.001	<.001	<.001		
(14) CEO age														1
Pearson's r	-0.006	-0.080	-0.088	0.010	-0.064	-0.015	-0.096**	-0.046	0.076*	0.169***	0.130***	0.195***	0.261***	
P-value	0.876	0.031	0.017	0.788	0.083	0.693	0.010	0.222	0.040	<.001	<.001	<.001	<.001	

Panel B: Pearson and P-value Correlations for the Variables Used in the CEO Departure Model.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) NGPs	1									
(2) Binary		1								
Pearson's r	0.068									
P-value	0.068									
(3) MV			1							
Pearson's r	-0.088*	-0.011								
P-value	0.019	0.761								
(4) Leverage										
Pearson's r	-0.128***	-0.052	0.671***	1						
P-value	<.001	0.164	<.001							
(5) Firm size										
Pearson's r	-0.135***	-0.078*	0.724***	-0.880***	1					
P-value	<.001	0.036	<.001	<.001						
(6) R&D										
Pearson's r	-0.151***	-0.698**	-0.135***	0.771***	0.786***	1				
P-value	<.001	<.001	<.001	<.001	<.001					
(7) Firm age							1			
Pearson's r	-0.020***	-0.080*	-0.121**	0.221***	0.171***	0.177***				
P-value	0.585	0.031	0.001	<.001	<.001	<.001				
(8) CEO age								1		
Pearson's r	0.006	-0.153***	0.076*	0.169***	0.195***	0.130***	0.261***			
P-value	0.876	<.001	0.040	<.001	<.001	<.001	<.001			
(9) ROE									1	
Pearson's r	0.134***	0.067	-0.761***	-0.775***	-0.795***	-0.695***	-0.148***	-0.088*		
P-value	<.001	0.070	<.001	<.001	<.001	<.001	<.001	0.017		
(10) ROA										1
Pearson's r	0.012	0.014	0.060	0.082*	-0.070	0.059	0.001	0.025	-0.062	
P-value	0.743	0.699	0.109	0.028	0.061	0.110	0.970	0.496	0.097	

Panel C: Pearson and P-value Correlations for the Variables Used in the R&D Investments Model.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) NGPs	1								
(2) ΔR&D		1							
Pearson's r	-0.146***								
P-value	<.001								
(3) MV			1						
Pearson's r	-0.088*	0.638***							
P-value	0.019	<.001							
(4) Leverage				1					
Pearson's r	-0.097**	0.722***	0.675***						
P-value	0.009	<.001	<.001						
(5) Firm age					1				
Pearson's r	-0.020	0.178***	0.121**	0.190***					
P-value	0.585	<.001	0.001	<.001					
(6) CEO age						1			
Pearson's r	-0.006	0.130***	0.076*	0.168***	0.261***				
P-value	0.876	<.001	0.040	<.001	<.001				
(7) ROI							1		
Pearson's r	0.045	-0.678***	-0.645***	-0.706***	-0.235***	-0.105**			
P-value	0.230	<.001	<.001	<.001	<.001	0.005			
(8) CashComp								1	
Pearson's r	-0.010***	-0.097**	0.087*	-0.043	-0.058	-0.082*	0.083*		
P-value	0.794	0.009	0.019	0.246	0.117	0.028	0.025		
(9) TotAtRisk									1
Pearson's r	-0.068	-0.037	0.049	0.023	-0.077*	-0.060	-0.021	0.599***	
P-value	0.067	0.318	0.189	0.533	0.037	0.108	0.577	<.001	

Note. All these variables are defined with more details in Table 3.

5.2 Pooled Regressions:

5.2.1 The Impact of NGPs on CEO Compensation Package

Table 6 displays the results from estimating Equations 1–3 using the OLS regression. In the first column, we show the findings from estimating the model of change in CEO cash compensation, the dependent variable after the NGPs occurred, and control variables. The coefficient of -0.023 (with *p value* of 0.010) on *ΔCash.Comp* demonstrates that the change in CEO cash compensation is significantly higher after the firm receives unsuccessful patents than the year prior to NGPs, as expected in *H1*. We find that R&D is negatively and significantly associated with the change in the log of cash compensation (*p* 0.002). We also find that firm age is negatively associated with the change in the cash compensation (*p* 0.032). We find no significance in the coefficients for other control variables. Such strong negative result of NGPs on ΔCash.Comp in the presence of other variables shows that the change in CEO cash compensation could be driven by the effect of NGPs. The model has an adjusted R^2 of 0.038, with 723 firm-year observations. Finally, prior research often applied granted patents in a similar model and showed inconsistent outcomes with the change in CEO cash compensation. We, however, use NGPs to document these intriguing results.

We conduct separate tests of the two components of the cash compensation (salary and bonus) to determine which variable is more impacted by NGPs. To do so, we run the same model for both variables separately. The second column of Table 6 indicates the results from the modified version of Equation 1, regarding the change in salary. The coefficient of -0.029 (with a p value of <.001) on *Δsalary* demonstrates that the subsequent reduction in CEO salary is significantly higher in the following year NGP, as predicted in *H2*. We also find that R&D is negatively and significantly associated with the change in the CEO salary (*p* 0.007). The model has an adjusted R^2 of 0.044. The other control variables—MV, leverage, firm age, and CEO age—have insignificant coefficients.

The third column of Table 6 reports the results of regressing the change in bonus following the NGPs. The results display a coefficient of -0.336 (with a p value of <.001) on *Δbonus*, which is significantly higher than salary. This finding is consistent with the most results in the literature that the CEO's compensation will face a reduction in the subsequent bonus when they show poor performance. Since the bonus is based on performance, generating NGP may motivate firms to reduce their CEOs' bonuses. We also find that firm age is positively associated with the change in the bonus (with a *p* value of 0.002). This result, which is as we expected in *H3*, reveals that old firms have more experience dealing with CEO bonuses when they show unexpected outcomes. The model has an adjusted R^2 of 0.042. Overall, the evidence supports the argument that the reduction in subsequent CEO short-term incentives is linked to prior performance. Our contribution to these arguments, however, is that NGP is a significant factor that may "exclusively" drive such an influence on the CEO's short-term incentives.

Table 6 Regression Analyses of Changes in the CEO's Short-Term Compensation (Total Cash Comp, Salary, and Bonus) in the year following NGPs: H1 using the Full Sample of 723 Year-Observations with 2,003 NGPs Over 2001-2020.

IND-V	**(1)**		**(2)**		**(3)**	
	Δ Cash.Com		**Δ Salary**		**Δ Bonus**	
	Coefficient	*P-value*	Coefficient	*P-value*	Coefficient	*P-value*
NGP	-0.023	0.010	-0.029	< .001	-0.336	< .001
MV	-0.018	0.498	-0.017	0.525	-0.007	0.820
Leverage	0.046	0.342	0.043	0.371	0.082	0.139
Firm Age	-0.155	0.032	-0.119	0.098	0.257	0.002
CEO Age	-0.011	0.197	-0.013	0.132	-0.011	0.256
R&D	-0.120	0.002	-0.103	0.007	0.027	0.550
Size	0.010	0.837	0.049	0.765	-0.006	0.917
Observations	723 FY		723 FY		723 FY	
Year Indicators	Yes		Yes		Yes	
Industry	Yes		Yes		Yes	
Adjusted R^2	0.038		0.044		0.042	
Constant	-1.288		-1.459		-2.156	

Note: * p < .05, ** p < .01, *** p < .001

Table 7 shows the results from estimating Equations 4–7 using the modified version of the first equation. We explore the possibility of a negative relationship between NGPs at time *t* and potential changes in the CEO's long-term incentives (i.e., *ΔToAtRisk*). The first column of Table 7 indicates the coefficients on *ΔToAtRisk*, which measures the changes in the total long-term incentives. The model has an adjusted R^2 of 0.025, with 723 firm-year observations. The result is negative but not statistically significant with a coefficient of -0.158 (*p* 0.053). For the rest of the controls, we find that R&D and leverage are both negatively and significantly associated with the change in the *ΔToAtRisk* (*p* 0.046 and <.001).

The second column of Table 7 shows the best results (i.e., *ΔStock-based compensation*). The model has an adjusted R^2 of 0.063, and the results indicate a coefficient of -0.530 (with a *p* value of <.001) on *Δstock*, which is significantly lower than the stock-based incentives in the year before. This finding is based on the fact that stock-based compensation is more sensitive to risk (failures in our study) than other long-term incentive components. This result is consistent with *H5*. We also find that firm age is negatively and significantly associated with the change in the *Δstock* (*p* 0.037), while market value indicates a positive and significant result (*p* <.001).

The other two dependent variables in columns three and four of Table 7 (i.e., *ΔOptions* and *ΔLTIP*) show insignificant association with NGPs. Thus, we reject *H6* and *H7* because they are not in line with our expectations. Overall, the evidence on how innovation failures could negatively impact the CEO's long-term incentives remains surprisingly scant in the corporate finance literature. Although we find mixed results, we emphasize that NGPs have a significant impact on, at least, one component of the CEO's long-term compensation (i.e., stock-based compensation).

Table 7 Regression Analyses of Changes in the CEO's long-Term Compensation (Total at Risk, Stock, Option, and LTIP) in the year Pos-NGPs: H2 with Full Sample of 723 Year-Observations with 2,003 NGPs Over 2001-2020.

IND-V	**(1)**		**(2)**		**(3)**		**(3)**	
	ΔToAtRisk		**Δ Stock**		**Δ Options**		**Δ LTIP**	
	Coefficient	*P-value*	Coefficient	*P-value*	Coefficient	*P-value*	Coefficient	*P-value*
NGP	-0.158	0.053	-0.530	< .001	-0.142	0.157	0.016	0.872
MV	0.009	0.720	0.182	< .001	0.046	0.129	0.032	0.306
Leverage	0.092	0.046	-0.041	0.628	0.090	0.108	0.026	0.646
Firm Age	-0.131	0.060	-0.267	0.037	-0.041	0.626	0.014	0.869
CEO Age	-0.013	0.060	-0.006	0.664	-0.031	0.002	-0.016	0.113
R&D	-0.127	<.001	-0.131	0.055	-0.126	0.005	-0.097	0.030
Size	0.037	0.439	0.144	0.103	0.078	0.178	0.073	0.221
Observations	723 FY		723 FY		723 FY		705 FY	
Year Indicators	Yes		Yes		Yes		Yes	
Industry	Yes		Yes		Yes		Yes	
Adjusted R²	0.025		0.063		0.040		0.007	
Constant	-0.349		-10.905		-1.229		-1.310	

Note: * p < .05, ** p < .01, *** p < .001

5.2.2 The Impact of Failure in Innovative on CEO Renewal Position

To use our data in the analysis of CEO departures after innovation failure, we compare, for each CEO, the number of years he held the position, including the year of NGP, i.e., one year prior to, during, and following NGPs, and that refers to the CEO with (R) the ‘‘renewal’’ of contract and with (F) the ‘‘failure’’ of renewal contract. Then, we construct the following indicator for each CEO *i* in year *t*:

$$\text{TOTAL} - \text{CEOs}_{it} = \begin{cases} 1 \quad \text{if} \displaystyle\sum_{n=t-2}^{t+1} R_n \text{ is} > \sum_{n=t-2}^{t} F_n \text{ is}; \\ 0 \quad otherwise. \end{cases}$$

TOTAL-CEOs$_{it}$ captures the number of all CEOs (i.e., 401) for firms with NGPs from 2001 to 2021. When using this proxy, we control for the total number of years CEOs remain in positions (before and after NGPs) over the target period (i.e., one year prior to, during, and following NGPs) because including a large number of years before and after NGPs might indicate biased results.

Table 8 Logistic Regression Analysis of the Relationship Between NGPs and CEO Departure: H: 8 using the Full Sample of 723 Year-Observations with 2,003 NGPs Over 2001-2020.

CEO Departures - Binary

Model	Deviance	AIC	BIC	df	X^2	p	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox & Snell R^2
H_0	558.761	562.761	571.928	721						
H_1	530.102	550.248	596.082	713	28.513	< .001	0.051	0.072	0.046	0.039

Note. Null model contains nuisance parameters: l-NGP

Specifically, an intriguing observation in our data prompts us to conduct additional tests. Using a logistic model, we begin by examining the relationship between CEO departures and our main independent variable, NGPs. We apply a binary variable, set to 1 if CEOs maintain their position in the post-NGP year and 0 otherwise. In short, the model summary above in Table 8 indicates that H_1 has an AIC (550.248) lower than H_0 (562.761) and the *p-value* less than .001, suggesting a significant relationship between the dependent (CEO leaving) and some independent variables, NGPs and controls.

Table 9 The relationship between the departure of the CEO and the NGPs Over 2001-2020.

Coefficients

					Wald Test		
	Estimate	Standard Error	Odds Ratio	z	Wald Statistic	df	p
(Intercept)	5.441	1.380	230.740	3.944	15.554	1	< .001
NGP	0.242	0.174	1.274	1.387	1.924	1	0.165
MV	0.062	0.041	1.064	1.539	2.370	1	0.124
Leverage	0.135	0.092	1.144	1.462	2.138	1	0.144
Size	-0.064	0.099	0.938	-0.641	0.411	1	0.522
R&D	-0.128	0.068	0.880	-1.890	3.571	1	0.059
Firm age	-0.143	0.131	0.867	-1.095	1.198	1	0.274
CEO age	-0.054	0.015	0.948	-3.568	12.732	1	< .001
ROE	0.063	0.057	1.065	1.091	1.190	1	0.275
ROA	0.007	0.014	1.007	0.504	0.254	1	0.615

Note. Binary level '1' coded as class 1.

The coefficient in Table 9 displays the interaction between CEO departure and NGPs, as well as a set of control variables. The p-value for R&D is not significant, indicating that the firm's investments have no impact on the CEO's departure. However, the CEO age variable shows a significant negative result with a p-value <.001, which can be interpreted as a motivation for CEOs to leave their positions. We previously stated that almost 24% of all firms' CEOs (i.e., 95 out of 401) left their positions the year following NGPs in our data set. Additionally, we noted that retirement accounted for 27% of CEO departures in the year following NGPs (i.e., 26/95), while resignation accounted for 70% (i.e., 67/95). The result of the CEO age reveals that even though resigning, which we interpreted as firing, was the primary reason for CEOs departures, it could be linked to their age, as the average age of all CEOs in our data set is 53, suggesting that these CEOs may opt for early retirement. Therefore, we reject the hypothesis (H11) that NGP has a negative impact on CEO departure4[5]. We conclude that while innovation failure could be a contributing factor—especially given the long tenure of these CEOs and their high number of NGPs—it is obviously not the main reason innovation firms replace their CEOs. Or put it differently, failure in innovation may indirectly push CEOs to leave their positions as they show poor innovative performance over the long term (i.e., with a contract of at least three years). Thus, if more innovative firms, particularly those with a high number of NGPs, tend to replace their CEOs in the year following NGPs, our hypothesis of CEO departure could potentially be accepted.

[5] Although we include a comprehensive set of control variables, the result of the logistic model remains unchanged. We emphasize that the possibility does not exist that NGPs affect the CEO's departure in our current sample data.

Another test we conduct is whether the potential change in the firm's R&D has a negative relationship with NGPs. The fourth model we run allows the coefficients on R&D to vary in the presence of the firm's NGP and other controls at time *t*. The column below of Table 10 reports the results from Model 4. The model has an adjusted R^2 of 0.060. We find that the coefficient on *ΔR&D*, which measures the change in a firm's research and investments, is negative and significant (-0.543 with a p value of <.001). We also find that both market value and leverage are positively and significantly associated with the change in the *ΔR&D,* with a p <.001, while ROI indicates a negative and significant result (p <.001). Overall, these findings support the literature that the firm reduces its subsequent R&D following the negative outcomes in the past year. More specifically, the main result in this model suggests that a CEO who has engaged in innovation activities that ended in failure is likely to be discouraged from involving future investments in R&D.

5.2.3 The Impact of Failure in Innovative on R&D Investments

Table 10 Regression Analyses of Changes in R&D Investment in the year following NGPs: Hypothesis 9 using the Full Sample of 723 Year-Observations with 2,003 NGPs Over 2001-2020.

		Δ R&D	
		Coefficient	p-value
NGPs		-0.543	< .001
MV		0.152	< .001
Leverage		0.346	< .001
Firm Age		0.016	0.828
CEO Age		0.006	0.525
ROI		-0.385	< .001
Cash.Comp		-0.002	0.968
TotEqtAtRisk		-0.110	0.029
Observations	723 FY		
Year indicators	Yes		
Industry	Yes		
Constant	4.184		
Adjusted R^2	0.60		

Note: * p < .05, ** p < .01, *** p < .001

Table 11 summarizes all the main results we show from our four different models. We present Pearson's results that clearly state a strong negative significant relationship between NGP and the changes in short-term CEO compensation, stock-based compensation, as well as R&D investment.

Table 11 Summarizes the Hypotheses' Testing Outcomes for all models.

Hypothesis	Relationships	Pearson's r	Supported
H1	NGPs - Δ l-Cash.Comp	-0.096*	**Yes**
H1 *a*	NGPs - Δ l-Salary	-0.123***	**Yes**
H1 *b*	NGPs - Δ l- Bonus	-0.126***	**Yes**
H2	NGPs - Δ l- TotAtRisk k	-0.072	**No**
H2 *a*	NGPs - Δ l-Stock	-0.128***	**Yes**
H2 *b*	NGPs - Δ l-Option	-0.053	**No**
H2 *c*	NGPs - Δ LTIPs	0.006	**No**
H3	NGPs - CEO REN-POS	0.068	**No**
H4	NGPs - Δ l-R&D	-0.146***	**Yes**

6. Conclusions and Implications for Future Research:

This paper sheds light on the relationship between failure in innovation and CEO compensation packages, as well as other additional tests. Using a unique sample of USPTO-NGPs, we find that there is a significant reduction post-NGPs year in CEOs' short-term incentives (jointly and separately). The same result holds for CEOs' long-term stock-based compensation. Such reduction results in a negative and significant correlation with NGPs. We do not, however, find a decline in the other components of the CEOs' long-term incentives (i.e., options and LTIP) response to NGPs, which suggests that firms only tolerate some long-term components for CEOs—with the expectation that it may enhance their performance in the long run to be more innovative—but not the short-term components. Henc, these findings reveal that CEOs' compensation packages are significantly linked when the firms face failure in innovation.

The compensation packages serve as an instrument to motivate CEOs to achieve high performance. On the one hand, CEOs may engage in a reckless shopping spree to build an empire without penalty for poor performance. On the other hand, if the penalty is severe, CEOs will be reluctant to extend the firm's investment in innovation, which is long-term, unpredictable, idiosyncratic, and involves a high probability of failure. To strike a balance between investing in innovation projects and risk aversion, our study suggests that firms might need to design optimal incentive packages that are more tolerant to CEOs who experience failure in innovation.

In addition, we set up two more empirical models to investigate (1) the intersection between CEO departure and (2) R&D investments with firms' innovation failure. The results indicate that R&D changes in response to NGPs are negative and statistically significant. This finding suggests that CEOs tend to sharply reduce the firm's subsequent investment in R&D, particularly when they face failures in obtaining patents. Although we observe that almost 24% of CEOs in our entire sample left their positions in the following year of NGPs, the CEO departure model does not reflect any significant correlation with NGPs, indicating that failure in innovation is not the main cause of the CEO departure. However, we argue that if more innovation firms, particularly those with a high number of NGPs, tend to replace their CEOs in the year following NGPs, our hypothesis of CEO departure could be accepted.

Finally, the outcomes of this study suggest the necessity for more investigation. First, we demonstrate that USPTO-NGP applications are important to corporate innovation. Our empirical evidence, however, speaks against the existing results in the literature, which show, in most cases, a positive association between CEO compensation and "innovation success" in both the short and long run. Given our results and previous related studies, more research could be done to connect changes in CEO compensation to failure in innovation. Second, future research can also benefit from our results by investigating whether CEOs' reactions to failure in innovation show good or poor firm performance. More precisely, a firm's poor performance in the short term, for example, might not be only from reductions in the CEO's compensation package or R&D investment, which is entirely under the CEO's control, but also from failure in innovation in the past year. We reiterate our argument that the existing literature on corporate innovation does not recognize the dark and unexpected side of innovation failure and whether such failures influence firms' activities in the short and long run.

Appendix:

Table 1: Variable Definitions

Variables	**Description**
Dependent Variables	
Δ Cash.Comp	natural logarithm for the sum of CEO's salary and bonus.
Δ Salary	natural logarithm for the CEO's salary
Δ Bonus	natural logarithm for CEO's *bonus*
Δ TotAtRisk	natural logarithm of the CEO's total compensation at risk (i.e., the sum of stock, option, and LTIP).
Δ Stock	natural logarithm of the CEO's stock-based compensation
Δ Option	natural logarithm of the CEO's option-based compensation
Δ LTIPs	natural logarithm of the CEO's long-term incentive payment (i.e., restricted stocks + unvested option).
Δ TST&TOP	natural logarithm of the total stock and options
Δ LT&ST	natural logarithm of the total long-term incentive (i.e., LTIP) + short-term incentive (i.e., bonus).
Δ Others	natural logarithm of the other compensation of CEO's as a fraction of the CEO's total remuneration
Δ CEO Total.Rem	natural logarithm of the CEO's total remuneration (i.e., the sum of Cash.Comp + TotAtRisk)
Δ R&D	natural logarithm of the change in research and development
CEO departure	binary variable equals 1 if a CEO has a renewed position after the NGP, and 0 otherwise
Independent Variables	
NGPs	patent applications that are submitted to the USPTO and ultimately rejected by USPTO examiners
ROA	natural logarithm of the return on assets divided by total assets
ROE	natural logarithm of the return on equities divided by total equities
ROI	natural logarithm of the return on investments divided by total invested capital x 100.
CEO age	the age of the CEO of a firm
CEO tenure (years)	the number of years the CEOs have been in the chief executive position at the current firm
CEO gender (%)	male or female sex scaled by percentage.
Leverage	natural logarithm of the total debt to total assets.
Size	natural logarithm of a firm's book total assets.
Firm Age	natural logarithm of the number of years since the IPO date
MV	the annual close price x the total number of outstanding shares.
R&D	natural logarithm in research and development at time *t*.

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