Coalitions, Retaliation, and Whistleblowing: Evidence from Memorials of Qing China

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Abstract

Whistleblowing by senior local officials is pivotal for monitoring official behavior and suppressing corruption. Yet, the act of reporting is a strategic decision, entangled with complex considerations such as the risk of retaliation by those being reported and the gains from collusion. Despite its importance, there's a notable gap in research on the strategic behavior of whistleblowers.

This paper taps into historical evidence from Qing China's memorials, which served as a confidential channel between the emperor and high-ranking local officials. Our focus is on memorials concerning natural disasters, specifically investigating whether officials obligated to report such disasters immediately would instead choose to form alliances to withhold information.

We introduce a theoretical model to examine how coalitions among top local officials like governor-general and governor influence the whistleblowing. The model suggests that local officials are prone to underreporting when they are further from the years of reassignment or when they expect more collaboration opportunities in the future. A critical determinant in an official's decision to disclose disaster information is the fear of peer retaliation; The more easily identifiable the whistleblower or the higher and politically stronger the position of their peers, the more likely underreporting becomes.

Using data from memorials between 1723 and 1909 during the Qing dynasty, our empirical analysis corroborates our hypothesis: officials more distant from reassignment years tend to underreport disasters, with the probability of underreporting increasing by 2.5% for each year further from evaluation. Subsequent analysis dismisses other potential reasons for underreporting, including officials seeking personal gain from disaster relief or considering minor disasters unworthy of reporting, thus reinforcing the credibility of our conclusions. Our paper also highlights the consequences of the absence of whistleblowers: namely, more famines and a greater number of popular uprisings.

Keywords: Whistleblowing; Political coalition; Disaster

JEL Codes: N45; D73; D74; H70

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1 Introduction

A whistleblower is typically regarded as an insider who have access to confidential information and uses it to expose illegal activities, such as corruption, mafia penetration or financial fraud in publicly traded companies. Many studies emphasize the importance of whistleblowing as a key method for curbing illegal activities, particularly when external oversight is lacking or unable to obtain internal information. However, the existing evidence does not support a definitive conclusion on whether whistleblowing systems are truly effective or not. Even with specially established reporting systems, insiders may choose not to blow the whistle due to various motivations, such as fear of retaliation from others. For example, Chinese central government invested 730 million RMB in a direct reporting system for hospitals following the SARS epidemic, aimed at facilitating early pandemic detection by allowing hospitals to directly report cases to the central government. Nonetheless, during COVID-19, the system remained unused, with no cases reported.

The primary challenge in empirically validating the effectiveness of whistleblowing systems and the factors that influence them stems from data availability. Strict confidentiality surrounding whistleblowers, including their identities and the content of their reports, is maintained in many places, which complicates efforts to assess the impact of whistleblowing.

This paper examines the factors influencing whistleblowers' decisions within a uniquely institutional context: the secret memorial system of the Qing Dynasty in China. Initiated by the Yung-cheng Emperor, this system was designed to allow local officials to communicate directly with the emperor without the interference of others, using a secure, one-to-one communication method where only the sender and the emperor held keys to the message box. From the Yung-cheng Emperor (in the 1660s) until the late Qing Dynasty (1912), this system enabled private exchanges between the emperor and top provincial officials, with few others privy to the contents. Local officials, possessing overlapping local information, were expected to compete in an idealized prisoner's dilemma by ẅhistleblowingẗo the emperor to gain trust and favor. However, in reality, the potential costs of reporting, such as retaliation from other officials, might incentivize local officials to form coalitions and withhold information from the emperor. Such informational blockages could result in significant social costs, particularly in critical decisions like disaster relief, where a lack of central knowledge and supplies could lead to the loss of thousands of lives.

We employ a theoretical model to derive the factors that influence officials' decisions to form information coalitions and reduce whistleblowing to the emperor. We consider a classic scenario: whether an official chooses to report or conceal information about a disaster occurring in their locality. Our findings indicate that the decision to conceal information, i.e., not to whistleblow, is associated with the following factors: (1) The longer the expected period during which an official will work with colleagues who share similar information; (2) the higher likelihood of disaster occurrence; (3) the greater likelihood of the whistleblower's private correspondence and identity being revealed; (4) the lower probability of exogenous separation; and (5) the higher net benefits of whistleblowing, where the professional rewards for exposing corruption outweigh the potential costs of retaliation.

To test our hypothesis, we construct a dataset consisting of 8,035 disaster-related secret memorials written by local officials to the emperor, sourced from the First Historical Archives of China. The dataset features a wide range of details from the memorials, such as titles, full texts, authorship, and dates. We then match these records with reliable local disaster data from county and prefectural chronicles to assess the impact of the disasters. Additionally, we collect data on various local characteristics, such as population, area, terrain ruggedness, and the personal characteristics of the officials, including their positions during their pollical careers, the timing of their imperial examinations, and their exam results.

Our findings suggest that the whistleblower system becomes ineffective due to the self-serving motivations of officials. We find that in less than half of the county-year observations where disasters occurred, local leaders reported the events to the emperor, which contrasts sharply with the explicit directive that all disasters should be reported. Our empirical conclusions also confirm the presence of information coalitions among officials, as predicted by our theoretical model, and their role in suppressing reports. Specifically, when officials anticipate longer collaboration with colleagues, a higher likelihood of disasters, a greater chance of whistleblower identity being exposed, a lower probability of exogenous separation, and lower net gains from reporting, they are more inclined to conceal information. Additionally, we uncover some interesting insights, such as when a superior official gains more trust from the emperor, other officials may expect that this trust will shield them from accountability for their mistakes or enable them to use their relationship with the emperor to retaliate more severely against others, leading to fewer reports being made to the emperor.

We consider and exclude a series of alternative explanations. It is possible that officials' disaster reporting behavior is influenced by several factors.First, local officials may refrain from reporting to the emperor because they perceive the disaster to be minor and worry about disturbing the emperor with trivial matters. This concern that might be more pronounced during critical periods for the empire, such as when it is at war with neighboring countries. Second, officials might report disasters to secure central government funds for their local budgets or with the hope of misappropriating these relief funds. Lastly, local officials may be unaware of the disaster due to inadequate information collection, especially in large, sparsely populated, or poorly connected regions. Through a series of heterogeneity analyses, we demonstrate that while these factors may indeed have an impact, the informational alliance among local officials remains critically important in their decision to report.

We also consider and rule out a range of alternative explanations that are relevant to the specific senario. For instance, officials nearing the end of their careers are more likely to report to the emperor in an attempt to impress him by demonstrating their diligence and concern for the people's suffering, thereby improving their chances of reappointment. If this is the case, then we would expect that officials seeking to impress the emperor might also submit a higher volume of memorials that are not disaster-related. Moreover, higher-ranking officials, with more connection and richer past working experience with the emperor, might produce more memorials to highlight their performance. However, our results do not support these hypotheses; we find no increase in memorials unrelated to disasters, and, at the same time, the likelihood of memorial submission rises among lower-ranking officials most vulnerable to retaliation, indicating a greater likelihood of the collapse of the entire information alliance.

Our study makes several contributions to the literature. First, we contribute to the literature on whistleblowing systems and the factors influencing their efficacy. Previous research has examined the role of financial incentives (Dyck et al., 2010), consumer reporting in tax compliance(Naritomi, 2019), and the shaping of moral beliefs(Heese et al., 2023). However, most studies focus on external motivators, such as financial rewards or external oversight. We extend this literature by examining the internal motivations and strategic considerations of whistleblowers, particularly the trade-offs between personal benefits and potential retaliation. Our findings highlight that whistleblowing systems, even those supported by substantial investments like the Chinese hospital direct reporting system post-Covid-19, may fail without careful consideration of whistleblower incentives.

Second, our paper contributes to the broader discussion on corruption, governance, and agency problems. Many studies focus on the deterrent effects of whistleblowing on corruption(Olken, 2007; Pan and Chen, 2018; Chassang and Miquel, 2019), or the exposure of illegal activities in corporate settings(Campello et al., 2017). By analyzing historical data from Qing China, we offer a unique perspective on how governance challenges manifest across vastly different institutional and temporal contexts. The interplay of coalition-building, local interests, and hierarchical control observed in our study provides a historical parallel to contemporary issues, such as financial fraud and regulatory capture in modern organizations.

Third, we add to the literature on informal institutions and their impact on formal governance mechanisms. Similar to studies that explore the interplay between formal and informal rules(Greif, 1993; Acemoglu and Robinson, 2013), our paper demonstrates how informal coalitions can subvert the intended functioning of a formal whistleblowing system. This finding enriches our understanding of the limitations of formal institutions, especially in historical contexts where informal norms and relationships wield significant influence over behavior.

Fourth, it also contributes to the literature on information transmission. There is a new and growing literature discussing economic impacts of new information channels. For instance, the emergence of shipping between London and Amsterdam and the construction of transatlantic cable, have both price implication at their respective time, suggesting they have greatly promote the transmission of information(Carlos and Nicholas, 1996; Hoag, 2006). The advantage of our article compared to these articles is that we can not only see the channels of information transmission, but also observe the specific information transmitted in these channels. Therefore, we differ from the literature by finding that the establishment of these channels, especially official channels may not necessarily share all local information to the central.

Lastly, Our paper is also related to a large literature on decentralization. Many papers supporting the idea of that decentralization leverages local agents' superior access to information for better governance outcomes(Oates, 1972; Qian and Roland, 1998; Huang et al., 2017). However, our findings offer a more nuanced perspective: advances in institutional design or information technology may not necessarily enhance the central authority's access to local knowledge. In contexts where local agents have strong incentives to form informational coalitions, decentralization might remain the only viable solution to harness local information effectively.

The remainder of the paper proceeds as follows. Section 2 provides the historical context. Section 3 develop a model of disaster reporting by government officials tailored to the administration of imperial China under the Qing dynasty. Section 4 describes the data construction and empirical setting. Section 5 presents the empirical results, corresponding to the hypotheses derived from the model. Section 6 addresses potential alternative explanations of our findings. Section 7 explores the severe consequences of information concealment.

2 History background

2.1 Confidential Memorials

The "Confidential memorials" or"Confidential fold",[1] represents a system that was designed to enable private, one-on-one communication between the emperor and his officials, circumventing any form of surveillance or external interference (Huang, 1994). The earliest form of this system was implemented by Emperor Kang-Hsi (1662-1722) to efficiently oversee and regulate imperial affairs in the southern territories (Ju, 1982; Spence, 1966). Kang-Hsi authorized his trusted servants to use specially crafted small containers for document transportation, which were securely locked. Only the reporter and the emperor possessed the keys. The emperor would annotate the received letters in red ink and then lock the box before returning it to the original sender,[2] thereby completing the information exchange(Miyazaki, 1957; Zimu, 2021).[3]

Emperor Yung-cheng, the successor of Kang-Hsi, expanded the use of the confidential memorial system to meet the demands of political struggles (Wu, 1970). Despite his victory in the succession struggle, Yung-cheng's brother, Prince Yunzhi, retained significant control over the court, leading Yung-cheng to use confidential memorials for direct communication

[1] We adopt the term "confidential fold,"as defined by wu1967memorial, to refer to the English translation of Tsou-che (奏折). However, there is no consensus on this terminology in the academic community. For example, elliott2001manchu uses the term "Palace Memorial."

[2] Rao1893 provides the most detailed data on the operation of confidential memorials in his work.

[3] For instance, Wang Hongxu (1645-1723), a trusted minister of Emperor Kang-Hsi, used confidential memorials to report to the emperor on several cases, including the trafficking of women in Suzhou, the bribery case involving Chen Rubi, the proposal for voluntary contributions to support the people in Shandong, the warehouse deficit case, and the case of Wang Shan's reckless comments on the succession.

with his officials(Yang, 2003; Fu, 2002). He encouraged local officials to provide him with a broad range of information, including local weather conditions, disasters, acts of kindness, complaints, and assessments of other officials. In Emperor Yung-cheng's reign the privilege to submit memorials was also extended to central government officials such as Hanlin scholars and Imperial Censors, as well as provincial level local officials(Bartlett, 1994; Zhuang, 2016)like governors-general(tsung-tu， 总督), governors(hsun-fu,巡抚), Provincial Administration Commissioner(pu-cheng-shi, 布政使), and Provincial Surveillance Commissioner(An-cha-ssu, 按察使). While Emperor Chien-lung, son of Yung-cheng, allowed all officials to submit memorials,"Influenced by the Legalist philosophy, they emphasize bureaucratic hierarchy and discourage such behaviors(Choi, 2004).[4]

Before confidential memorials were introduced, emperors relied on Ti-pen (题本) and Imperial Censors(Yu-shih 监察道御史) to gather local information.[5] Ti-pen, a public and lengthy process, required officials to send their written memorials to the Ministry of Personnel, where they would be examined by the Censorate, then passed to the cabinet, and finally delivered to the emperor. This process often allowed the emperor's rivals to access critical information first. On the other hand, Censorate reports increasingly became tools for political attacks rather than fulfilling their supervisory role, as conflicts between Manchu and Han officials, along with factional political struggles,[6] intensified. Memorials, unlike the other two methods, became favored by central rulers for providing direct and timely information to the emperor without any clear partisan bias. This system remained in use until the end of the Qing dynasty.

The confidentiality of memorials has always been a significant concern.[7] Emperor Chien-lung set up a new Grand Council,[8] assigning some of the trusted ministers to respond to memorials in order to reduce the emperor's workload (Fairbank and Teng, 1940; Liu, 2023). To ensure the quality of their work, lower-ranking officials were responsible for transcribing the memorials. This meant that the transcribers, inspectors, and ministers who responded to the memorials all knew their contents, which weakened the confidentiality of the memorials(Liang and Zhu, 1983). To strengthen the confidentiality of memorials, the emperor repeatedly required that the Grand Council and the ministers who received secret memorials from the provinces must not disclose their contents, with those who violated this rule being punished. In addition, sev-

[4]Huang Shuwan was twice warned for "unjustified criticism of superiors, violating bureaucratic hierarchy"

[5]The Censorate provided a means for examining administrative practices and judicial oversight during the Qing dynasty, and even allowed for questioning the emperor's conduct (Hucker, 1951).

[6]Censors possessed the power of fengwen (风闻), which allowed them to make accusations without a source. However, this led to the proliferation of rumors. Although the emperor repeatedly issued laws to restrict this power, they had little effect(Gu, 1998; Guy, 2021).

[7]The emperor was highly concerned about the confidentiality of memorials concerning formal rules. park1997corruption mentions an example: in a memorial submitted by Minister of War Agui to Emperor Chien-lung, a commoner named Wu Guozhi's accusation against the local governor was suddenly inserted. The emperor was enraged by this breach of the memorial process and punished Wu Guozhi

[8]We follow bartlett1994monarchs in distinguishing between the Grand Council under Emperor Yung-cheng and Emperor Chien-lung. Under Yung-cheng, the Grand Council was specifically established to handle military affairs. Under Chien-lung, it was expanded to include agents from the inner court and a logistics office. Its essence was not military but rather secret political operations under the guise of "handling affairs under imperial orders."

eral reforms were made to the Grand Council, including standardizing the selection process for lower-ranking officials. In general, the confidentiality of memorials was relatively trustworthy, as many ministers used memorials when impeaching their colleagues.[9]

2.2 Collusion Among Qing Dynasty Officials During Natural Disasters

As a predominantly agricultural empire, the Qing Dynasty was highly susceptible to the effects of natural disasters, which could lead to famine, a decrease in population, and even rebellious inclinations among those suffering from starvation.[10] Consequently, the Qing government prioritized the prediction and relief of agricultural disasters. Local officials were required to monitor rainfall closely from the spring to predict the annual harvest. They had to report accurately on local disasters to the emperor, allowing him to supervise relief efforts and assess the need to mobilize resources from other areas to provide aidBai1999.

However, local officials were incentivized to conceal or under-report disasters to the emperor, because truthfully reporting a disaster could put them at a disadvantage(Huang et al., 2017; Pan and Chen, 2018). Although the Qing Dynasty had an intricate system for assessing officials, the relationship between assessments and promotions was not particularly strong.Instead, the emperor's impression played a more significant role in promotions.[11] Bad news, even if the officials were not to blame, could affect the emperor's mood and create a negative impression of the officials.[12] More importantly, officials might fear that a shrewd emperor could speculate that the current disaster was caused by their incompetence or corruption in previous infrastructure projects. For instance, floods might very well be the result of embezzlement by officials during the construction of dikes and dams, leading to investigations into their misconduct.

Concealing information from the emperor requires all officials aware of the disaster to form an information alliance and act collectively:[13] If any one of them were to reveal the situation to the emperor, the rest would face punishment. This type of alliance is considered feasible by officials because the number of officials in a province who can independently report to the emperor is limited, usually to the three top-ranking officials: the governor-general, governor,

[9]One example is when Zhang Guangsi secretly memorialized to impeach Yue Zhongqi for improper military conduct, stubborn arrogance, and unclear orders. Upon receiving Zhang Guangsi's confidential memorial, Emperor Yung-cheng immediately stripped Yue Zhongqi of his official position.

[10]Many studies have demonstrated the relationship between natural environmental factors and rebellions(Bai and Kung, 2011; Jia, 2014; Miao et al., 2021b). Before the Taiping Rebellion, which resulted in the deaths of 160 million people, various disasters such as floods, droughts, locust infestations, epidemics, and earthquakes occurred frequently, leading to massive displacement and numerous social problemsKang1995.

[11]The emperor sought to retain control over important official appointments, requiring interviews (known as yinjian 引见) with these officials after their evaluations(Huang, 1988).

[12]Ji Xiaolan, due to his outspoken nature and criticism of court affairs, offended Emperor Chien-lung several times, resulting in his demotion to remote areas. These demotions were not due to Ji Xiaolan's political performance but rather to the emperor's displeasure with his frankness.

[13]In the 42nd year of Kang-Hsi's reign, severe floods and droughts struck Shandong, causing widespread famine. The officials collectively concealed the disaster until it was discovered by the emperor during a southern inspection tour.

and Provincial Administration Commissioner.[14] These three officials are responsible for more than 80% of the disaster memorials sent to the emperor. Lower-ranking officials, although authorized to report directly to the emperor, rarely do so. They are afraid that revealing crucial information will provoke retaliation from their superiors, and in many cases, these retaliations are extremely harsh. One example is the case of Li Yuchang, a candidate for county magistrate, who, after uncovering the concealed disaster in Shanyang Prefecture and preparing to report both the disaster and the embezzlement by higher officials, was ultimately murdered by local authorities.Most memorials from lower-ranking officials to the emperor consist of expressions of gratitude and well-wishes.

The information alliance might be ineffective, as the emperor could obtain information through alternative channels. Officials from other provinces, whether they happen to pass through the disaster-stricken province or experience similar calamities in their own regions, might report the situation to the emperor. Alternatively, an active Imperial Censor, who was responsible for oversight, could uncover the situation and report it to the emperor.[15] In such circumstances, local officials could face severe punishment from the emperor.

The emperor was deeply resentful of the information alliances formed by local officials.[16] To him, their failure to report not only signified disloyalty but also, by withholding essential information, undermined his authority to govern the empire.[17] A notable example was when Emperor Jiaqing observed that Zhang Changgen, the Provincial Administration Commissioner of Hubei, and his colleague Zu Zhiwang used the identical phrase " To offer comforting words to His Majesty" (Kou Wei Rui Huai) in their memorials. In the emperor's view, the use of the same phrase indicated that the two had communicated with each other, so he severely criticized them both. To prevent excessive cooperation and information alliances that could undermine his authority, the emperor was careful not to assign officials who had previously collaborated to positions where they might work together again(Wei, 1992).

3 Model

In this section, we develop a model of disaster reporting by government officials tailored to the administration of imperial China under the Qing dynasty. The model aims to capture the

[14]The governor-general and provincial governor share similar responsibilities as the main officials in charge, but the governor-general might manage several provinces. The commissioner of civil affairs is responsible for civil matters.

[15]In the third year of Emperor Chien-lung's reign, Imperial Censor Suozhu discovered flooding in Xiong County while passing through and reported it to the emperor.

[16]In a confidential memorial, Emperor Yung-cheng issued a directive: "If you local officials form cliques for personal gain and deceive your superiors while hiding the truth, I will punish you severely without leniency."

[17]The emperor was particularly concerned about officials forming factions for personal interests. In the fourth year of Yung-cheng's reign (1726), Zhejiang Imperial Censor Xie Jishi impeached Tian Wenjing, the governor of Henan. However, Emperor Yung-cheng discovered that the contents of Xie Jishi's impeachment memorial were consistent with those of Li Fu (Tian Wenjing's rival and another favored courtier of the emperor). Suspecting they had formed a political alliance in secret, the emperor subsequently sentenced Xie Jishi to imprisonment.

first-order features of Qing regional governance: a large number of officials and jurisdictions, frequent rotation of officials to new assignments, a system for direct monitoring of local conditions by the central bureaucracy, and, most importantly for our purposes, a whistle-blowing system. The purpose of the model is to micro found the hypotheses tested in the subsequent empirical analysis.

In practice, a team of officials was assigned to each jurisdiction. The assignments of officials lasted for a fixed period. At the end of the period, officials were reassigned. After reassignment, an official worked in a different jurisdiction with a different team of officials. Given the size of China, the size of the imperial bureaucracy, and the life expectancies of officials, this meant that, over the span of an official's career, it was quite unlikely that reassignments would result in an official working with any of his previous teammates. Although, in practice, imperial officials had may tasks, we focus on only one task: providing information about disasters.

In addition to information from the officials, the central government independently collected information about the condition of jurisdictions though imperfect monitoring by informants. These informants where sometimes able to provide independent reports about provincial conditions.

Finally, the central government also had a whistle-blowing system, i.e., a system permitting officials to confidentially report to the central government conditions in their jurisdiction. When the system functioned as intended, the messages from the officials to the center were confidential. However, reporting systems did not always function as intended. In some cases, the identity of officials sending messages was leaked. When the identify of a whistle blower was leaked, officials working with the official knew that in past assignments, the official had contradicted the "rosy" reports about provincial conditions made by his colleagues.

3.1 Model structure

We aim to approximate these stylized with a simple theoretical model. In the model, the agents are the officials. Officials are members of a countably infinite set, $\mathbb{N}_0 := \{0, 1, 2, \ldots\}$, and are indexed by i. These officials are risk neutral and patient. Officials act in a countable set of periods, $\mathbb{N}_0$, indexed by t. The payoff to a given official in a given period equals the sum of current and future expected rewards.

In period 0, two officials are assigned to each jurisdiction. If officials i_1 and i_2 are assigned to the same jurisdiction in a given period we will say that i_1 and i_2 *partners* in that period and that i_2 is i_1's partner and i_1 is i_2's partner. After periods 0 and 1 end, those officials who are still fit for service, are reassigned, i.e., given a new assignment of partners and jurisdictions. This process of continues ad infinitum. In each period, officials receive rewards based on (a) the messages they send to the center about conditions in their jurisdiction. (b) the messages their partner sends and (c) information produced by central government monitoring. Officials maximize their expected payoffs, the sum of current period rewards and expected future rewards is subsequent periods. The specifics of the model structure are provided in the following subsections.

3.1.1 Inter-period dynamics

Because every jurisdiction is staffed the same two officials for two periods, we call these two-period time blocks *cycles* and the two periods within each cycle are called *stages*. At the conclusion of a cycle, each official is either separated from government employment or continues employment with the civil service and receives a new assignment. The assignment function satisfies the condition that no official partners with the same official more than once.[18]

Continuation occurs with probability $\beta \in (0,1)$ and separation occurs with probability $1 - \beta$. Separation might result from an as exogenous shock, e.g., ill health, or from the official being terminated for performance reasons unrelated to disaster reporting, e.g., oppression of the local population that leads to a rebellion. When an official, say official i, is separated, i's period rewards in subsequent periods equal 0 and a new official is added to the bureaucracy, who is also be labeled with i.

Because the same two officials interact with each other only once, neither official directly observes the actions of other officials in periods before the one and only period where the officials serve together. Because matched officials interact with each other for two periods, we call the first period of interaction stage $s = 0$ and the second stage $s = 1$. Periods can be identified with cycles and stages as follows: for any period t, let c equal the quotient of t resulting from Euclidean division of t by 2 and let s equal the remainder, e.g., period $t = 13$ corresponds to cycle $c = 6$ and stage 1.

Inter-period dynamics are depicted in Figure 1.

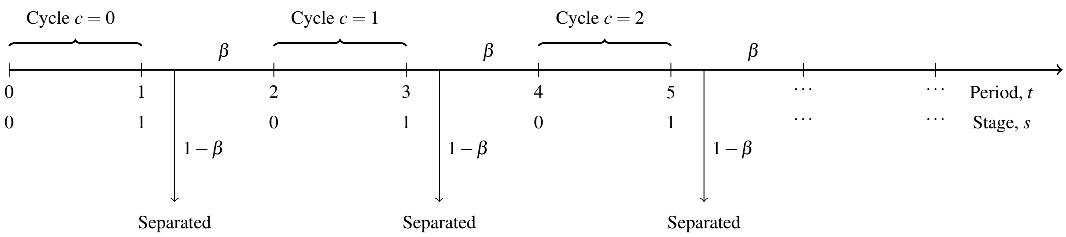


Figure 1. Evolution of officials' careers

3.1.2 The intra-period game

In each jurisdiction, at the start of each period, there are two possible states of the world, $\omega \in \Omega$, where $\Omega = \{\mathscr{D}, -\mathscr{D}\}$, where $\mathscr{D}$ $(-\mathscr{D})$ represents the (non) occurrence of disaster in the period.

[18] Our specification assumes that an assignment exists with the property that, if an official partners with an official in one cycle, the official does not partner with that same official in any other cycle. Given that there are a countably infinite number of cycles, it is not entirely obvious that such assignments exist. In Appendix Section A.1, we show that the existence of such assignments follows from a classical result on graph factorization.

The probability of a disaster in a given period and jurisdiction equals δ. This probability is independent of the probability of a disaster at any other date in any other jurisdiction. Whether a disaster occurred in a given period/jurisdiction is common knowledge shared between the two officials. After observing whether a disaster occurred, official send confidential message to the center related to whether a disaster occurred.

The central government does not directly observe whether a disaster occurred. However, the central government has monitoring mechanisms that gather information about jurisdictions. In a given jurisdiction and period, the mechanism produces two signals: a perfectly informative signal that reveals $\omega \in \{\mathscr{D}, -\mathscr{D}\}$ and an uninformative signal. The informative signal is realized with probability η. This probability, η, is random and varies across periods and jurisdictions. In each period/jurisdiction, the value of η is determined by an independent draw from the realizations of random variable, $\tilde{\eta} \overset{\text{dist}}{=} \text{Uniform}[0,1]$. At the start of each period, the officials observe $\eta \in [0,1]$, i.e., they know how effectively they are being monitored by the central government in the current period. However, they do not observe whether monitoring actually revealed the disaster before they send messages to the center. The sequencing of actions in each period is formally described below.

- In each period at each jurisdiction, the two officials observe whether a disaster has occurred and observe the efficiency of monitoring, η drawn from $\tilde{\eta}$ for the jurisdiction and the period.
- The two officials, $i = 1,2$ send messages, m^i, where $m^i \in M = \{\mathscr{D}, -\mathscr{D}\}$.
- If no disaster occurred, i.e., $\omega = -\mathscr{D}$, officials always report no disaster and each receives a reward of u.
- If a disaster occurred, i.e., $\omega = \mathscr{D}$, the rewards to the officials depend on the messages they send and on whether monitoring revealed the disaster.
  - If both officials send message $\mathscr{D}$, each official receives a reward of d.
  - If one official sends message $\mathscr{D}$, and the other sends message $-\mathscr{D}$, the official sending $\mathscr{D}$ receives a period reward of b, and the official sending $-\mathscr{D}$ receives 0.
  - If both officials send $-\mathscr{D}$ then
    * if monitoring does not reveal $\mathscr{D}$, both officials receive u,
    * if monitoring reveals $\mathscr{D}$, both officials receive 0.

The intra-period game played by the officials is depicted in Figure 2.

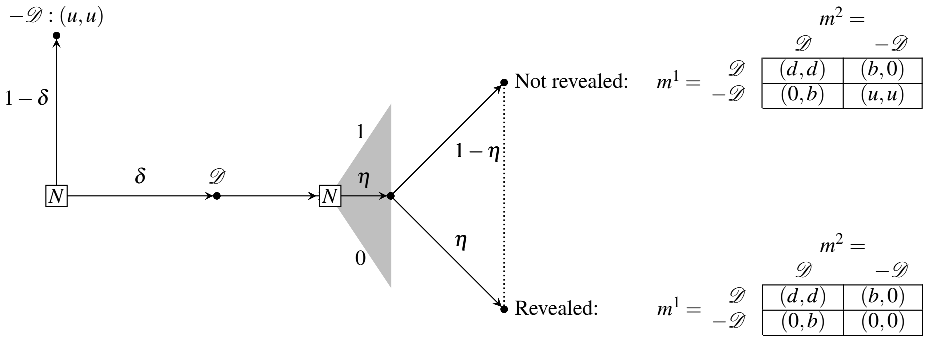


Figure 2. Game played in each period

In our baseline analysis, we concentrate our attention on parameters that make the single shot game "interesting" in the sense that neither always reporting disasters nor always covering up disasters is a dominant strategy. We discuss these assumptions in Section 3.2, after we have developed some understanding of the tradeoffs determining officials' strategies.

Assumption 1. $$0 < d < b < u < d + b.$$

3.1.3 The whistle-blowing system

The messages sent by an official in a given cycle are observed by the central government, the official himself, and the official's partner in a given cycle. If the whistle-blowing system is leak proof, because the assignment system ensures that the future partners of the official do not included his past partners, in the current cycle, the officials will not observe the message history of their partners. If a whistle-blowing system is leaky, there is some chance that messages sent by an in past cycles will be leaked and thus become common knowledge.

We model leakage in a very simple fashion: We term an official who, in either stage 0 or stage 1, who sent the disaster message when his partner sent the no-disaster message an *informer*. Note that sending the disaster message when, in fact a disaster did not occur, is a strictly dominated strategy. So an official can only be an informer in a cycle/stage where a disaster, in fact, occurred. Informers in a given cycle are *identified* with probability ι. Thus, at the end of a cycle, the set of identified officials equals the set of all officials identified in the cycle plus all officials identified in previous cycles. We represent the set of official identified by the end of cycle c, with I_c. The formal mathematical definition of I_c, which is rather clunky, is provided in the Appendix Section A.3.

3.2 Equilibria in the one-shot game

Before we proceed to analyze the dynamic model, we consider a single-shot game where officials only send messages in only one period. As the following result, Result 1, shows, in the one-shot game there are at most two Nash equilibria. In the first equilibrium, which we call the *disclosure* equilibrium, both officials report the disaster, i.e., $m^1 = m^2 = \mathscr{D}$, in the second, which we call the coverup equilibrium, neither official reports the disaster, i.e., $m^1 = m^2 = -\mathscr{D}$. the number of equilibria and their properties depend on the intensity of monitoring.

Let,

$$\eta_N := \frac{u-b}{u}, \quad \eta_{\text{PO}} := \frac{u-d}{u}. \tag{1}$$

Note that $\eta_N = 1-(b/u)$; b/u is a normalized measure of the single period reward for "blowing the whistle" on a partner official attempting to cover up a disaster. Hence, parameter changes that increase η_N decrease the *whistle-blowing reward*. Similarly we can think of η_{PO} as the *disaster penalty* imposed on officials simply because the officials truthfully reported a disaster, e.g. an earthquake, which, given modern theories of physical causation, would not be attributed official misconduct. As the following result shows, equilbrium outcomes and offical welfare in the one-shot game are largely determined by η_N and η_{PO}.

Result 1. For any fixed level of monitoring efficiency, η, the Nash equilibria of the single-shot game satisfy the following conditions.

(a) For all $\eta \in [0,1]$, a disclosure equilibrium exists.

(b) A cover-up equilibrium exists if and only if $\eta \in [0, \eta_N]$.

(c) Cover-up is Pareto optimal if and only if $\eta \in [0, \eta_{\text{PO}}]$.

(d) The disclosure equilibrium is risk dominant.

Result 1 shows that the disclosure equilibrium is supported by all levels of monitoring efficiency, η. If an official fails to disclose a disaster and his partner discloses, then the official's reward is $0 < d$, the reward from reporting. When $\eta \leq \eta_N$, a cover-up equilibrium also exists. If both officials report no disaster, each officials payoff equals 0, if monitoring reveals the disaster, and equals u, if monitoring does not reveal the disaster. The probability of revelation is η. Thus, the payoff from following the coverup strategy to a given official is $(1-\eta)u$. Defecting from the coverup equilibrium produces a payoff of b. Thus the Nash condition is satisfied if and only if $(1-\eta)u \geq b$, i.e., $\eta \leq \eta_N$. The equilibrium payoff of officials in the cover-up equilibrium is $(1-\eta)u$ and is d in the disclosure equilibrium. Thus, the cover-up outcome is Pareto optimal (for the officials) if and only if $\eta \leq \eta_{\text{PO}}$. Because, $u > b$, $\eta_N < \eta_{\text{PO}}$. Hence, for η under which a cover-up equilibrium exists, it produces a higher payoff to the officials than a disclosure equilibrium. For $\eta \in (\eta_N, \eta_{\text{PO}})$, the cover-up outcome maximizes the official's payoffs but the cover-up outcome cannot be supported by a Nash equilibrium in the one-shot game.

Finally we show, in Appendix Section A.2, that the disclosure equilibrium is always risk dominant (Harsanyi, 1995; Harsanyi and Selten, 1988). Thus, when $\eta \leq \eta_N$, the game has two equilibria, one equilibria, the cover-up equilibrium, is Pareto dominant (frequently called "payoff dominant" in the literature) and the other, the disclosure equilibrium, is risk dominant. The risk-dominant equilibrium is, roughly speaking, the equilibrium that minimizes the risk generated by strategic uncertainty, i.e., uncertainty about the other agent's actions. 2×2 games in which one equilibrium is risk dominant and another is Pareto optimal are called "Stag-hunt games." Such games have been the subject of considerable interest in the literature.[19] Aumann (1990) argues that the when the payoff dominance and risk dominance refinements point to different equilibria, trust between the parties, largely determined by cultural conventions, determines the equilibrium most likely to be played.

At this point, the implications of the parameter assumptions (Assumption 1) are fairly easy to identify. The assumption that $d > 0$ simply implies that, when monitoring reveals a disaster, the officials' payoffs are higher when they disclose rather than when are caught sending misleading messages to the center. So $d > 0$ is a required assumption for modeling any administrative system that aims for truthful disclosure by officials.

The assumption that $b > d$, is more interesting. This assumption implies that an officials reward for disclosing a disaster is larger when his partner attempts to covers up the disaster, b, than when his partner also discloses, d. So our assumption that $b-d > 0$ amounts to assuming that the benefits of informing exceeds the costs of partner retaliation. If this assumption was reversed, and we assumed instead that $b-d < 0$, equation (1), shows that $\eta_{\mathrm{PO}} < \eta_N$. This implies that whenever covering up disasters is Pareto optimal for any two paired officials, a coverup equilibrium exist even in the one-shot game. As we shall see, in a multiperiod setting, the one-shot Nash equilibrium is always supported by a Nash equilibrium of the multiperiod game. So, under the assumption that $b-d < 0$, whenever coverup is in the interests of the officials, a coverup equilibrium exists.

Although the Qing civil service examination system was much more meritocratic than the patronage-based civil service systems then current in the West, some officials, typically ethnic Manchu officials, had strong ties to the Imperial court. Such partners could impose significant cost an official who contradicted their reports about jurisdictional conditions. Thus, officials at some point in their careers could well partner with a politically powerful official able to impose retaliation costs exceeding the rewards from informing. For the sake of tractability, our model assumes that official are homogeneous and thus we cannot capture this possibility in our model. However, we do take this situation into account in our empirical analysis.

The assumption that $u > d$ captures a consensus belief under the Qing period: official malfeasance, e.g., extortion, corrupt administration of justice, etc. can cause natural disasters. The assumption that $b < u$ is required to fit the stylized fact that misreporting by officials was alway in the direction of underreporting disasters. If $b-u > 0$, then, for η sufficiently small, in any Nash equilibrium, the probability that, in a no-disaster state, an official reports a disaster is positive, i.e. officials will with some probability "cry wolf" and report no-existent disasters.

The assumption that $d+b > u$ ensures that, in the one-shot game, disclosure equilibria are risk dominant for all possible realizations of monitoring intensity, $\eta \in [0,1]$. Thus, in the

[19]See Van Damme (Section 5, 2002) for more detailed discussion, from a rational choice perspective, of risk dominance versus payoff dominance and see (Young, 1993) for an analysis based on a learning-based equilibrium refinements.

one-shot setting, this assumptions simplifies the discussion of equilibrium configurations, and, in the subsequent multiperiod analysis, simplifies some of the discussion of the plausibility of collusive strategies.

3.3 The multiperiod game

We now consider complete game and address the following question: what is the scope for coverup equilibria in the dynamic setting described in Section 3.1? We start our analysis with two observations: first, as shown in Section 3.2, even if we ignore incentive compatibility, covering up disasters does not always maximize officials' payoffs. When monitoring intensity, η, is very high, i.e., $\eta > \eta_{\text{PO}}$, external monitoring is likely to reveal disasters and thus, attempts to coverup disasters are likely to fail and simply result in the officials being punished for their duplicity. In such cases, officials' welfare is reduced by covering up disasters. Second, the memoryless dynamic strategy of simply covering up the disaster in all disaster periods in which $\eta \leq \eta_N$ and disclosing whenever $\eta > \eta_N$, is a Nash equilibrium of the dynamic game. Thus, at the least, officials can obtain the payoff from covering up whenever $\eta \leq \eta_N$.

Because, $0 < \eta_N < \eta_{\text{PO}} < 1$, we will consider strategies for officials in the dynamic game that stipulate cutoff levels for disclosure between η_N and η_{PO}. Under such strategies, officials coverup disasters when monitoring intensity, η is less than the cutoff and disclose disasters when monitoring intensity exceeds the cutoff. We call these cutoff levels *coverup thresholds* and label them with $\hat{\eta}_s$, $\hat{\eta}_s \in [\eta_N, \eta_{\text{PO}}]$ and $s = 0, 1$.

Remark 1. As one might expect, when officials play coverup threshold strategies, coverup thresholds determine the probability that disasters will be concealed from the central government. To see this, note that s disaster in stage s will be concealed if and only if (a) a disaster occurs, (b) the officials "cover up" the disaster, i.e., both officials send the no-Disaster message, and (c) monitoring does not reveal the disaster. Conditioned on a disaster occurring, the probability that the officials coverup, is $\mathbb{P}[\tilde{\eta}_s \leq \hat{\eta}_s]$. Because, $\tilde{\eta}_s$ is uniformly distributed between 0 and 1, this probability equals $\hat{\eta}_s$. The probability that monitoring does not reveal given that monitoring intensity equals η is $1 - \eta$. Hence, conditioned on a disaster occurring, the probability that the disaster is concealed, which henceforth we refer to as the *coverup probability*, equals

$$\int_0^{\hat{\eta}_s} (1 - \eta)\, d\eta = \frac{1}{2}\left(1 - (1 - \hat{\eta}_s)^2\right).$$

Inspection of the this equation shows that the coverup probability is strictly increasing function of the coverup threshold.

3.4 Coverup strategies

Since the game is symmetric, the random moves of nature which produce realized monitoring intensity in each stage and cycle are independently and identically distributed, we consider only symmetric Markovian equilibria where the state variables are the stage, s, the realized monitoring intensity, η, in the cycle/stage, and I_c, the set of identified informers at the start of the cycle, c. First, consider *cycle strategies*: strategies that officials might adopt in a given cycle. Because we restrict attention to symmetric equilibria, we suppress subscripting by i, the index counter for officials. We define two cycle strategies which we will combine to define candidate strategies for officials in the dynamic game.

1. Disclosure cycle strategy: In both stages 0 and 1, send the disaster message if and only if a disaster occurred.
2. $(\hat{\eta}_0, \hat{\eta}_1)$-cycle coverup strategy: In both stage 0 and stage 1, send the no-disaster message if a disaster did not occur. If a disaster occurred, then
   - In stage 0, send the no-disaster message if $\eta_0 \leq \hat{\eta}_0$; otherwise, send the disaster message.
   - In stage 1, If the official' cycle partner sent the same message the official sent in in stage 0 and $\eta_1 \leq \hat{\eta}_1$, send the no-disaster message; Otherwise, send the disaster message.

A $(\hat{\eta}_0, \hat{\eta}_1)$-*coverup strategy* is defined as follows: If the official and the official's partner have not been identified at the start of cycle c, use the $(\hat{\eta}_0, \hat{\eta}_1)$-cycle coverup strategy. Otherwise, use the disclosure cycle strategy. A more formal mathematical definition is provided in Appendix Section A.4.

One game theoretic interpretation of coverup strategies, in the spirit of Aumann (1990) and Young (1993), is that coverup strategies represent a convention that stipulates when officials disclose and when they coverup disasters. An official will follow this convention, and expect his parter to follow the convention, as long as he has not observed, either through information leaking out of the whistle-blowing system or partner actions in previous stages of the current cycle, that his partner has violated the convention and his partner has not observed that he has violated the convention. Otherwise, trust that convention will be followed in the current cycle collapses, creating considerable strategic uncertainty. In which case, both officials adopt the risk-dominant disclosure cycle strategy.

3.5 Payoffs

Our aim is to identify conventions that are self-enforcing, i.e., Nash equilibria, and then determine the self-enforcing convention that maximizes the Officials' payoffs. To do this, we need to first calculate the officials' payoffs. Since we aim to derive the conditions the symmetric Markovian coverup strategies described in Section 3.4, we focus on the payoffs resulting from following the coverup strategies and the payoffs resulting from defection from the coverup strategies.

For a given cycle c, consider stages and jurisdictions such that a disaster occurred in stage $s \in \{0, 1\}$. If the two official send the no disaster message, $-\mathscr{D}$ whenever $\eta_s \leq \hat{\eta}_s$ and send the disaster message, $\mathscr{D}$, when $\eta_s > \hat{\eta}_s$, then our assumption that $\hat{\eta}$ is uniformly distributed implies that each official's expected reward in the stage equals $r(\hat{\eta}_s)$, where $r : [\eta_N, \eta_{\mathrm{PO}}] \to \mathbb{R}$, is defined as follow:

$$r(\hat{\eta}) := \int_0^{\hat{\eta}} (1-\eta)\, u\, d\eta + (1-\hat{\eta})\, d = u\frac{1}{2}(2-\hat{\eta})\,\hat{\eta} + d\,(1-\hat{\eta}). \tag{2}$$

If the two officials truthfully disclose, each receives a reward of d. We represent difference between $r(\hat{\eta})$ and d with $\Delta r(\hat{\eta})$ and note that

$$\Delta r(\hat{\eta}) := r(\hat{\eta}) - d = u\frac{1}{2}\hat{\eta}\,(2\,\eta_{\mathrm{PO}} - \hat{\eta}). \tag{3}$$

Two simple properties of Δr will be important for the subsequent analysis and are noted in the next lemma.

Lemma 1. $\Delta r > 0$ *and is strictly increasing in* $\hat{\eta}$.

Proof. The lemma follows from inspection of equation (3). □

Now consider the future expected payoff. At the start of cycle c, let V_N, represent the payoff to a given official if all officials follow the cycle coverup strategy in cycle c and all cycles after c. In cycles $(c, c+1, c+2, \ldots)$ the official expected reward in each cycle is $(\delta\, r(\hat{\eta}_0) + (1-\delta)\, u) + \big(\delta\, r(\hat{\eta}_1) + (1-\delta)\, u\big)$ if the official has not been separated before the start of the cycle and equals 0 otherwise. Because the probability of not being separated after the end of any cycle is β, the expected future payoff at the start of cycle c equals

$$\sum_{k=0}^{\infty} \beta^k \Big(\delta\, r(\hat{\eta}_0) + (1-\delta)\, u\big) + \big(\delta\, r(\hat{\eta}_1) + (1-\delta)\, u\big)\Big).$$

We denote this expected payoff with V_N. Using the geometric summation formula, we see that

$$V_N(\hat{\eta}_0, \hat{\eta}_1) = \frac{\big(\delta\, r(\hat{\eta}_0) + (1-\delta)\, u\big) + \big(\delta\, r(\hat{\eta}_1) + (1-\delta)\, u\big)}{1-\beta}, \tag{4}$$

Similarly the expected payoff to a given official assuming that the official and all of the official's future partners follow the cycle disclosure strategy in cycle c all future cycles, denoted by V_I is

$$V_I(\hat{\eta}_0, \hat{\eta}_1) = \frac{\big(\delta\, d + (1-\delta)\, u\big) + \big(\delta\, d + (1-\delta)\, u\big)}{1-\beta}.$$

The difference between V_N and V_I, denoted by ΔV defines a function $\Delta V : [\eta_N, \eta_{\mathrm{PO}}]^2 \to \mathbb{R}$, where

$$\Delta V(\hat{\eta}_0, \hat{\eta}_1) := V_N(\hat{\eta}_0, \hat{\eta}_1) - V_I(\hat{\eta}_0, \hat{\eta}_1) = \delta\, \frac{\Delta r(\hat{\eta}_0) + \Delta r(\hat{\eta}_1)}{1-\beta}. \tag{5}$$

3.6 Viability of coverup strategies

Using the definitions of Δr, and ΔV we can now develop the conditions that must be satisfied for the $(\hat{\eta}_0, \hat{\eta}_1)$-coverup strategy to be a Nash equilibrium. In each stage of each cycle each official decides whether to follow the coverup strategy or defect. Because the officials' actions are "hardwired" when no disaster occurs, we need only consider disaster states. In a disaster state, officials observe monitoring efficiency and then decide whether to follow the coverup strategy. If all other officials are following the coverup strategy in cycles before c, then no officials have been identified as informers at the start of c, i.e., $\mathrm{Id}_c = \varnothing$. The coverup strategy will be a Nash equilibrium, if and only if, in both stages 0 and 1 of each cycle, no official can defect from the coverup strategy and increase his expected payoff.

When the coverup strategy calls for reporting the disaster in stage s, i.e., $\eta_s > \hat{\eta}_s$, then defecting from the coverup equilibrium by not reporting the disaster is clearly not optimal for any official. Because the official's cycle partner is following the cycle coverup strategy, the partner will report the disaster. Thus, the payoff to the defecting official in the current stage from defection is 0 and the payoff from following the coverup strategy is d. Moreover, if defection occurs in stage 0, then, in stage 1, because his partner is following the coverup strategy, and the coverup strategy calls for the partner to switch to the disclosure cycle strategy when the partners send different messages in stage 0. The best stage 1 response of an official who defected in stage 0, will be to also disclose the disaster. This produces a lower expected stage 1 payoff for the defecting offical than the expected reward from following the coverup strategy. Thus, when $\eta_s > \hat{\eta}_s$, defecting from the coverup equilibrium by not reporting the disaster lowers the current cycle payoff of the defecting official. Because being an "overeager disaster concealer" does not risk being identified as an informer, expected future cycle rewards given this sort of defection are the same as future cycle payoffs from non-defection and equal to V_N. Thus, when $\eta_s > \hat{\eta}_s$, defecting always results in lower cycle payoffs and never increases expected future cycle rewards. Thus, when $\eta_s > \hat{\eta}_s$, defecting from the coverup cycle strategy is never optimal.

Thus, the viability of a coverup strategy depends only on the viability of the coverup strategy when the strategy calls for reporting no disaster, i.e., when $\eta_s \leq \hat{\eta}_s$ in a given stage and a disaster occurs in that stage. The coverup strategy will be viable if and only if the payoff from conforming with the coverup strategy at least equals the payoff from "whistle-blowing," i.e., sending the disaster message when the officials cycle partner is conforming with the coverup strategy and is thus sending the no-disaster message. The conditions for conformity with the coverup strategy being a best response in stage 1 and stage 2 are provided below.

$$\text{Stage 0: for all } \eta_0 \in [0,\hat{\eta}_0] \qquad \underbrace{\big((1-\eta_0)u-b\big)}_{\text{T1}}+\underbrace{\delta\,\Delta r(\hat{\eta}_1)}_{\text{T2}}+\beta\,\underbrace{\iota\,\Delta V(\hat{\eta}_0,\hat{\eta}_1)}_{\text{T3}} \geq 0. \tag{6}$$

$$\text{Stage 1: for all } \eta_1 \in [0,\hat{\eta}_1] \qquad \overbrace{\big((1-\eta_1)u-b\big)}^{\text{T1}}+\beta\,\overbrace{\iota\,\Delta V(\hat{\eta}_0,\hat{\eta}_1)}^{\text{T3}} \geq 0; \tag{7}$$

Equation (7) provides the Nash condition for stage 1. In this stage the official knows that rotation will occur at the end of the stage. So the effects of defection are captured by its effects on stage 1 rewards and expected rewards in future cycles. The effect on stage 1 rewards is captured by term T1: because $\eta_1 \leq \hat{\eta}_1$, the coverup strategy calls for an official to report no disaster, the official's partner is compliant with the coverup strategy, so the partner reports no disaster. If the official complies, the officials payoff is u if monitoring does not reveal the disaster, which occurs with probability $1-\eta$ and equals 0 if monitoring reveals the disaster (see Figure 2). Thus the stage 1 reward for compliance is $(1-\eta)\,u$. If the official defects, his stage 1 payoff equals b. So the difference between the stage 1 payoff from compliance and defection equals $(1-\eta)u-b$.

The change in an official's expected payoff in future cycles is given by term T3. If the official complies, future expected payoffs in cycles $(c+1,c+2,\ldots)$ are given by V_N. If the official does not copy and "blows the whistle" by sending the disaster message, then, if the official's whistle blowing is not observed by the officials future partners, the official's expected future payoff is also V_N; but, if an official's whistle blowing is leaked to the other officials, which occurs with probability ι, the coverup strategy calls for all future partners of the official to play the cycle disclosure strategy. In this case, the official's expected future payoff equals V_I. Thus, the expected difference between the official's expected future payoffs under compliance with the equilibrium and defection equals $\iota\,\Delta V$. Because, the probability that an official in cycle c will be an official in cycle $c+1$ is β, the expected effect of defection in cycle c on the official's payoff is $\beta\,\iota\,\Delta V$.

At stage 0, there is another effect of defection, captured by term T2. If the official defects in stage 0, defection will be observed by his partner. The coverup cycle strategy calls for the partner, after observing defection in stage 0 to report a disaster if it occurs. If the official complies in stage 0, the partner reports the disaster only when realized monitoring efficiency $\eta \leq \hat{\eta}_1$. As shown in equation (3) the expected difference between rewards under compliance and defection when a disaster occurs in stage 1 is Δr. Because the probability of a disaster occurring in stage 1 equals δ, the anticipated effect of stage 0 defection on stage 1 rewards equals $\delta\,\Delta r$.

Next note that because the gain from complying with the coverup equilibrium is decreasing in realized monitoring efficiency, the inequalities in equations (7) and (6) will be satisfied for all $\eta \in [0,\hat{\eta}_s]$ if and only if they are satisfied for $\eta = \hat{\eta}_s$. So we can reduce the question of whether a coverup strategy is a Nash equilibrium to the question of whether the following inequalities are satisfied:

$$\begin{aligned}
&\text{Stage 0:} \quad \big((1-\hat{\eta}_0)\,u - b\big) + \delta\,\Delta r(\hat{\eta}_1) + \beta\,\iota\,\Delta V(\hat{\eta}_0,\hat{\eta}_1) \geq 0,\\
&\text{Stage 1:} \quad \big((1-\hat{\eta}_1)\,u - b\big) + \beta\,\iota\,\Delta V(\hat{\eta}_0,\hat{\eta}_1) \geq 0.
\end{aligned} \tag{8}$$

Next note that, the definition of the highest level of monitoring intensity consistent with coverup in the one-shot game, η_N (Result 1) shows that $(1-\hat{\eta}_s)\,u - b = u\,(\eta_N - \hat{\eta}_s)$. Thus, substituting in the definitions of ΔV, Δr and rearranging shows that, the inequalities in expression (8) can be expressed as follows:

$$\begin{aligned}
&\text{Stage 0:} \quad u\left(\left(\frac{\beta\,\iota}{2\,(1-\beta)}\,\delta\,\left(2\,\eta_{\mathrm{PO}}^2 - (\eta_{\mathrm{PO}}-\hat{\eta}_1)^2 - (\eta_{\mathrm{PO}}-\hat{\eta}_0)^2\right) + \eta_N\right) + \delta\,\hat{\eta}_1\left(\eta_{\mathrm{PO}} - \frac{\hat{\eta}_1}{2}\right) - \hat{\eta}_0\right) \geq 0,\\
&\text{Stage 1:} \quad u\left(\left(\frac{\beta\,\iota}{2\,(1-\beta)}\,\delta\,\left(2\,\eta_{\mathrm{PO}}^2 - (\eta_{\mathrm{PO}}-\hat{\eta}_1)^2 - (\eta_{\mathrm{PO}}-\hat{\eta}_0)^2\right) + \eta_N\right) - \hat{\eta}_1\right) \geq 0.
\end{aligned} \tag{9}$$

In order to simplify these rather bulky expressions, first we define

$$\kappa := \frac{\beta\,\iota}{2\,(1-\beta)}. \tag{10}$$

Next, note that the specific value of $u > 0$, has no effect on whether the inequalities in equation (9) are satisfied. Thus, henceforth, without loss of generality, we drop u from the equilibrium conditions. Now define the following functions, e_0 and e_1 as follows:

$$e_0(\hat{\eta}_0,\hat{\eta}_1) := \kappa\,\delta\,\left(2\,\eta_{\mathrm{PO}}^2 - (\eta_{\mathrm{PO}}-\hat{\eta}_1)^2 - (\eta_{\mathrm{PO}}-\hat{\eta}_0)^2\right) + \eta_N + \delta\,\hat{\eta}_1\left(\eta_{\mathrm{PO}} - \frac{\hat{\eta}_1}{2}\right), \tag{11}$$

$$e_1(\hat{\eta}_0,\hat{\eta}_1) := \kappa\,\delta\,\left(2\,\eta_{\mathrm{PO}}^2 - (\eta_{\mathrm{PO}}-\hat{\eta}_1)^2 - (\eta_{\mathrm{PO}}-\hat{\eta}_0)^2\right) + \eta_N. \tag{12}$$

Thus, using simplifications and definitions (equations (11) and (12)) we have shown that we can characterize the equilibrium conditions, equation (9), compactly as follows:

Lemma 2. *A coverup strategy, $(\hat{\eta}_0,\hat{\eta}_1)$, is a Nash equilibrium if and only if*

$$(\hat{\eta}_0,\hat{\eta}_1) \in [\eta_N,\eta_{PO}]^2, \tag{C}$$

$$e_0(\hat{\eta}_0,\hat{\eta}_1) \geq \hat{\eta}_0, \tag{Eq-0}$$

$$e_1(\hat{\eta}_0,\hat{\eta}_1) \geq \hat{\eta}_1. \tag{Eq-1}$$

3.7 Optimal coverup strategies

Let,

$$\mathscr{N}_{\text{eq}} = \{(\hat{\eta}_0, \hat{\eta}_1) \in [\eta_N, \eta_{\text{PO}}]^2 : e_0(\hat{\eta}_0, \hat{\eta}_1) \geq \hat{\eta}_0 \ \& \ e_1(\hat{\eta}_0, \hat{\eta}_1) \geq \hat{\eta}_1\}.$$

represent the set of Nash coverup strategies. Our aim is to find the Nash coverup strategy that maximizes officials' welfare. Along the equilibrium path, the payoff to officials under the $(\hat{\eta}_0^*, \hat{\eta}_1^*)$-coverup strategy equals $V_N(\hat{\eta}_0^*, \hat{\eta}_1^*)$. Thus we can define an optimal coverup strategy as follows.

Definition 1. At coverup strategy $(\hat{\eta}_0^*, \hat{\eta}_1^*)$ is an *optimal coverup equilibrium* if

$$V_N(\hat{\eta}_0^*, \hat{\eta}_1^*) = \max\{V_N(\hat{\eta}_0, \hat{\eta}_1) : (\hat{\eta}_0, \hat{\eta}_1) \in \mathscr{N}_{\text{eq}}\}.$$

Abstracting from technical details, the solution to the problem of identifying optimal coverup equilibria depends on only two properties of the problem. First, as inspection of equations (11) and (12) shows, officials' welfare is strictly increasing in the coverup threshold, i.e., ceteris paribus, increasing either $\hat{\eta}_0$ or $\hat{\eta}_1$ strictly increases the objective function, V_N. Second, as inspection of equations (11) and (12) shows, e_0 is increasing in $\hat{\eta}_1$ and e_1 is increasing in $\hat{\eta}_0$. Thus, increasing e_0 (e_1) relaxes constraint Eq-1 (Eq-0). Hence, if $(\hat{\eta}_0, \hat{\eta}_1)$ is a Nash equilibrium and, for either $s = 0$ or $s = 1$, $\hat{\eta}_s \neq \eta_{\text{PO}}$ and constraint (Eq-s) is not satisfied as an equality, $\hat{\eta}_s$ can be increased without violating either (Eq-1) or (Eq-0). This implies, by our first observation, that the $(\hat{\eta}_0, \hat{\eta}_1)$-coverup strategy is not optimal. This analysis yields the following result.

Lemma 3. *If* $(\hat{\eta}_0^*, \hat{\eta}_1^*)$ *is an* optimal coverup equilibrium, *then* $(\hat{\eta}_0^*, \hat{\eta}_1^*)$ *satisfies the following* complementary slackness conditions*:*

$$\hat{\eta}_0 - e_0(\hat{\eta}_0^*, \hat{\eta}_1^*) \geq 0, \qquad \eta_{PO} - \hat{\eta}_0 \geq 0, \qquad (e_0(\hat{\eta}_0^*, \hat{\eta}_1^*) - \hat{\eta}_0)(\eta_{PO} - \hat{\eta}_0) = 0; \tag{13}$$

$$\hat{\eta}_1 - e_1(\hat{\eta}_0^*, \hat{\eta}_1^*) \geq 0, \qquad \eta_{PO} - \hat{\eta}_1 \geq 0, \qquad (e_1(\hat{\eta}_0^*, \hat{\eta}_1^*) - \hat{\eta}_1)(\eta_{PO} - \hat{\eta}_1) = 0. \tag{14}$$

Proof. See Appendix Section A.5. □

To complete our derivation, we show that the complementary slackness conditions in Lemma 3 are equivalent to $(\hat{\eta}_0, \hat{\eta}_1)$being a fixed point of the map

$$T(\hat{\eta}_0, \hat{\eta}_1) := (\min[e_0(\hat{\eta}_0, \hat{\eta}_1), \eta_{\text{PO}}], \min[e_1(\hat{\eta}_0, \hat{\eta}_1), \eta_{\text{PO}}]).$$

Then, using Tarski's lattice fixed point theorem (Tarski, 1955) and Marinacci and Montrucchio's (2019) uniqueness conditions for Tarski fixed points, we show that a fixed point of T

exists and that this fixed point is unique.[20] These results allow us to establish our characterization of optimal coverup strategies which is provided by the next proposition.

Proposition 1. *There exists a unique optimal coverup equilibrium.*

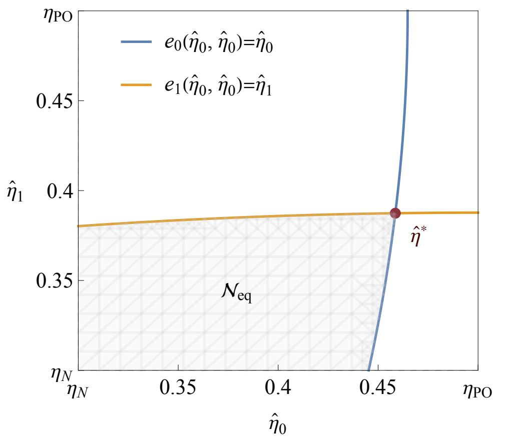
Proof. See Appendix Section A.5. □

An example of a coverup equilibrium is provided in Figure 3. In both panels, $\hat{\eta}_0^* > \hat{\eta}_1^*$, i.e., the probability that officials coverup disasters is larger when the reassignment date is more distant, date 0 than when the reassignment date is near, date 1. We will show in the following proposition that the this is a general feature of the model. Also note that, in Panel **??** of the figure, the whistle blowing system is only "slightly" leaky, i.e. $\iota = 0.15$. Yet the coverup probabilities in the dynamic game, provided by the point $\hat{\eta}^*$ are significantly larger than the coverup probabilities in the one-shot game coverup equilibrium provided by the point (η_N, η_N). In the figure, we compute the fixed point by starting and the minimum point of the lattice $[\eta_N, \eta_{\text{PO}}]^2$, (η_N, η_N), and iterating T.[21] Tarski's theorem ensures convergence of the iterates to the fixed point.[22]

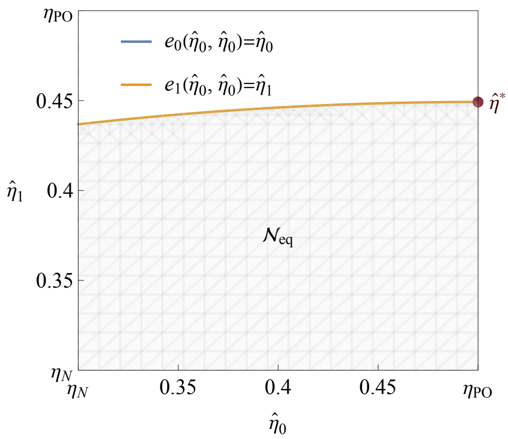
[20] It is possible to solve for interior optimal coverup equilibria algebraically by using the closed-form solution for the roots of a quintic equation. However, this "solution" is very opaque and very long. Merely writing down the closed-solution uses up about one page of text. Moreover, the fixed-point analysis can be easily extended to encompass more stages and/or the more of officials assigned to jurisdictions. However, the algebraic approach is not extensible. Algebraically solving an extended version of he model requires finding closed-form expressions for the roots of polynomials of degree greater than four. Such closed-form expressions generally do not exist.

[21] In other words, by defining the sequence, $\eta^n := (\hat{\eta}_0^n, \hat{\eta}_1^n)$, $n \in \mathbb{N}_0$ by $\hat{\eta}^0 = (\eta_N, \eta_N)$ and $\hat{\eta}^n = T(\hat{\eta}^{n-1})$, for $n \geq 1$.

[22] In fact, convergence can be quite fast: four iterations of T are sufficient for matching the first four digits of $\hat{\eta}^*$ in the panels of the figure.



[$\iota = 0.15$]



[$\iota = 0.50$]

Figure 3. *Optimal coverup equilibria.* In the panels, the horizontal (vertical) axis depicts $\hat{\eta}_0$ ($\hat{\eta}_1$). The optimal coverup equilibrium is represented by $\hat{\eta}^* := (\hat{\eta}_0^*, \hat{\eta}_1^*)$. The common parameters for the example are $\beta = 0.80$, $\eta_N = 0.30$, $\eta_{\text{PO}} = 0.50$, and $\delta = 0.60$. In panel **??**, the probability that the identity of a whistle-blower will be leaked, ι, is 0.15; In panel **??**, the probability that the identity of a whistle-blower will be leaked, ι, is 0.50. In Panel **??**, the optimal coverup equilibrium, $(\hat{\eta}_0^*, \hat{\eta}_1^*) \simeq (0.4586, 0.3874)$. In Panel **??**, the optimal coverup equilibrium, $(\hat{\eta}_0^*, \hat{\eta}_1^*) \simeq (0.5000, 0.4492)$.

The comparative static properties of the equilibrium, which define the hypotheses we test in the subsequent analysis, are presented in the following proposition. The proposition uses the strictly monotonic relationship between coverup thresholds and and coverup probabilities verified in Remark 1.

Proposition 2. *In the unique optimal coverup equilibrium, the coverup probabilities in stage 0, $\hat{\eta}_0^*$, and stage 1, $\hat{\eta}_1^*$ satisfy the following conditions:*

(a) The coverup threshold is larger stages where reassignment date is more distant, i.e., $\hat{\eta}_0^* > \hat{\eta}_1^*$, unless both thresholds equal the Pareto optimal threshold η_{PO}.

(b) The coverup attempt probability is increasing in the disaster penalty $(u-d)/u := \eta_{PO}$, the

leakiness of the whistle-blower system, ι, the frequency of disasters, δ, and the probability of continuation, β.

(c) The coverup attempt probability is decreasing in the whistle-blowing reward, $b/u := 1-\eta_N$.

Proof. See Appendix Section A.5. □

The first comparative static, part (a), follows because whistle blowing in stage 0, leads not only to lost rents from in future cycles resulting from being identified as a whistle-blower, but also leads to lost rents in stage 1 of the current cycle, thus the costs of whistle blowing are higher in stage 0 than in stage 1. Hence, the coverup threshold, is higher in stage 0 than it is in stage 1. The intuition for parts (b) and (c) is simply that any change in model parameters that relaxes the incentive constraints (Eq-0) and Eq-1 in Lemma 2) increases the optimal coverup thresholds, $\hat{\eta}_0^*$ and $\hat{\eta}_1^*$ and thus the probability of a disaster coverup. These constraints are relaxed by changes in in period rewards that increase the disaster penalty or reduce the whistle-blowing reward. Constraints are also relaxed by by changes in the parameters that increase the long-term payoff gain from not being an identified whistle blower, i.e., increases in the disaster probability, δ, or the continuation probability, β, and by increases in the likelihood that whistle-blowing leads to identification, ι.

4 Data and Statistical description

The data for this study primarily derive from two sources: the Confidential memorials communicated between the emperor and ministers, as well as a database of county gazetteers that document local catastrophic events.

4.1 Confidential Memorials

Our data comes from the original memorial texts preserved in the First Historical Archives of China.Although the earliest memorial records are from the mid-to-late Kang-Hsi period, many were lost due to the lack of a systematic preservation method at the time; after being annotated by the emperor, these memorials were often returned to the reporters and stored in their possession(Yang,2003). However, Emperor Yung-cheng established a system for regularly retrieving memorials, which ensured the preservation of the vast majority of these confidential communications.The data sample in this study spans from the beginning of Emperor Yung-cheng's reign in 1723 to the end of the Qing Dynasty in 1909, encompassing a total of 1.25 million memorials. Each memorial includes the minister's name, the date, the content of the memorial, and the emperor's response, or "Chu-p'i." Fig.4 illustrates how Huang Guocai(黄国材), the governor of Fujian, reported on the rainfall, harvest, and grain prices across various prefectures in Fujian on March 6th of the first year of Yung-cheng's reign. The emperor, in his reply, encouraged Huang Guocai to continue his diligent work in his new position.

A substantial segment of the confidential memorials focuses on agricultural monitories the possibility that local officials may deliberately withhold information regarding natural disasters. To explore whether officials choose to report information to the emperor in the event of local disasters, we use disaster related keywords to filter memorials. Those keywords include: "hail (雹)," "insects (虫)," "earthquake (震)," "wind (风)," "drought (旱)," "fire (火)," "flood (洪)," and "epidemic (疫)." We excluded from our sample memorials related to agricultural monitoring and early warnings. We also excluded memorials that mentioned terms such as "water (水)" or "fire (火)" in contexts unrelated to natural disasters, such as in words of "firewords (烟火)". Our dataset comprises 7,714 memorials.

4.2 Natural Disasters in local records

Local gazetteers provide accurate documentation of regional details, covering local boundaries, natural environments, and historical and cultural elements. Most of these gazetteers were authored by independent, respected local intellectuals, driven by a desire to enhance their reputation or demonstrate their abilities. As a result, they produced detailed and reliable records. During the Qing Dynasty, local gazetteers were frequently revised to verify, update, and refine the information they contained. Their work was not subjected to central government censorship(Zhang, 2012; Almond et al., 2019).

We use the Qing Shigao(Draft History of Qing,清史稿) and the Ai Ru Sheng(爱如生) database to compile records of natural disasters that occur in each county between Emperor Yung-cheng and the end of the Qing Dynasty. These disasters are categorized into eight types: hail, locusts, earthquakes, windstorms, droughts, fires, floods, and epidemics. The data is organized at the county-year level, resulting in 287,045 entries across 1,535 counties over 187 years. From 1723 to 1909, a total of 6,898 natural disasters are recorded that covers at least one county, with an average of 0.024 disasters per county per year. The probability of a province experiencing at least one disaster per year is 0.69, underscoring the importance of disaster reporting and the top-down relief system in a centralized state.

To demonstrate the extent to which local officials concealed information about natural disasters, we created a comparison chart that contrasts the nationwide occurrence of natural disasters documented in local gazetteers with those actually reported across different periods. The difference should be regarded as the disaster concealment. As shown in Fig.5, it is evident that disaster concealment was quite severe, with approximately 46% of disasters being hidden. There are also notable differences over time, with certain periods—such as the Taiping Rebellion and the Nian Rebellion after 1850—exhibiting a significantly higher likelihood of information being concealed compared to other periods.

Building on the previous theoretical analysis, this paper constructs a county-level indicator of whether local officials concealed information (cover_up). It is defined as the occurrence of a disaster in a county that was not reported to the emperor.The focus is on the collusion and concealment by officials after a disaster occurs, so the sample is limited to cases where a disaster actually occurred. The final sample used in the paper includes 6,898 instances, of which 3,775 disasters were concealed.

4.3 Distance from reassignment years

The study focuses on the information alliance among three key officials: the Governor-General, the Governor, and the Provincial Administration Commissioner. The Governor-General and Provincial Governor were officials subordinate to the central government and were evaluated through the Jingcha (京察) system. Assessments were conducted every three years, beginning in the first year of Emperor Yung-cheng's reign. The Provincial Administration Commissioner, on the toher hand, were categorized as a local official and was evaluated through the Daji system, with assessments also conducted every three years, beginning in the fourth year of Emperor Kang-Hsi's reign. Typically, the Daji year occurs two years after the Jingcha(Kuagang, Qing). These evaluations typically took place at the end of the year, although delays occasionally occurred when officials were on business trips.[23]

We manually compiled the actual assessment years for provincial senior officials from sources such as the Qing Shigao(清史稿) and the Qing Shilu(清实录), allowing us to determine the time proximity to the nearest assessment year for officials within the information alliance. For example, in 1849, the senior officials in Anhui Province were Governor-General Lu Jianying, Provincial Governor Wang Zhi, and Provincial Administration Commissioner Li Benren. The nearest Jingcha year was 1849, and the Daji year was 1851. Therefore, their respective time distances to the nearest assessment year were 1, 1, and 3. Consequently, we define the time distance to the nearest assessment year for the information alliance of local officials in Anhui Province in 1849 as 1.

4.4 Control Variables

Official Characteristics: We obtain the characteristics of officials from the Qing Dynasty Official Database,[24] published by the Institute of Modern History of the Academia Sinica. The database covers central and local senior officials from the fifty-first year of Emperor Chien-lung's reign to the end of the Qing Dynasty. These records provide detailed information on the officials' birth and death dates, career trajectories, places of origin, and banner affiliations. For officials before fifty-first year of Emperor Chien-lung's reign, we incorporate additional information from the resumes of senior officials found in the "Complete Records of Grand

[23] In other words, the scheduled assessment might be postponed or delayed, with the extension ranging from one to two years. There are various reasons for such delays, such as when either the Governor-General or the Provincial Governor is away on a business trip and has not yet returned to the province, or when a newly appointed Governor-General or Provincial Governor, unfamiliar with the local situation, requests a delay in the assessment of the subordinate officials(Miao et al., 2021a).

[24] For more information, visit http://ssop.digital.ntu.edu.tw/

Secretaries and Ministers of the Qing Dynasty,"[25]"Factual Record of Qing Dynasty,"[26] and biographical databases. We use these officials career records to match senior officials to each province and year and construct the county-year panel data from the Yung-cheng era to the end of the Qing Dynasty. To control for potential biases, the empirical analysis specifically considers these officials' personal characteristics.

County-Level Characteristics:We used the ChinaW Database created by Skinner et al. (2008) to gather several county-level characteristics such as county area, terrain harshness, governance complexity, distance to the provincial capital, and irrigation infrastructure. We selected data from the year 1820 as control variables, as it provides unique historical records of key characteristics during the Qing Dynasty.

4.5 Statistical Description

Table.1presents the descriptive statistics. During the Qing Dynasty from 1723 to 1909, there were a total of 6,898 documented natural disasters, with a concealment rate of 54.7%, indicating that more than half of the disaster information was deliberately concealed by local officials and not never reached the decision makers, significantly undermining the effectiveness of policy-making. The median time gap to the next officials assessments within the information alliance is one year, implying that official assessments and position changes among Qing Dynasty officials occurred very frequently.

Our regression analysis controls for county fixed effects, which means we don't have to include any non-time-varying county characteristics such as proximity to coastlines, the Yangtze River, provincial capitals, military garrisons, and churches, as well as the complexity of governance in each county. For time-varying county characteristics, we examined the state of public infrastructure, including whether a county had transportation and irrigation facilities. Our research revealed that fewer than 10% of counties in Qing Dynasty China had both transportation and irrigation infrastructure, indicating that Qing Dynasty China generally had a limited ability to respond to disasters and encountered significant challenges in maintaining external communications(Dincecco and Katz, 2016; Ni and Uebele, 2019).

5 Empirical analysis

In this section, we empirically examine the five hypotheses outlined in Chapter Three using a unique dataset of Qing Dynasty confidential memorials. Our analysis identifies several factors

[25]This book compiles the resumes of over 5,300 officials who served as Grand Secretaries, Ministers, Viceroys, and Governors during the more than 270 years of the Qing Dynasty, from the Shunzhi(顺治) to the Xuantong(宣统) reigns.

[26]This resource is managed by the Institute of History and Philology at Academia Sinica. The database primarily utilizes Ming and Qing dynasty archives, supplemented by the Draft History of Qing and Biographies housed in the National Palace Museum's collection, and other authoritative historical materials recognized by the academic community. For detailed information, visit https://newarchive.ihp.sinica.edu.tw/sncaccgi/sncacFtp?@@0.8692518964972644.

linked to officials' collusion behavior: their proximity to anticipated reassignment or retirement, the probability of future cooperation opportunities, the risk of whistleblower identity disclosure, the likelihood of third-party exposure of collusion, and the net benefits of engaging in collusion.

5.1 Cover up more likely in first year of than the second year

First, we explore the potential correlation between the time distance of local officials within information alliances to their next assessment and their selective reporting of disaster information (i.e., concealment behavior). We developed the following specification using panel data on disaster occurrences at the county-year level:

$$[Cover\_up]_{ipt} = \alpha + \beta[reassignment\_distance]_{pt} + X_i + G_{pt} + \theta_i + \mu_t + \varepsilon_{ipt}$$

$[Cover\_up]_{ipt}$ denotes whether there was concealment of disaster information by senior officials in province p for county i in year t. $[Cover\_up]$ number of 1 implies that a disaster took place in that particular year but was not reported to the emperor by whistleblowers, providing evidence of an intentional act of concealment. $[reassignment_distance]_{pt}$ refers to the minimum time distance to the next assessment for members of the information alliance of senior officials in province p during year t, expressed in years. If an assessment is scheduled for the current year, the reassignment distance is 1, and so forth, with the distance being 2 if the assessment is scheduled for the next year.

X_i represents time-varying county-level control variables such as the presence of transportation infrastructure and the irrigation facilities;G_{pt} captures personal characteristics of provincial officials, including civil examination scores and ethnic background. Additionally, we incorporate county-level fixed effects θ_i and year fixed effects μ_t to control for potentially omitted county characteristics and temporal trends that may influence disaster concealment behavior. Finally, our analysis clusters standard errors at the county level to address potential spatial autocorrelation in the residuals, as detailed in Table.1.

This section examines the behavior of whistleblowers, particularly whether they or other members of their information alliance choose to reveal information about disasters to the central government while they are being assessed or reassigned. Table.2 displays the regression results from Equation (1), supporting Hypothesis I: when the time distance to assessments rises for provincial officials, the probability of concealing disasters increases. More precisely, each additional year away from an evaluation period increases the probability of covering up by 2.5 percentage points. Considering that, on average, 6.4 counties per province report disasters each year, this results in an approximate 16% rise (*0.025) in the likelihood of concealing these disasters per province every year. These findings indicate that early collusion among local officials significantly impedes the quality of information received by the central government(Mookherjee, 2006; Jia, 2014).

To ensure the robustness of our analysis, we considered several potential sources of bias. First, An official's reassignment might not be an exogenous event, but rather the result of their inadequate disaster prevention or lack of governance capacity.[27] We have excluded officials from our sample who were reassigned due to inadequate disaster prevention efforts to mitigate endogeneity concern. Second, in column (3), we considered the potential correlation between natural disasters and other significant ceremonial events, such as the emperor's ascension, birthdays, or the emperor's mother's birthdays.[28] During these events, it is mandatory for officials to convey their felicitations and greetings to the emperor in accordance with the regulations set by the Ministry of Rites. This requirement provides an opportunity for officials to send confidential memorials to the emperor, potentially increasing the likelihood of whistleblowers secretly revealing local information. To eliminate the influence of such factors, we manually collected data on the emperor's ascension, birthdays, and the birthdays of the emperor's mother and removed samples coinciding with these significant events. Our findings remained strong and robust even after taking these factors into account.

One potential concern with our results is that using a simple dummy variable may not fully capture the magnitude of the collusion collapse. Specifically, if collusion is completely broken, we would expect that the majority, if not all, officials would report the disaster, which is distinct from a scenario where collusion is only partially broken and only one officials report.

Another approach to assessing the collapse within the alliance is to evaluate the reporting probability of the politically weakest member of the top three provincial officials, the civil administration commissioner, who usually has the lowest likelihood of reporting due to fear of retaliation(Olson and Zeckhauser, 1966). When this member begins reporting, it signifies a predicted breakdown of cooperation. As a result, we calculated the reporting probability of the weakest member of the alliance—the Commissioner of Civil Administration. Our empirical results indicate that commissioner reporting frequency increases as the reassignment date approaches.

5.2 Cover up more likely when disasters are more likely

We focus on exploring the underlying mechanisms of expected collaboration among local officials, specifically examining how the frequency of local natural disasters influences whistleblowers' decisions to report these events. The main hypothesis indicates that officials in disaster-prone areas might be less willing to blow the whistle if they anticipate more oppor-

[27] During the Chien-lung era of the Qing Dynasty, Bi Yuan, the governor of Shandong, was removed from his position by the court due to his ineffective management of the Yellow River, which resulted in slow progress in river control projects and poor outcomes. Similarly, during the Jiaqing era of the Qing Dynasty, Yang Yingju, the governor of Zhejiang, was transferred from his post for his inadequate performance in preventing and managing typhoons and floods, which led to severe disaster conditions.

[28] In the 48th year of Kang-Hsi's reign (1709), Cai Shengyuan, the governor of Zhejiang, secretly reported to Emperor Kang-Hsi in a memorial that Yao Anshi, the governor of Fujian, was engaged in corruption and abuse of power. Cai Shengyuan detailed various illegal activities committed by Yao Anshi during his tenure. Eventually, Emperor Kang-Hsi ordered a thorough investigation, resulting in Yao Anshi's dismissal.

tunities for future collaboration in concealing disasters information(Tirole, 1986; Mechtenberg et al., 2020).

However, identifying future collaboration opportunities presents several challenges. Firstly, obtaining predictions for future disaster probabilities is challenging. We use the historical frequency of disasters as a proxy for future opportunities for cooperation, denoted as "Disaster Prone." This variable represents the frequency of natural disasters experienced by the region over a range of time periods. It is based on the assumption that individuals in agrarian societies cannot accurately forecast the future but rely on historical experience. Another challenge is that officials' estimates of disaster probabilities may be based on historical data of varying lengths, and we are unable to ascertain the specific time spans officials refer to in their decision-making processes. Here, we using historical data spanning different lengths—specifically, the past 100, 50, 30, 5, and 3 years. The definitions of the other variables in Equation (2) align with those in Equation (1).

Table.3provides empirical evidence supporting our analysis. After controlling for county-level, annual fixed effects, county, and official characteristics, we find a significant positive correlation between the historical frequency of disasters and the likelihood of officials concealing them. This pattern becomes more evident as the time window narrows(Postman and Phillips, 1965). The impact of disasters occurring within the last three years is eight times greater than that of the past thirty years. This indicates that officials intuitively use the frequency of recent disasters to predict future disaster frequencies, thereby influencing their decision to withhold information from the central government.

5.3 Cover up more likely when the probability that whistleblower private correspondence is revealed

One significant factor that may cause local officials in the information alliance to be reluctant to report to the central government is the concern over the potential disclosure of the whistleblower's identity. When the whistleblower reports the disaster to the emperor, other officials find themselves in precarious positions and are likely to receive imperial reprimands because of their concealment. They might retaliate against the whistleblower.[29] Previous literature indicates that fear of identity leakage and retaliation are significant factors that discourage individuals from coming forward as whistleblowers(Elliston, 1982; Chassang and Miquel, 2019; Mechtenberg et al., 2020).

Identity disclosure risk can be associated with multiple factors. For example, a smaller number of officials in the alliance makes it easier for other officials to deduce the whistleblower's identity. Additionally, it is customary for the emperor to seek advice from important

[29] While serving as the Governor-General of the Yellow River Conservancy, Su Tingkui faced a breach of the Yellow River dike. Together with the Governor of Henan, he requested one million taels of silver to repair the dike. After the project was completed, 300,000 taels were saved. Breaking from the usual pattern of corruption, Su Tingkui refused to share the surplus with the governor and chose to return the remaining silver to the state. As a result, he was falsely accused and dismissed from his position.

ministers, particularly the Grand Councilor, regarding the content of memorials. This allowed the ministers in the Grand Council to potentially know the identity of the whistleblower, and local officials who had strong relationships with the ministers might gain access to this information.[30] We therefore considered the following factors that might influence the likelihood of whistleblower identity disclosure: (1) a reduced number of local alliance members; (2) the number of ministers in the Grand Council; (3) the relationship between the local officials and the Grand Councilor; and (4) the existence of the co-regency system where every memorial presented to the emperor also needed to be sent to another influential minister.

Column (1) of Table.4 examines the impact of the number of information alliance members on the formation of these alliances. Changes in the number of members within an information alliance, whether across sections or over time, were quite common during the Qing Dynasty. Usually, a province is expected to have a governor-general, a governor, and a Provincial Administration Commissioner. In practice, while every province had a Provincial Administration Commissioner, the positions of Governor-General and Provincial Governor were more flexibly appointed. Some provinces had a Governor-General overseeing multiple provinces, while others might not have a Provincial Governor at all. Administrative structures were adjusted according to the changing needs of the emperor(Liu, 1996); for example, the position of Provincial Governor in Sichuan was abolished in 1759 due to war. We find that a reduction in the number of information alliance members significantly increased the tendency to conceal information. Specifically, when the team consisted of only two members, the rate of concealing information increased by 12 percentage points.

The Qing emperors established the Grand Council to provide support in military and political affairs, as well as to manage the transcription of official documents, including confidential memorials. This results in a situation where the Grand Council ministers could access the details of these officials' communications with the emperor, despite the emperor's strict requirement for them to keep it confidential. This information could be made available to local officials through their connections with the Grand Councillors. Columns (2)–(3) of Table.4show how the number of Grand Councillors and whether a minister had a relationship with a Grand Councillor affect the likelihood of concealment. Both factors significantly increased the probability of concealing disaster information by 1.0 and 1.8 percentage points, respectively. This implies that as the transmission process extends, the secrecy of the information decreases, making local officials more cautious in reporting to avoid potential personal risks.

A major breach of memorial confidentiality occurred during the late Chien-lung period when Ho Shen, serving as the head of the Grand Council for 20 years, held immense power. Ho Shen required that all memorials be sent to him for review before being delivered to the emperor(Gao, 1997). His main objective was to prevent anyone from reporting his wrongdo-

[30]In the late Qing Dynasty, Yikuang, one of the Grand Councilors, was frequently accused of leaking confidential memorials. During the political struggle between Emperor Guangxu and Empress Dowager Cixi, Yikuang, in an effort to protect himself, disclosed some of Emperor Guangxu's memorials to Cixi, leading to the veto of several of Guangxu's decrees by Cixi.

ings to the emperor. This co-regency system was well known among officials, leading to a significant compromise in the confidentiality of memorials and an reduction in officials' motivation to submit them. In Column (5) of Table.4, we consider this issue, and the results, in line with Hypothesis III, show that during Ho Shen's reign of power, the probability of concealing disaster information rose to 10%, greatly undermining the central government's understanding and control over local affairs.

5.4 Cover up less likely when the probability of exogenous separation is higher

To test Hypothesis IV, we examine the concealment decision of local officials in highly uncertain environments, particularly when facing the end of their careers, periods of imperial succession and anti-corruption campaigns and literary inquisitions.

Columns (1) and (2) of Table.5 examine how senior local officials, when faced with severe illness or advanced age, reduce their cooperation with other officials to avoid potential political risks in their remaining tenure(Du, 1995). We analyze the five years before an official's death or illness (Column 1) and the five years leading up to retirement (Column 2). The findings suggest that approaching the end of their careers leads to a significant decrease in information concealment, with officials preferring to maintain a good relationship with the central government rather than risk being involved in information alliances that could be seen as disloyal or corrupt.

Particularly, the period of imperial transitions represents a peak of political uncertainty(Jens, 2017; Zhang et al., 2023). Anticipating the death of an elderly emperor, officials may exhibit stronger motivation to establish factions and engage in factional conflicts in order to secure favorable positions in the upcoming regime, thereby increasing political uncertainty(Rawski, 1998). Column (3) of Table.5shows that during imperial transitions, officials deliberately decrease their concealment of disasters by 3.8 percentage points, which means officials reduce their cooperation with others as a strategic move in political struggles, consistent with our Hypothesis IV.

We also examine other variables that contribute to career uncertainty among officials, including anti-corruption measures and literary inquisitions initiated by the central government(Guy, 1987; Woodside, 2002). Both significantly increase the possibility that officials could be entangled in matters unrelated to disaster relief, and this uncertainty affects their decision on whether to engage in information alliances. We analyzed four peaks of anti-corruption campaigns during the Chien-lung era, specifically the E'leshunyuan case(1749-1752),[31] the Heng-

[31] The Elexun Case: While serving as the Governor of Zhejiang, Elexun extorted 8,000 taels of silver from local merchants and was subsequently reported. Elexun's daughter was a favored concubine of Emperor Chien-lung. In the end, Chien-lung decreed that Elexun should be given the option to commit suicide.

wen case(1757-1760),[32] the Lianghuai Salt Monopoly case(1768-1771),[33]and the Gansu Disaster Relief Embezzlement case(1781-1784).[34] For the literary inquisition, we start with the nationwide "Fake Sun Jiagan Memorial" incident in 1751, during Chien-lung's severe repression of literary offenses, and end with the ascension of Jiaqing in 1796. Results from Columns (4) and (5) reveal that when faced with greater political uncertainty caused by anti-corruption and literary inquisitions, officials decreased both the hiding of information and their participation in information alliances, which supports our main hypothesis.

5.5 Cover up more likely when the net benefit of whistleblowing is larger, net benefit equals career rewards from exposing corruption less retaliation costs

We explore the net benefits of whistleblowers reporting disaster information from perspectives of both cost and benefit(Near and Miceli, 1996; Kaptein, 2011). The primary challenge is the unobservability of the direct costs and benefits of whistleblowing, so we consider several indirect factors that influence the overall net benefits: (1) The potential for retaliation from other officials(Johnson et al., 2024); (2) The emperor's preference, particularly his tolerance for withholding information.

First, we explore the role of social status differences among officials within the local information alliance team. Although Qing Dynasty officials formally held the same official titles, their actual social status was influenced by various factors, particularly ethnic background. For instance, officials from the Manchu Banners, who had familial ties with the emperor, enjoyed more privileges than their Han counterparts. This is evident not only in the promotion opportunities but also in the emperor's increased tolerance and consideration for Manchu officials' errors, which prevents him from dismissing or punishing them at will. On the other hand, these privileged Manchu officials, leveraging their relationship with the emperor, could more easily retaliate against those who reported them(Rhoads, 2000).

This asymmetry in status has an impact on the behavioral decisions made within information alliances. When there is a noticeable difference in status among officials, those with lower status, considering their marginal position and potential retaliation, are less inclined to report, thereby facilitating the maintenance of the alliance. Column (1) of Table.6 provides empirical evidence of how the presence of ethnic diversity within the alliance actually prolongs its duration. Compared to alliances where members share the same ethnic background, those with

[32] The Hengwen Case: Hengwen, the Governor-General of Yunnan and Guizhou, was reported by his subordinates for corruption. Emperor Chien-lung ordered him to commit suicide. This marked the first time in the Qing Dynasty that a high-ranking official at the level of Governor-General lost his life due to corruption.

[33] The Case of Salt Certificates in Lianghuai: Local salt administration officials colluded with salt merchants, resulting in the tax silver that should have been submitted to the national treasury being either withheld or used as bribes to the salt administration. This led to a deficit exceeding 10 million taels. Enraged, Emperor Chien-lung ordered the execution of all officials involved in the case.

[34] The Gansu Relief Fraud Case: The largest anti-corruption case during the Chien-lung era, it involved Wang Danwang, the governor of Gansu, who falsely reported drought conditions and embezzled relief funds, with all provincial officials participating in the embezzlement scheme. Once exposed, all the officials involved in Gansu were sentenced to death.

ethnic diversity experience a 1.3 percentage point increase in reporting concealment. Similarly, greater disparities in official ranks also reduce the motivation of marginalized officials to report and therefore facilitate the information alliance. Similarly, an increase in rank disparity diminishes the motivation of lower-ranking officials to report. In Column (2), we find that when the team experiences the greatest rank difference—comprising only a Governor-General and a Provincial Administration Commissioner—there is a tendency to maintain the information alliance, resulting in less local information being conveyed to the central government.

Additionally, we explore on how the relationship between officials and the emperor influences concealment decisions. When an official in the information alliance enjoys a close relationship with the emperor, the emperor tends to be more forgiving of their mistakes. These officials are more likely to use their political power and relationship with the emperor to sanction and retaliate against whistleblowers, thereby strengthening the information alliance.[35] This effect is shown in Column (3), where the likelihood of disaster concealment increases by 27.3 percentage points when a trusted confidant of the emperor holds a senior local position. Ironically, these ministers exploit the emperor's trust to withhold critical local disaster information, becoming the political shield for the local information alliance.

The possibility that the emperor will hold officials personally accountable after a disaster is an important factor in their decision on whether to report information to the emperor. Disasters where officials are clearly at fault are less likely to be reported to the emperor than those beyond their control, as the latter allow officials to evade responsibility. We classify natural disasters into preventable ones, such as pestilence, epidemics, and fires and non-preventable ones, such as frost, earthquakes, droughts, wind, and floods. Results in Column (4) confirm that officials are indeed more inclined to conceal preventable disasters.

A further factor influencing whether an official will be held accountable after reporting a disaster is whether they had reported a disaster the previous year(Wei, 2003). Frequent disaster reports could lead the emperor to question the official's governance abilities and suspect that the funds from the last disaster relief were emb ezzled, resulting in a more severe punishment for the official. The results in Column (5) indicate that officials are more likely to conceal disasters if they had reported disasters the previous year.

5.6 Cover up less likely when third parties participate in the disclosure process

An important obstacle to local information alliances arises from the existence of alternate channels for reporting directly to the emperor(Olken, 2007; Gao et al., 2015). During the Qing dynasty, Imperial Censors, despite their inferior rank, had the explicit responsibility of directly reporting any information they heard to the emperor. In addition, the emperor encouraged officials to report what they observed while traveling to their posts and upon returning to the

[35] During the Chien-lung era, Imperial Censor Cao Xibao impeached He Shen's family members for abusing their power and engaging in corruption. However, the emperor defended He Shen and accused Cao Xibao of using public office to settle personal scores, resulting in Cao Xibao's dismissal.

capital, allowing them to provide information about other provinces.Fig.7 shows Yung-cheng's recognition and encouragement of Nian Gengyao, the Governor of Guangdong, for reporting the locust infestation he observed while passing through Jiangsu Province. Based on Hypothesis VI, we examined several factors that could influence the reporting of disaster information to the emperor through alternative channels. These factors consist of the province's geographic location, the activity level of the Imperial Censors, whether the natural disaster affected multiple provinces, the presence of other emperor-controlled institutions, and whether the region is a stronghold for the imperial examination system.

According to the classics study provinces located at the far ends of the imperial transportation network are less likely to have third-party information passed on to the emperor, as other officials rarely travel through these areas. This increases the motivation for local officials to hide information from the emperor. The findings in Column (1) significantly support this pattern, showing that in provinces at the end of the imperial road network, officials are less likely to be discovered concealing information and are more inclined to hide disaster situations.

Additionally, whether other officials report a province's disaster to the emperor may be related to the scale of the natural disaster. If a widespread disaster affects more than one province, it is likely that officials from other provinces will inform the emperor(Wei, 2003). This may raise the emperor's suspicion that the disaster has affected other regions. Forming an information alliance among senior officials across provinces to conceal information is clearly more challenging than within a single province. Large-scale interprovincial natural disasters, due to their extensive and severe impact, are more likely to attract attention from other local governments and central government intervention, increasing the severe consequences of withholding information. We introduced a variable for interprovincial disasters. The findings suggest that when natural disasters affect multiple regions, local officials significantly reduce their concealment of disaster information, and this effect intensifies with an increasing number of affected areas, consistent with Hypothesis VI.

One of the emperor's key strategies to prevent local corruption and abuse of power was the implementation of supervisory institutions such as the Censorate to monitor the actions of local officials. A Imperial Censor was typically responsible for several provinces and was required to travel to these areas to collect any information relevant to the province under scrutiny and report it to the emperor(Chang, 2022).As shown in Column (3), when more Imperial Censors were conducting inspections in the region, local officials reduced information concealment by 20%, thereby strengthening central government control.

Aside from Imperial Censors, any high-ranking official with close ties to their disaster-stricken hometown could also serve as a channel for reporting the disaster to the emperor. Chinese scholar who passed the imperial examinations and rose to prominent positions often maintained strong ties with their hometowns, mainly because they typically owned land and had family ties there, and they intended to return to their hometowns after retirement(Elman, 1990; McDermott, 2013). Their concern for their hometown could drive them to report disasters to the emperor out of a sense of moral duty, thereby disrupting the information alliances of local officials. We use the number of "chin-shih(进士)" (successful candidates in the highest imperial examinations) as a proxy variable to assess the number of high-ranking officials from a region. We hypothesize that regions with more "chin-shih(进士)" are likely to produce more high-ranking officials,[36] thereby increasing the probability of whistleblowing and reducing the strength of information alliances. The results in Column (4) confirm our hypothesis, implying that this family- and community-based information transmission mechanism reduces the capacity and inclination of local officials to conceal information.

6 Alternative hypotheses

While our earlier empirical results support the research hypothesis, it is worth considering that there may be other hypotheses that could explain the observed data patterns. In this section, we discuss three possible alternative hypotheses.

6.1 Too small disaster to Report Hypothesis

First, we consider the self-censorship mechanism that local officials might apply when faced with disasters. In deciding whether to report a disaster to the emperor, officials often compare the potential benefits of obtaining relief with the risk of punishment for poor disaster prevention. If the disaster is small in scale, reporting it might not only fail to bring the expected relief but could also expose the official's deficiencies in governance, irritate the emperor by bothering him with trivial matters, and harm the official's political prospects. Therefore, if local officials believe they can control the disaster on their own, they might refrain from reporting it to avoid the risks involved and only to report when the disaster reaches a level that exceeds their ability to manage it independently.

To test this "Too small disaster to Report" hypothesis, we define disasters affecting only a single county as minor disasters, using them as a proxy for situations that officials can resolve independently. We use the following empirical specification:

$$
\begin{aligned}
[Cover\_up]_{ipt} = \alpha + \beta_0[KeyVariable] + \beta_1[SmallDisaster] + \beta_2[KeyVariable \times SmallDisaster] \\
+ X_i + G_{pt} + \theta_i + \mu_t + \varepsilon_{ipt}
\end{aligned}
$$

$[Cover\_up]_{ipt}$ denotes whether senior officials in province p concealed disaster information about county i in year t. *KeyVariable* refers to a series of proxy variables empirically tested in Section 5 to verify Hypotheses I through VI. These include Reassignment distance, Expected

[36] The title "Jinshi" denotes those who passed the imperial civil service examination in China and achieved either jia (first-class) or yi (second-class) rankings in the final imperial interview. Obtaining the status of Jinshi provided individuals with high political status and a faster path to promotion, along with tax exemptions for their entire family(Elman, 1990; Shang and Shang, 2004).

disaster frequency in the province, Team size of the alliance, Chien-lung anti-corruption period, Rank disparity within the team, and whether the province has active Imperial Censors. $SmallDisaster$ indicates whether the scale of the disaster is minor, with a value of 1 suggesting the disaster affected only a single county.

Panel A of Table.8 presents the empirical regression results for the 'Too small disaster to Report' hypothesis. We focus on the interaction term coefficient between Key Variable and SmallDisaster. The results show that these coefficients are negative but not significant, suggesting that minor disasters do not have a substantial impact on the key hypothesis. Column (1) of the table shows that even minor-scale disasters can raise the probability of concealment by 4.8%. Column (2) demonstrates that as the distance to the next assessment grows, the likelihood of concealing increases by 2.9%, and this impact of hiding diminishes when the natural disaster is mild. Columns (3) to (7) present the key indicators for Hypotheses 2 to 4, and the results indicate that the hypothesis suggesting that minor disasters were not reported is not supported.

6.2 The Report for Relief Hypothesis

Another possibility is that local officials are motivated to report disasters primarily to obtain financial support from the central government, including direct grain aid in times of severe disasters and special policies, such as allowing local merchants to achieve entry level Keju status through donations. This hypothesis suggests that officials who report disasters are from regions facing significant local fiscal burdens. At the same time, officials could be self-interested: they report disasters because of the prospect of embezzling some of the disaster relief funds. This assumption could be valid, as there have been cases where counties falsely reported disasters to obtain relief policies from the central government.[37]

To verify this hypothesis, we particularly examine whether regions with tax difficulties and higher levels of corruption are more likely to report disasters in order to secure central government subsidies. The characteristic of tax difficulty is derived from the Qing Dynasty's classification of counties during the Chien-lung period. If the character "Pi(疲)"[38]appears, it signifies that the county was officially classified by the Qing government as having tax collection challenges. The empirical results are presented in Panel B of Table.8.

The results show that, after controlling for other factors that might influence disaster reporting behaviors, regions with lower tax revenues or higher level of corruption do not exhibit

[37]Officials could obtain substantial rent-seeking gains and engage in corruption through this process. In 1882 (the eighth year of Emperor Guangxu's reign), a severe flood occurred in Anhui. Zhou Jinzhang, a candidate for a Daotai position in Zhili, received 170,000 taels of relief silver to distribute in southern Anhui. Upon reaching the disaster area, he allocated only 20,000 taels for relief efforts, while the remaining 150,000 taels were used for "commercial investments" to earn profits.

[38]Qing dynasty government employed a system of four characters to measure the difficulty of local governance : Chong(冲), Fan(繁), Pi(疲), Nan(难). These characters denote whether a place is a crucial transport hub, has complex administrative affairs, faces fiscal difficulties, or has unruly local customs. Any locality could be characterized by any of these states, resulting in 16 possible combinations.

a significant tendency to report more disasters. This finding challenges the report for relief hypothesis, suggesting that although local officials may consider the lure of relief funds, it is not the primary driver of their reporting behaviors.

6.3 Information Isolation Hypothesis

In this section, we examine another possible explanation: senior local officials may be unaware of disasters because they are kept in the dark by their subordinates. Although Chinese local officials serve as the emperor's regional representatives and are tasked with gathering local information, the reality presents challenges. The vast size of each province in China, along with the difficulties in transportation and communication in ancient times, made information collection difficult. Furthermore, many local officials are newly appointed and may not have developed lasting relationships with their subordinates, such as prefectural and county officials. This could lead to a failure in information transmission, preventing senior officials from understanding local conditions and, thus, reporting them to the emperor. This hypothesis seems reasonable, as it also anticipates that officials are less likely to report disasters in the early part of their tenure compared to the later part.

We hypothesize that the ability of senior local officials to understand disaster conditions within their jurisdiction is influenced by geographical distance. In other words, if officials fail to report due to a lack of local information, then officials who are farther from the disaster-affected counties should exhibit this phenomenon more significantly due to the greater difficulty in collecting local information. To test this hypothesis, we used the distance from the county to the provincial capital as a proxy for an official's ability to obtain information, examining whether this variable affects disaster reporting. Panel C of Table.8 presents the results of the regression analysis. The results show that the geographical location of the disaster-affected county does not influence the likelihood of senior officials reporting the disasters. It suggests that senior local officials, with help of the bureaucratic system, are capable of overcoming geographical barriers to accurately obtain disaster information, even in relatively remote areas. Thus, their failure to report information is more likely due to intentional concealment.

7 Effect of concealing the local disaster information

The model and empirical analysis above indicate that the information alliances among local officials tend to be sustained by the time remaining before their next reassessment, as well as other contributing factors. The existence of these alliances prevents the central government from accurately understanding local conditions. Such decision-making errors could have serious implications during the Qing Dynasty. After a long period of Malthusian growth, China's lower classes were extremely impoverished, with minimal surplus grain(Broadberry et al., 2018). As a result, even moderate disasters, in the absence of external aid, could result in widespread famine. This would likely exacerbate local discontent towards the central government and the empire, leading to the rapid spread of rebellious ideas and the potential overthrow of the dynasty(Iyigun et al., 2017).

In this section, we assess the consequences of local information concealment, focusing on two outcome variables: famine and rebellion.Data is drawn from the "Table of Natural and Human Disasters Throughout Chinese History" to quantitatively assess the impact of information concealment by local officials on social stability and welfare.

Table 8 presents the relationship between local officials conceal disasters and the incidents of famine and rebellion in their areas. The results show that information concealment increases the probability of famine by 3 percentage points, while also raising the likelihood of local uprisings by 6%. This underscores the vital importance of effective information transmission for the empire. Despite the central government's long-standing efforts to enhance its capacity to gather local information and respond accurately to disasters and crises, the practice of local officials concealing information for personal gain not only impedes the central government's decision-making process but also poses a serious threat to social stability.

8 Conclusion

Utilizing unique Qing Dynasty memorial data, this paper explores the information dynamics between the central and local governments. A whistleblower model is introduced to discuss how the cooperation and collusion among senior local officials impact the operation of the centralized system, showing that the multiple motivations of whistleblowers align with our empirical findings. We also rule out a series of alternative explanations for these empirical results.

Figure

Figure 4. Confidential Memorial Box. The officials and emperors used this small box for one-to-one communication. Each held a key to ensure that the content would not leak out.

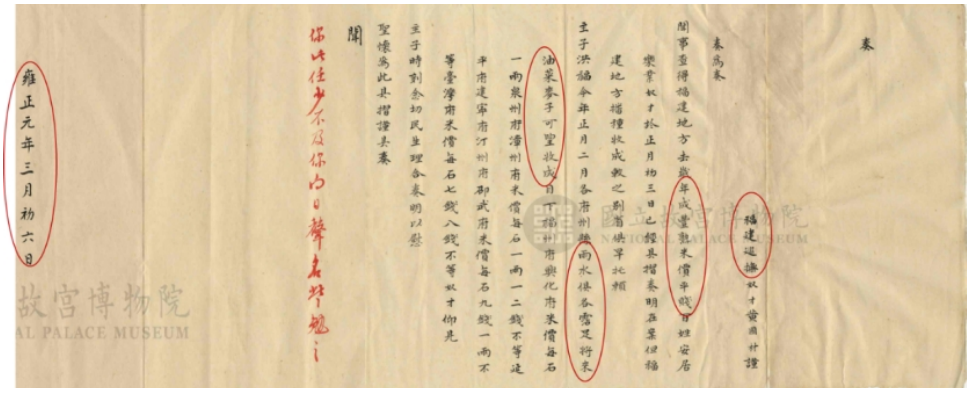


Figure 5. On March 6th of the first year of Yung-cheng's reign, Huang Guocai, the governor of Fujian province, reported rainfall and grain production in various prefectures and counties of Fujian.

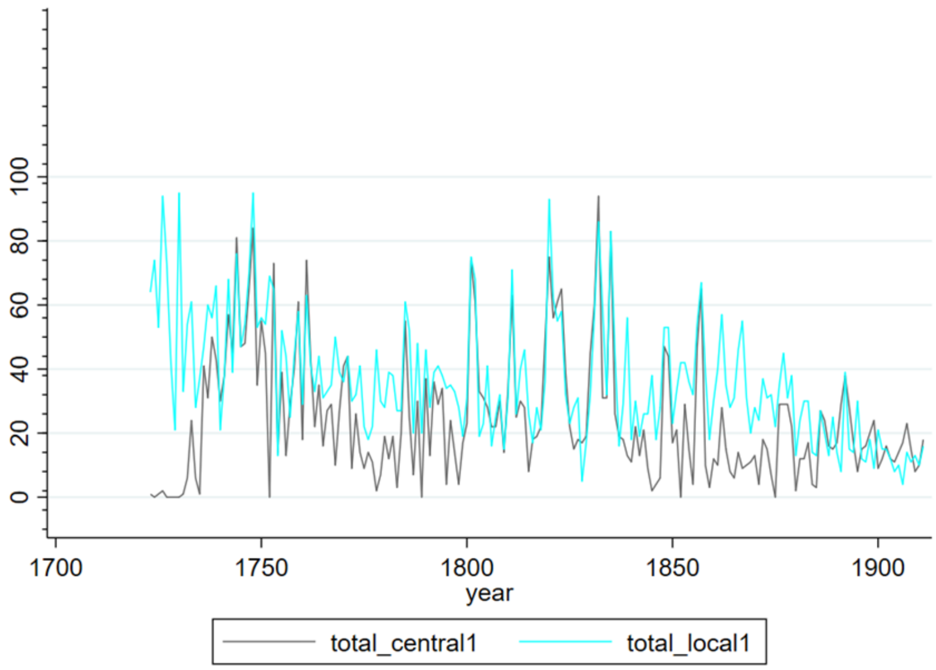


Figure 6. The number of disaster reports submitted annually to the central government (darker shade) and the average number of reported disasters per year by local governments (lighter shade).

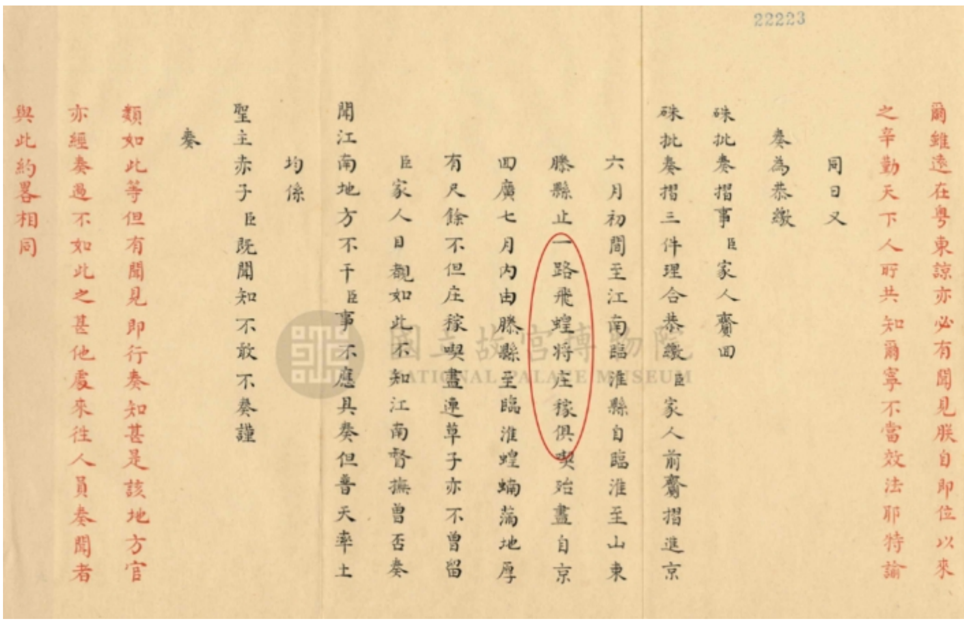

22223
爾雖遠在粵東諒亦必有聞見朕自即位以來
之辛勤天下人所共知爾寧不當效法耶特諭
同日又
奏為恭繳
硃批奏摺事臣家人齎回
硃批奏摺三件理合恭繳臣家人前齎摺進京
六月初間至江南臨淮縣自臨淮至山東
滕縣止一路飛蝗將庄稼俱喫殆盡自京
回廣七月內由滕縣至臨淮蝗蝻滿地厚
有尺餘不但庄稼喫盡連草子亦不曾留
臣家人目覩如此不知江南督撫曾否奏
聞江南地方不干臣事不應具奏但普天率土
均係
聖主赤子臣既聞知不敢不奏謹
奏
類如此等但有聞見即行奏知甚是該地方官
亦經奏過不如此之甚他處來往人員奏聞者
與此約畧相同

Figure 7. The confidential memorial of Nian Gengyao contains information from other provinces. Guangdong governor Nian Gengyao reported the locust infestation in Linhuai County, Jiangsu province, and Yung-cheng wrote in his vermilion rescript that he could report such matters directly to him.

Table 1. Data Description

Notes: This table reports summary statistics for the main variables used in the paper. For each variable, we present its definition, the number of observations, mean, median, standard deviation (Std), minimum (Min), and maximum (Max). The data sample covers the period from 1723 to 1909, starting from the implementation of the confidential memorial system during the Yongzheng reign to the end of the Qing dynasty.

Variable Names	**Definition**	**Observation**	**Mean**	**Median**	**Std**	**Min**	**Max**
Cover_up	= 1 if local officials did not report a disaster	6898	0.547	1	0.498	0	1
Reassignment distance	= the time distance of the closest reassignment for local officials	6898	1.362	1	0.55	1	3
Two_Person	= 1 if the information coalition team consists of only two people	6898	0.301	0	0.459	0	1
Infrastructure irrigation	= 1 if there are irrigation facilities in the locality	6898	0.006	0	0.077	0	1
Infrastructure transportation	= 1 if there are transportation facilities in the locality	6898	0.007	0	0.081	0	1
Genealogy	= 1 if there is a genealogy in the locality	5102	31.509	0	201.18	0	3885
Tusi	= 1 if there is a Tusi	5102	23.121	23	1.56	21	34
Secret_religion	= 1 if there are secret religions	5102	0.075	0	0.264	0	1
confusion	= Number of Confucian temples	5102	0.544	1	0.538	0	3
Tri	= Degree of ruggedness (high/low)	5102	526.3	338.87	555.02	-94.96	3032.2
Population	= Population	4280	2.516	2	1.528	0	8
Juangong	= Total number of donations	5102	13.227	0	39.067	0	357
Land tax	= Land tax	5102	11.152	11.375	1.639	0	13.461
Area	= area (log)	5102	7.409	7.43	0.716	2.736	9.761

Table 2. Cover up more likely in the first year than the second year

Notes: This table presents the regression results examining the relationship between reassignment distance (reassignment_distance) and the probability of disaster concealment (Cover_up). Column (1) reports the baseline results. Columns (2) through (5) introduce robustness checks: removing demoted officials (Column 2), excluding cases involving significant news events (Column 3), controlling for the local disaster count (Column 4), and considering commissioners' reports (Column 5).Standard errors clustered at the county level are shown in parentheses. All regressions include county fixed effects, year fixed effects, and control variables at the county and official levels.

Variable	**Base** (1)	**Remove demoted officials** (2)	**Remove Big News** (3)	**Control Local disaster count** (4)	**Commissioner's report** (5)
Rotation distance	0.025^{**}	0.026^{**}	0.024^{*}	0.190^{***}	0.027^{***}
	(0.013)	(0.013)	(0.013)	(0.071)	(0.009)
Observations	6689	6599	6644	6689	6689
county FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Number of clusters	749	746	748	749	749
Adjusted R-squared	0.397	0.400	0.398	0.528	0.397

Table 3. Cover up more likely when disasters are more likely

Notes: This table provides empirical evidence exploring the relationship between the historical frequency of local natural disasters and the likelihood of officials concealing these events (Cover_up). The independent variable, Opportunities, captures the expected frequency of future collaboration within specified time windows ([-100, -1], [-50, -1], [-30, -1], [-5, -1], and [-3, -1]). Standard errors clustered at the county level are shown in parentheses. All regressions include county fixed effects, year fixed effects, and control variables at the county and official levels.

Future Collaboration	**[-100,-1]**	**[-50,-1]**	**[-30,-1]**	**[-5,-1]**	**[-3,-1]**
	(1)	(2)	(3)	(4)	(5)
Opportunities	0.0003^{**}	0.0008^{**}	0.0019^{***}	0.0050^{**}	0.0154^{*}
	(0.000)	(0.000)	(0.000)	(0.002)	(0.009)
Observations	6637	6637	6637	6637	6637
county FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Number of clusters	747	747	747	747	747
Adjusted R-squared	0.395	0.395	0.396	0.395	0.394

Table 4. Cover up more likely when the probability that whistleblower private correspondence is revealed

Notes: This table examines the factors influencing the likelihood of whistleblower identity disclosure in the context of local alliances and central governance structures. The independent variables include: (1) the presence of two members in the local alliance, (2) the number of Grand Council ministers, (3) the relationship strength among Grand Council ministers, (4) the existence of the co-regency system, and (5) whether the Grand Council holds appointment authority.Standard errors clustered at the county level are shown in parentheses. All regressions include county fixed effects, and most specifications include year fixed effects and other control variables.

Variable	**Two Members**	**Number of Grand Council Ministers**	**Relationship among Grand Council Ministers**	**Co-regency system**	**The Grand Council has appointment authority**
	(1)	(2)	(3)	(4)	(5)
Key	0.120^{***}	0.010^{**}	0.018^{**}	0.101^{***}	0.061^{***}
	(0.042)	(0.004)	(0.014)	(0.019)	(0.014)
Observations	6,501	6,326	6,069	6,689	6,689
county FE	YES	YES	YES	YES	YES
Year FE	YES	NO	YES	NO	NO
Controls	YES	YES	YES	YES	YES
Number of clusters	561	722	724	749	749
Adjusted R-squared	0.399	0.151	0.409	0.152	0.150

Table 5. Cover up less likely when the probability of exogenous separation is higher

Notes: This table examines the concealment decisions of local officials in highly uncertain environments, focusing on scenarios where exogenous factors increase the probability of career separation. The independent variables include: (1) approaching the end of a career due to illness or age, (2) the five years leading up to retirement, (3) periods of imperial succession, (4) anti-corruption campaigns, and (5) literary inquisitions. Standard errors clustered at the county level are shown in parentheses. All regressions include county fixed effects, year fixed effects, and control variables.

Variable	**End of Career** (1)	**Retirement** (2)	**Time of Emperor Succession** (3)	**Anti-Corruption Campaign** (4)	**Literary Inquisition** (5)
Key	-0.087***	-0.031**	-0.038***	-0.090***	-0.026*
	(0.026)	(0.013)	(0.015)	(0.021)	(0.015)
Observations	6,689	6,689	6,689	6,689	6,689
county FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Number of clusters	749	749	749	749	749
Adjusted R-squared	0.397	0.397	0.148	0.150	0.148

Table 6. Cover up less likely when the net benefit of whistleblowing is larger

Notes: This table examines the relationship between the net benefits of whistleblowing and the likelihood of disaster information concealment (*Cover_up*). We considers several indirect factors influencing the overall net benefits: (1) the potential for retaliation from other officials (e.g., differences between Manchu and other ethnicities); (2) the influence of hierarchical roles (e.g., Governor-General vs. Commissioner); (3) the emperor's preference for trusted ministers; (4) the preventability of disasters; and (5) the history of disaster reporting in the previous year. Standard errors clustered at the county level are shown in parentheses. All regressions include county fixed effects, year fixed effects, and control variables.

Variable	**Manchu vs. Other Ethnic** (1)	**Governor-General vs. Commissioner** (2)	**Emperor's Trusted minister** (3)	**Preventable Disaster** (4)	**Disasters Were Reported Last Year** (5)
Key	0.0133***	0.183***	0.273***	0.032**	0.011**
	(0.015)	(0.027)	(0.032)	(0.014)	(0.005)
Observations	6,689	6,689	6,689	6,689	6,637
county FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Number of clusters	749	749	749	749	747
Adjusted R-squared	0.396	0.400	0.398	0.397	0.395

Table 7. Cover up less likely when third parties participate in the disclosure process

Notes: This table examines the role of third parties in the information disclosure process and their impact on reducing the likelihood of disaster information concealment (Cover_up). The analysis considers the following factors: (1) End of the Road, which indicates provinces at the terminal points of the imperial road network; (2) Magnitude of the Disaster, whether these disasters extend across provincial boundaries;(3) Active Censors; and (4) Number of Chin-shih.Standard errors clustered at the county level are reported in parentheses. All regressions include relevant fixed effects and control variables.

Variable	**End of the Road** (1)	**Magnitude of the Disaster** (2)	**Active Censors** (3)	**Number of chin-shih** (4)
Key	0.279***	-0.184***	-0.202***	-0.086***
	(0.050)	(0.061)	(0.014)	(0.032)
Observations	6,689	6,689	6,689	6,689
Lev FE	YES			
county FE		YES	YES	
Year FE	YES	YES		YES
Controls	YES	YES	YES	YES
Number of clusters	749	749	749	749
Adjusted R-squared	0.394	0.397	0.180	0.299

Table 8. Alternative Hypotheses

Notes: This table examines three alternative hypotheses regarding disaster reporting and concealment behavior. Panel A investigates the ”Too Small Disaster to Report” hypothesis, focusing on minor disasters that affect only a single county. Panel B: ”Report for Relief” Hypothesis uses the character Pi from the Qing Governance system as an indicator of regions facing tax collection challenges. Panel C evaluates the ”Information Isolation Hypothesis,” using the distance to the provincial capital as a proxy for officials' ability to gather and report information. Standard errors clustered at the county level are shown in parentheses. All regressions include relevant fixed effects and control variables.

Panel A: Too small disaster to Report Hypothesis

Variable	**Small disaster** (1)	**Reassignment distance** (2)	**[-3,-1]** (3)	**Two-person** (4)	**Anti-Corruption Campaign** (5)	**Governor-General vs. Commissioner** (6)	**Active Censors** (7)
keyVariable		0.029**	-0.025	0.128***		0.188***	
		(0.013)	(0.032)	(0.040)		(0.027)	
Too small disaster to Report Hypothesis	0.048**	0.088*	0.063**	0.060**	0.053***	0.056**	0.049
	(0.020)	(0.049)	(0.026)	(0.023)	(0.020)	(0.022)	(0.035)
KeyVariable × Too small disaster to Report Hypothesis		-0.029	-0.011	-0.041	-0.065	-0.029	-0.001
		(0.034)	(0.011)	(0.048)	(0.079)	(0.065)	(0.040)
Observations	6,689	6,689	6,637	6,689	6,689	6,689	6,689
county FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES
Number of clusters	749	749	747	749	749	749	749
Adjusted R-squared	0.397	0.397	0.395	0.399	0.397	0.400	0.397

Panel B: The Report for Relief Hypothesis

Variable	**Fiscal burdens** (1)	**Reassignment distance** (2)	**[-3,-1]** (3)	**Two-person** (4)	**Anti-Corruption Campaign** (5)	**Governor-General vs. Commissioner** (6)	**Active Censors** (7)
keyVariable		0.032**	-0.023	0.093*		0.190***	
		(0.015)	(0.034)	(0.052)		(0.039)	
The Report for Relief Hypothesis	0.003						
	(0.015)						
KeyVariable × The Report for Relief Hypothesis		-0.018	-0.001	0.070	-0.043	-0.012	-0.006
		(0.026)	(0.062)	(0.059)	(0.043)	(0.052)	(0.025)
Observations	6,707	6,707	6,655	6,707	6,707	6,707	6,707
Lev FE	YES	NO	NO	NO	NO	NO	NO
county FE	NO	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES
Number of clusters	753	753	751	753	753	753	753
Adjusted R-squared	0.394	0.397	0.394	0.399	0.396	0.400	0.396

Panel C: Information Isolation Hypothesis							
Variable	**Distance to capital** (1)	**Reassignment distance** (2)	**[-3,-1]** (3)	**Two-person** (4)	**Anti-Corruption Campaign** (5)	**Governor-General vs. Commissioner** (6)	**Active Censors** (7)
keyVariable		0.056	-0.558	0.212		0.568	
		(0.205)	(0.710)	(0.735)		(0.661)	
Information Isolation Hypothesis	0.005						
	(0.010)						
KeyVariable × Information Isolation Hypothesis		-0.002	0.038	-0.007	-0.022	-0.028	-0.003
		(0.015)	(0.051)	(0.053)	(0.030)	(0.048)	(0.016)
Observations	6,689	6,689	6,637	6,689	6,689	6,689	6,689
Lev FE	YES	NO	NO	NO	NO	NO	NO
county FE	NO	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES
Number of clusters	749	749	747	749	749	749	749
Adjusted R-squared	0.394	0.397	0.394	0.398	0.396	0.400	0.396

Table 9. Implication

Notes: This table examines the relationship between disaster concealment by local officials and the subsequent occurrence of famine and rebellion in their jurisdictions. Column (1) focuses on the probability of famine, while Column (2) examines the likelihood of rebellion.Standard errors clustered at the county level are shown in parentheses. All regressions include country fixed effects, year fixed effects, and control variables.

Variable	**Famine** (1)	**Rebellion** (2)
Cover up	0.029^{**}	0.006^{**}
	(0.005)	(0.003)
Observations	6689	6689
Country FE	YES	YES
Year FE	YES	YES
Controls	YES	YES
Number of clusters	749	749
Adjusted R-squared	0.239	0.0614

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A Appendix: Proofs and auxiliary results

A.1 Footnote 18: Existence of a countably infinite collection of partitions

Formally stated, and assignment is a collection of cycle assignment functions. A cycle assignment function for cycle $c \in \mathbb{N}_0$, is a function $g_c : \mathbb{N}_0 \to \mathbb{N}_0$. Each cycle assignment function satisfies the following conditions: for all $c \in \mathbb{N}_0$, $g_c : \mathbb{N}_0 \to \mathbb{N}_0$ is a bijection, and for all c, i and $j \in \mathbb{N}_0$, $\#(g_c^{-1}(j)) = 2$, and, the partitions generated by each g_c, i.e., $\mathscr{P}_c := \{g_c^{-1}(0), g_c^{-1}(1), g_c^{-1}(2), \ldots\}$ are disjoint.

Define a pairing partition of a set as a partition of the set into two-element subsets, called pairs. The assignment of partners in each cycle, c, entails partitioning the $\mathbb{N}_0$ officials into $\mathbb{N}_0$ pairing partitions. In order for the officials to never work with the same partner more than once, it must be the case that the partitions are disjoint, i.e., $\mathscr{P}_{c'} \cap \mathscr{P}_{c''} = \varnothing$. Because there are $\mathbb{N}_0$ cycles, our definition of the assignment function only makes sense if an infinite collection of disjoint pairing partitions exists. Although the existence of countably infinite set of pairing partitions of a countable set is fairly obvious, the existence of a countably infinite set of disjoint pairing partitions might not be obvious.

The existence of such collections of pairing partitions is, in fact, an old established result in infinitary combinatorics. However, the result is framed in graph theory context. So, to make the references provided interpretable for readers, we will first rephrase the result in graph theory terms and then refer readers to the relevant references.

Framed in terms of graph theory, the graph G that we consider is defined by its set of vertices, the set of officials, $\mathbb{N}_0$, and its edges, E, all pairs of officials, i.e., two element subsets of V. Since there are a countable number of officials, the graph is an infinite graph. Because all pairs are admissible, the graph is a complete graph.

A 1-factor of the graph is spanning subgraph satisfying the condition that each vertex in the subgraph has only one neighbor. Thus a 1-factor is a collection of pairs (the edges) such that each official is an element of one and only one pair, i.e., each 1-factor is a partition of the set of officials. A 1-factorization is a collection of disjoint 1-factors.

In the first published book on graph theory (König, 1936), König showed that a countably infinite graph can be factored into a countable set of 1-factors (Andersen and Thomassen (1980, pg. 248) and König (1990, pg. 306). Since each 1-factor is a partition of $\mathbb{N}_0$ into disjoint pairs and the partitions generated by the 1-factors are disjoint, König's result implies that there exists a countable set of disjoint pairing partitions of $\mathbb{N}_0$. Thus, a countably infinite set of disjoint pairing partition exists.

A.2 Proof of risk-dominance for Result 1

It is well known that in symmetric 2×2 games, risk dominance is equivalent to potential maximization (e.g., Guisasola and Saari, 2020). So, we establish the risk dominance of disclosure equilibria by showing that one-shot game has a potential and that the potential is maximized at $(m^1, m^2) = (\mathscr{D}, \mathscr{D})$. The candidate potential function, P, is defined in Table 10.

P		$m^2 =$	
		$\mathscr{D}$	$-\mathscr{D}$
$m^1 =$	$\mathscr{D}$	$\frac{3}{4}d - \frac{1}{4}(u(1-\eta) - b)$	$-\frac{1}{4}(d + (u(1-\eta) - b))$
	$-\mathscr{D}$	$-\frac{1}{4}(d + (u(1-\eta) - b))$	$\frac{3}{4}(u(1-\eta) - b) - \frac{1}{4}d$

Table 10. Potential function, P, for the single-shot game.

We only need to show that $P(\mathscr{D}, \mathscr{D}) - P(-\mathscr{D}, \mathscr{D}) = u^1(\mathscr{D}, \mathscr{D}) - u^1(-\mathscr{D}, \mathscr{D})$ and $P(\mathscr{D}, -\mathscr{D}) - P(-\mathscr{D}, -\mathscr{D}) = u^1(\mathscr{D}, -\mathscr{D}) - u^1(-\mathscr{D}, -\mathscr{D})$, where u^1 represents the payoff of official 1 the one-shot game. The corresponding equalities for official 2 follow from the symmetry of the game and the potential function, P. Direct calculation, using the specification of P in Table 10, verifies that these conditions are satisfied.

Inspection of Table 10 shows that when assumption 1 is satisfied, $P(\mathscr{D}, \mathscr{D}) > P(m^1, m^1)$, whenever $(m^1, m^1) \neq (\mathscr{D}, \mathscr{D})$. Thus, the disclosure equilibrium is the unique risk dominant equilibrium. $\square$

A.3 Formal definitions of the whistle blowing system

The assignment function for cycle c, g_c, generates a partitions of size 2 of $\mathbb{N}_0$. These partitions generate equivalence relation: $i' \sim_c i''$ if $g_c(i') = g_c(i'')$. The *partner* of official i in cycle c, denoted by $p_c(i)$, can thus be defined as $p_c(i) :=$ the unique $i' \in \mathbb{N}_0$ such that $i \sim_c i'$ and $i' \neq i$. With a slight abuse of notation, we will suppress the dependence of the partner and simply denote the partner of i in cycle c, by $-i$. We represent the set officials who at some stage s of cycle c report disaster their partner reports no disaster by D_c. Note that, because we have assumed that, when no disaster occurs, officials always report no disaster, if $i \in D_c$, a disaster must have actually occurred in i's jurisdiction in some stage of cycle c. So we can think of officials in D_c as officials who blew the whistle in cycle c.

If the whistle-blowing system is perfectly implemented the identity of the whistle-blower will not be revealed to other officials, if the system is leaky there is some chance the official name will be leaked. In each jurisdiction and cycle we assume that the whistle blower is identified as an informer when $\tilde{\iota}_c(j) = 1$, where $\{\tilde{\iota}_c(j), (c, j) \in \mathbb{N}_0 \times \mathbb{N}_0$ are a collection of iid Bernoulli random variable, and $\mathbb{P}[\tilde{\iota}_c(j) = 1] = \iota \in (0, 1)$. Thus, an official is identified as a whistle blower in cycle c if $i \in W_c$, $g_c(i) = j$ and $\tilde{\iota}_c(j) = 1$. The set of officials identified as whistle blowers in cycle c is represented by I_c. The formal definitions of W_c and I_c are provided below.

$$W_c := \{i \in \mathbb{N}_0 : \text{ for some stage } s \in \{0,1\} \text{ of } c, (m^i_{c,s}, m^{-i}_{c,s}) = (\mathscr{D}, -\mathscr{D})\}, \quad c \in \mathbb{N}_0.$$
$$I_c := \{i \in \mathbb{N}_0 : i \in D_c \text{ and } \tilde{\iota}_c(g_c(i)) = 1\}, \quad c \in \mathbb{N}_0.$$

The set of ever identified whistle-blowers at the start of cycle c is defined inductively and denoted by Id_c, i.e.,

$$\mathrm{Id}_c = \begin{cases} \varnothing & c = 0, \\ \mathrm{Id}_{c-1} \cup I_{c-1} & c > 0, \end{cases}, \quad c \in \mathbb{N}_0.$$

A.4 Formal definition of cycle strategies

Definition 2. For $(\hat{\eta}_0, \hat{\eta}_0) \in [\eta_N, \eta_{\mathrm{PO}}]^2$, a $(\hat{\eta}_0, \hat{\eta}_1)$-*coverup cycle strategy* consists of a strategy for each official $i \in \mathbb{N}_0$ at stages 0 and 1 of every cycle c, denoted by cs^i_0 and cs^i_1 respectively where $\mathrm{cs}^i_0 : \Omega_0 \times [0,1] \times [\eta_N, \eta_{\mathrm{PO}}] \to M_0$ and $\mathrm{cs}^i_1 : M_0^2 \times \Omega_1 \times [0,1] \times [\eta_N, \eta_{\mathrm{PO}}] \to M_1$, defined as follows:

$$\mathrm{cs}^i_0(\omega_0, \eta_0, \hat{\eta}_0) := \begin{cases} -\mathscr{D} & \text{if } \omega_0 = -\mathscr{D}, \\ -\mathscr{D} & \text{if } \omega_0 = \mathscr{D} \text{ and } \eta_0 \leq \hat{\eta}_0, \\ \mathscr{D} & \text{if } \omega = \mathscr{D} \text{ and } \eta_0 > \hat{\eta}_0; \end{cases} \tag{A-1}$$

$$\mathrm{cs}^i_1(m^i_0, m^{-i}_0, \omega_1, \eta_1, \hat{\eta}_1) := \begin{cases} -\mathscr{D} & \text{if } \omega_1 = -\mathscr{D}, \\ -\mathscr{D} & \text{if } \omega_1 = \mathscr{D} \text{ and } \eta_1 \leq \hat{\eta}_1 \text{ and } m^i_0 = m^{-i}_0 \\ \mathscr{D} & \text{if } (\omega_1 = \mathscr{D} \text{ and } \eta_1 > \hat{\eta}_1) \text{ or } m^i_0 \neq m^{-i}_0. \end{cases} \tag{A-2}$$

Definition 3. A *disclosure cycle strategy* is a strategy for each official $i \in \mathbb{N}_0$ at stages 0 and 1 denoted by ds^i_0 and ds^i_1 respectively, where $\mathrm{ds}^i_0 : \Omega_0 \to M_0$ and $\mathrm{ds}^i_1 : \Omega_1 \to M_1$ given by $\mathrm{ds}_0(\omega_0) = \omega_0$ and $\mathrm{ds}_1(\omega_1) = \omega_1$.

Definition 4. For $(\hat{\eta}_0, \hat{\eta}_1) \in [\eta_N, \eta_{\mathrm{PO}}]^2$, a $(\hat{\eta}_0, \hat{\eta}_1)$-*coverup strategy* is defined as follows: For all $i \in \mathbb{N}_0$, the cycle disclosure strategy for i in cycle c is the $(\hat{\eta}_0, \hat{\eta}_1)$-*coverup cycle strategy* whenever, $i \notin \mathrm{Id}_c$ and $p_c(i) \notin \mathrm{Id}_c$. Otherwise i's cycle strategy in cycle c, is the disclosure cycle strategy.

A.5 Proofs of Results

Proof of Lemma 3. First, to obtain a contradiction suppose that condition (13) is not satisfied and $(\hat{\eta}^*_0, \hat{\eta}^*_1)$ is an optimal coverup strategy. Because, by the definition of an optimal coverup strategy $(\hat{\eta}^*_0, \hat{\eta}^*_1) \in \mathscr{N}_{\mathrm{eq}}$, so the first two conditions in condition (13) are satisfied. Thus, if these conditions are not satisfied $\hat{\eta}^*_0 < \eta_{\mathrm{PO}}$ and $e_0(\hat{\eta}^*_0, \hat{\eta}^*_1) - \hat{\eta}_0 > 0$. Because, e_0 is continuous, there exists $\hat{\eta}_0'$, such that $\hat{\eta}_0^* < \hat{\eta}_0' \leq \eta_{\text{PO}}$ such that

$$e_0(\hat{\eta}_0', \hat{\eta}_1^*) - \hat{\eta}_0 \geq 0. \tag{A-3}$$

Now consider, condition (14). Because $(\hat{\eta}_0^*, \hat{\eta}_1^*)$ is a coverup equilibrium, $e_1(\hat{\eta}_0^*, \hat{\eta}_1^*) - \hat{\eta}_1^* \geq 0$. Next note that $D_0 e_1 > 0$, so, because $\hat{\eta}_0' > \hat{\eta}_0^*$, $e_1(\hat{\eta}_0', \hat{\eta}_1^*) \geq e_1(\hat{\eta}_0^*, \hat{\eta}_1^*)$. Thus,

$$e_1(\hat{\eta}_0', \hat{\eta}_1^*) - \hat{\eta}_1^* \geq 0.. \tag{A-4}$$

Thus, $(\hat{\eta}_0', \hat{\eta}_1^*)$ satisfies the coverup equilibrium conditions. Finally note that, Because $(\hat{\eta}_0', \hat{\eta}_1^*) \gneqq (\hat{\eta}_0^*, \hat{\eta}_1^*)$, $V_N(\hat{\eta}_0', \hat{\eta}_1^*) > (\hat{\eta}_0^*, \hat{\eta}_1^*)$. So, $(\hat{\eta}_0^*, \hat{\eta}_1^*)$ is not an optimal coverup equilibrium. This contradiction establishes that condition (13) is satisfied in any optimal coverup equilibrium. The argument for establishing condition (A-3) follows from an identical proof because it is also the case that $D_1 e_0 > 0$. $\square$

A.5.1 Proof of Proposition 1

Define, the fixed-point function: $T : [\eta_N, \eta_{\text{PO}}]^2 \to [\eta_N, \eta_{\text{PO}}]^2$ as follows:

$$T(\hat{\eta}_0, \hat{\eta}_1) := (\min[e_0(\hat{\eta}_0, \hat{\eta}_1), \eta_{\text{PO}}], \min[e_1(\hat{\eta}_0, \hat{\eta}_1), \eta_{\text{PO}}]). \tag{A-5}$$

Let $T_s(\hat{\eta}_0, \hat{\eta}_1)$. $s = 0, 2$, represent the coordinate functions of T, i.e., $T_s(\hat{\eta}_0, \hat{\eta}_1) := \min[e_s(\hat{\eta}_0, \hat{\eta}_1), \eta_{\text{PO}}]$. This proof is a consequence of the following Lemmas.

Lemma A.1. *A coverup strategy, $(\hat{\eta}_0, \hat{\eta}_1)$ satisfies the complementary slackness conditions if and only if $(\hat{\eta}_0, \hat{\eta}_1)$ is a fixed point of T, i.e., $T(\hat{\eta}_0, \hat{\eta}_1) = (\hat{\eta}_0, \hat{\eta}_1)$.*

Proof of Lemma A.1. The definition of T implies that $T(\hat{\eta}_0, \hat{\eta}_1) \in [\eta_N, \eta_{\text{PO}}]^2$ and that, if $T(\hat{\eta}_0, \hat{\eta}_1) = (\hat{\eta}_0, \hat{\eta}_1)$, then

$$T_s(\hat{\eta}_0, \hat{\eta}_1) - \hat{\eta}_s = 0, \quad s = 0, 1.$$

This condition is satisfied if and only if

$$\min\left[e_s(\hat{\eta}_0, \hat{\eta}_1) - \hat{\eta}_s, \eta_{\text{PO}} - \hat{\eta}_s\right] = 0, \quad s = 0, 1. \tag{A-6}$$

Because, by definition, the domain of T_s is $[\eta_N, \eta_{\text{PO}}]$, $\eta_{\text{PO}} - \hat{\eta}_s \geq 0$, Equation (A-6) cannot be satisfied if $e_s(\hat{\eta}_0, \hat{\eta}_1) - \hat{\eta}_s < 0$. So, $e_s(\hat{\eta}_0, \hat{\eta}_1) - \hat{\eta}_s \geq 0$. Because, $\eta_{\text{PO}} - \hat{\eta}_s \geq 0$ and $e_s(\hat{\eta}_0, \hat{\eta}_1) - \hat{\eta}_s \geq 0$, equation (A-6) can only be satisfied if either $\eta_{\text{PO}} - \hat{\eta}_s = 0$ or $e_s(\hat{\eta}_0, \hat{\eta}_1) - \hat{\eta}_s = 0$. Clearly, if

$$\eta_{\text{PO}} - \hat{\eta}_s \geq 0 \text{ and } e_s(\hat{\eta}_0, \hat{\eta}_1) - \hat{\eta}_s \geq 0 \text{ and } \left(\eta_{\text{PO}} - \hat{\eta}_s = 0 \text{ or } e_s(\hat{\eta}_0, \hat{\eta}_1) - \hat{\eta}_s = 0\right), \quad s = 0, 1. \tag{A-7}$$

then equation (A-6) is satisfied. Thus equation (A-6) is satisfied if and only expression (A-7) is satisfied. (A-7) is equivalent to the complementary slackness condition in Lemma 3. □

Lemma A.2. *A fixed point of T exists and this fixed point is unique.*

Proof of Lemma A.2. First note that $[\eta_N, \eta_{\text{PO}}]^2$ is a complete lattice under the standard lattice order for $\mathbb{R}^2$ and that T is an increasing map, i.e., $\hat{\eta}'' \geq \hat{\eta}' \Rightarrow T(\hat{\eta}'') \geq T(\hat{\eta}')$. Thus Tarski's fixed point theorem (Tarski, 1955), implies that T has a least fixed point, $\hat{\eta}^*$, where

$$\hat{\eta}^* = \sup\{\hat{\eta} : \hat{\eta} \leq T(\hat{\eta})\}. \tag{A-8}$$

Marinacci and Montrucchio (2019) provides conditions for the least fixed point being the only fixed point. These conditions, specialized to our problem, can be summarized as follows: (a) $[\eta_N, \eta_{\text{PO}}]^2$ is lattice conves, i.e., ithe convex combination of any two points in $[\eta_N, \eta_{\text{PO}}]^2$ is in $[\eta_N, \eta_{\text{PO}}]^2$; (b) T is lattice concave, i.e., the two coordinate functions T_0 and T_1 are concave and (c): (i) points on the lower perimeter of $[\eta_N, \eta_{\text{PO}}]^2$, namely points in $[\eta_N, \eta_{\text{PO}}] \times \{0\} \cup \{0\} \times [\eta_N, \eta_{\text{PO}}]$ are never fixed points of T and (ii) every point not in the lower perimeter majorizes some point, say $\hat{\eta}^o$, which is a sub-solution, i.e., $\hat{\eta}^o \lneqq T(\hat{\eta}^o)$.

The lattice concavity simply means that if $\hat{\eta}', \hat{\eta}'' \in [\eta_N, \eta_{\text{PO}}]^2$ and $\hat{\eta}' \leq \hat{\eta}^o \hat{\eta}''$, then $\hat{\eta}^o \in [\eta_N, \eta_{\text{PO}}]^2$. So it is apparent that (a) is satisfied. Now consider (b). Inspection shows that e_s, $s = 0, 2$ is concave. Thus $T_s = \min[e_s, \eta_{\text{PO}}$ is concave. So (b) is satisfied. Inspection shows that T has no fixed points on the lower perimeter. Thus (ci) is satisfied. To establish (cii), first note that $\hat{\eta}_N = (\eta_N, \eta_N)$ is the unique minimal element of $[\eta_N, \eta_{\text{PO}}]^2$ and $\hat{\eta}_N \lneqq T(\hat{\eta}_N$. So $\hat{\eta}_N$ is a sub-solution every point not in the lower perimeter majorizes $\hat{\eta}_N$. So (cii) is also satisfied.mThus, $\hat{\eta}^*$ is the unique fixed point of T. □

Proof of Proposition 1. Lemma 3 shows that satisfying the complementary slackness conditions (CSC) in the lemma is a necessary condition for $(\hat{\eta}_0^*, \hat{\eta}_1^*)$ being an optimal coverup strategy. Lemma A.1 shows that the CSC conditions are satisfied if and only if $(\hat{\eta}_0^*, \hat{\eta}_1^*)$ is a fixed point of T (defined by equation (A-5)). Lemma A.2 shows that T has a unique fixed point. □

A.5.2 Proof of Proposition 2

To establish the proposition we require an ancillary (very simple) general result. Let T^p represent the fixed point map when the exogenous parameters of the model p, i.e., $\eta_{\text{PO}}, \eta_N, \kappa, \delta$. Consider two sets of exogenous parameters, p_1, and p_2. To simplify notation define $T^1 := T^{p_1}$ and $T^2 := T^{p_2}$. Let $\hat{\eta}_1^o$ and $\hat{\eta}_2^o$ represent the fixed points of T^1 and T^2 respectively.

Result A.1. *If for all $\hat{\eta} \in [\eta_N, \eta_{PO}]$.*

$$T^2(\hat{\eta}) \geq T^1(\hat{\eta}), \textit{ then } \hat{\eta}_2^o \geq \hat{\eta}_1^o.$$

Proof. First for all parts of the proof note that being the (unique) fixed point of T is equivalent to being an optimal coverup equilibrium (Proposition 2).

Because $\hat{\eta}_1^o$ is fixed point of T^1, $\hat{\eta}_1^o = T^1(\hat{\eta}_1^o)$. $T^1 \le T^2$ by hypothesis. So $\hat{\eta}_1^o \le T^2(\hat{\eta}_1^o)$. Equation (A.1) shows that $\hat{\eta}_2^o = \sup\{\hat{\eta} : \hat{\eta} \le T^2(\hat{\eta})\}$. Thus, by the definition of a supremum, $\hat{\eta}_2^o \ge \hat{\eta}_1^o$. □

Proof of Proposition 2. To prove part (a), simply not that the definitions of e_0 and e_1 (equations (11) and (12)) imply that $e_0 > e_1$. The definition of T (equation (A-5)) implies that $T_0(\hat{\eta}_0, \hat{\eta}_1) \ge T_1(\hat{\eta}_0, \hat{\eta}_1)$. So if $(\hat{\eta}_0^*, \hat{\eta}_1^*)$ is the fixed point of T, then $\hat{\eta}_0^* = T_0(\hat{\eta}_0^*, \hat{\eta}_1^*) \ge T_1(\hat{\eta}_0^*, \hat{\eta}_1^*) = \hat{\eta}_1^*$. Next note that the definition of T implies that $\hat{\eta}_0^* = \hat{\eta}_1^*$ if and only if

$$\begin{aligned} \hat{\eta}_0^* &= T_0(\hat{\eta}_0^*, \hat{\eta}_1^*) = \min[e_0(\hat{\eta}_0^*, \hat{\eta}_1^*), \eta_{\text{PO}}] \\ \hat{\eta}_1^* &= T_1(\hat{\eta}_0^*, \hat{\eta}_1^*) = \min[e_1(\hat{\eta}_0^*, \hat{\eta}_1^*), \eta_{\text{PO}}] \end{aligned}$$

So $\hat{\eta}_0^* = \hat{\eta}_1^*$ if and only if

$$\min[e_0(\hat{\eta}_0^*, \hat{\eta}_1^*), \eta_{\text{PO}}] = \min[e_1(\hat{\eta}_0^*, \hat{\eta}_1^*), \eta_{\text{PO}}].$$

Because $e_0 > e_1$ this equality can only be satisfied if $e_1(\hat{\eta}_0^*, \hat{\eta}_1^*) \ge \eta_{\text{PO}}$, in which case $e_1(\hat{\eta}_0^*, \hat{\eta}_1^*) \ge \eta_{\text{PO}}$ and thus, $\hat{\eta}_0^* = \eta_{\text{PO}}$ and $\hat{\eta}_1^* = \eta_{\text{PO}}$.

To prove parts (b), first not that e_0 and e_1 are increasing in the parameters η_{PO}, δ, and κ. By definition κ is increasing in both β and ι. Thus, holding the other parameters fixed, if we compare the fixed point maps resulting from the larger value of the parameter, say the fixed point map T'' with the fixed point map resulting for the smaller parameter, say T' the definition of T implies that $T'' \ge T'$), which as shown by Result A.1, implies that the fixed point of T'' is larger than the fixed point of T', i.e., the probability of coverup is larger.

To prove part (c) first note that e_0 and e_1 are increasing in the parameter η_N, and that disclosure reward equals $1 - \eta_N$, a decreasing function of η_N. To complete the proof, just apply the same argument used for part (b). □