How Rules and Compliance Impact Organizational Outcomes: Evidence from Delegation in Environmental Regulation

James Fenske*, Muhammad Haseeb†, and Namrata Kala‡

Abstract

The divergence between regulations as written and regulations as enforced can affect regulated entities. Combining new data on firms' permit applications and internal regulatory communication with a natural experiment, we show that delegating regulatory authority increased approval rates for pollution-intensive firms, altering entry composition. However, one third of applications were not delegated, violating formal rules. Senior officers were less likely to delegate applications with greater pollution potential, and less likely to delegate if they had applied more scrutiny to applications before the reform. We highlight how and when divergences between policy design and actual implementation occur, and their consequences.

Keywords: formal authority, de jure and de facto regulation, delegation, environmental regulation, pollution, India

*University of Warwick. j.fenske@warwick.ac.uk

†University of Bristol. m.haseeb@bristol.ac.uk

‡MIT Sloan School of Management. kala@mit.edu.

We would like to thank audiences at the Aix-Marseille School of Economics, Cornell University, Deakin University, MIT, NBER, Northwestern University, Stanford University, the Stockholm School of Economics, the University of Bristol, the University of Gottingen, the University of Manchester, and the University of Warwick for comments. We would also like to thank Alessandro Bonatti, Laura Boudreau, Jordi Blanes i Vidal, Joseph Doyle, Robert Gibbons, Daniela Scur, Raffaella Sadun, and Silvia Vannutelli for comments. We are grateful to Sushil Mathew for excellent research assistance. Authors acknowledge funding from the Private Enterprise Development in Low-Income Countries (PEDL) initiative.

1 Introduction

Formal rules are pervasive in organizations, but may be implemented differently by different actors, impacting organizational outcomes (Schein, 2010). Related to these differences between formal rules and their potentially uneven implementation is the distinction between *de jure* vs. *de facto* implementation of regulations, which has been of longstanding interest since it impacts the efficacy and welfare consequences of regulations. Quantifying the dispersion in regulatory implementation by regulators and linking this dispersion to organizational outcomes is empirically challenging, since it requires data on regulators' actions, exogenous variation in rules, and consequences on regulated agents.

In this paper, we combine new data with a natural experiment and a model to estimate the impacts of formal rules and when they are not followed, regarding an important aspect of organizational structure – the allocation of decision rights. We estimate how the delegation of formal authority affects its actual allocation, the consequences of this delegation on regulated firms, and the circumstances that lead senior officers in the organization to withhold this authority.

The data we use comprise the universe of all environmental permit applications from Kerala, an Indian state with a population of over 34 million people. Most firms (except in sectors that are completely non-polluting), are required to obtain these permits. The data contain both detailed information on the application and internal communications within the environmental regulator (equivalent to a state Environmental Protection Agency (EPA) in the United States). They consist of more than 64,000 firms' applications and half a million emails involving individual regulators and applicant firms (the number of firms in our data is much larger than those available in standard firm datasets for India such as the Annual Survey of Industries). Moreover, each application is a well-defined task or problem with observable characteristics (e.g. size, sector, pollution potential and pollution emitted by the applicant firm) and a clear outcome (whether the application was accepted). There are also clear rules on who has the *de jure* authority to decide whether to grant the permit. A unique feature of the data is that we observe both the links in communication (i.e. who communicated with whom) as well as the content of communication.

We combine these data with a natural experiment that changed the allocation of authority to make decisions on certain types of applications. In July 2019, junior officers working within the regulatory agency were given the *de jure* authority to approve or reject applications from firms in industries that the central government had previously deemed to have relatively low pollution potential. In particular, applications are assigned a color code denoting their pollution potential, comprising Red (high pollution potential), Orange (intermediate) and

Green (low), which are largely a function of their industry. Delegation gave junior officers decision rights over Green applications, which was previously with the senior officers.

The first part of the paper estimates the impact of delegation on regulated firms. We use event study and differences in differences (DID) approaches that compare applications in industries for which junior officers gained *de jure* decision rights to those for which they did not, before and after the reform. First, we show that the delegation reform has a strong first stage. Green applications are more likely to be decided by junior officers by 54.1 percentage points. The reform had meaningful impacts on the outcomes of applicant firms. Applications from Green industries became close to 3 percentage points more likely to be approved, 5.5 percentage points when considering treatment on the treated effects. We find that this increase in acceptance is driven largely by more pollution-intensive firms within these Green industries. Furthermore, using evidence from our own recently conducted field survey, we show that accepted Green firms received lower scrutiny with respect to compliance with siting requirements, specifically the mandated minimum distances from amenities such as schools.

In the second part of the analysis, we show that delegation was imperfectly followed; applications in Green industries became 27.8 percentage points more likely to be decided by an officer *above* the officer with closing authority, i.e. above the junior officer. Thus, the probability of noncompliance with the rules, or divergence between *de jure* and *de facto* allocation of authority, increases. What drives this gap? To understand the incomplete delegation that we observe, we use a parsimonious model in which the senior officer chooses whether or not to delegate to a junior officer. She is tasked with approving or denying applications, some of which may not be compliant with regulations. She will delegate only if the costs of wrongfully approving a non-compliant application are low relative to the junior officer's propensity to effectively scrutinize the application. The senior and junior officers differ in their costs of exercising scrutiny, in their costs of effort, and in the consequences they face from a wrongful approval; these differences can reflect both innate differences and asymmetric information. This model identifies several conditions that make delegation more likely.

We identify empirical proxies for several of these model parameters, and test for heterogeneous responses to the delegation reform that are consistent with this framework. First, we use the data on communication to proxy for the senior officer's effectiveness. The approval process includes senior officers, junior officers (who received authority to decide Green applications), and subordinate officers who process these applications and conduct compliance checks. Subordinate officers (the most junior in this hierarchy, who are also responsible for conducting scrutiny for these applications) frequently make recommendations regarding approving applications. Using pre-reform data, we measure officers' propensities to overturn subordinate officers' approval recommendations before the reform. This measures agreement with the subordinate, and is a proxy for senior officers' efficacy (since it requires pointing out mistakes that the subordinate has missed). Senior officers who are more effective by this proxy respond less to the reform in terms of delegation i.e. baseline agreement with subordinate officers predicts greater delegation. Second, we use greater pollution potential as a proxy for higher costs to the senior of wrongful approval. We show that applications with higher pollution potential are delegated less than others after the reform, consistent with the framework. Third, we proxy for the senior's costs of effort using the number of applications received in the past 120 days. If the senior's workload rises in this way, delegation is more likely, consistent with a higher cost of effort. In sum, the results paint a picture of delegation impacting applicant firm outcomes, and where the allocation of decision rights is determined by cautious senior officers in partial noncompliance with formal decision rights. Overall, these results highlight the mechanisms underlying differences in *de jure* and *de facto* regulations.

We conduct several tests to show the robustness of our main results, some of which we mention here. We find no evidence of differential changes in the observable characteristics of applications, and show that our results are not driven by industries in which firms can potentially change their production scale to reduce their regulatory burden (i.e. industries where regulatory scrutiny is a function of reported firm size). Our results are robust to several alternative specifications and estimation choices, and to limiting the sample to subgroups of Green and other applications that are most similar to each other in their observable characteristics. We also provide evidence against an alternative interpretation of the decision to delegate grounded in corruption. Delegation is no less likely for applications that represent large capital investments (and so may be vulnerable to bribes), or in districts with greater levels of political corruption.

The paper relates to several literatures. First, the paper relates to empirical work on the allocation of authority within organizations.[1] Bandiera et al. (2021) conduct a field experiment with procurement agents in Pakistan, and find that giving procurement agents more authority lowers procurement prices without affecting quality. Kala (2024) studies a natural experiment that gave the managers of well-performing state-owned enterprises in India more autonomy over strategic decisions (like capital expansion and labor restructuring), and finds that autonomy increased value added but not productivity. The agency problem

[1] Following Aghion and Tirole (1997), there is a rich theoretical literature on the causes and consequences of delegation (see Bolton and Dewatripont (2013) for a review). Also related is Aghion et al. (2021), who find that decentralization for private firms predicts survival during the Great Recession, consistent with managers having better information about local economic conditions.

is different in this setting, since the senior officer is trading off the effort to resolve an application herself vs. the possibility that the junior officer may not resolve it satisfactorily. Consequently, whether delegation leads to positive outcomes for the organization is also different – in this case, delegation increases approval rates for relatively polluting firms. These results show the costs of delegation highlighted by theoretical work. These results also show how and why authority is withheld by senior regulators.

Second, we contribute to the growing literature on communication and problem solving within organizations.[2] There is recent and growing empirical work on communication within organizations, largely focused on higher-income settings. Sandvik et al. (2020) find that incentivizing sales agents to communicate improves productivity of workers who were encouraged to seek advice from their peers, and Espinosa and Stanton (2022) find that training workers frees up managerial time. Battiston, Blanes i Vidal and Kirchmaier (2021) show that face to face communication in a UK police organization increases productivity for those who receive help, but causes negative productivity externalities for workers who provide help. Impink, Prat and Sadun (2020) find that email communication patterns within firms are impacted by CEO turnover, which first decreases and then increases communication. This paper shows that communication patterns within an organization change in response to de jure changes in authority, but that officers who wish to retain *de facto* authority strategically exclude from their communications other officers who should have *de facto* authority. This limited change in communication is a mechanism through which the impact of the reform on organizational outcomes is limited. Further, we show that the textual content of communication within an organization can provide rich measures of effort and effectiveness, providing a nuanced picture of this organizational change.[3]

Most broadly, our paper is related to the literature on state capacity and regulatory capacity. A growing literature has shown the importance of state capacity (Aneja and Xu (2024); Bergeron, Tourek and Weigel (2024); Best, Hjort and Szakonyi (2023); Decarolis et al. (2020); Fenizia (2022); also see Besley et al. (2022) and Pomeranz and Vila-Belda (2019) for excellent reviews) as well as the effects of performance pay for bureaucrats (Dal Bó,

[2]A substantial portion of this literature is theoretical, and studies how communication as well as the costs of specialization by agents in an organization determine how problems should be transferred within the organizational hierarchy and solved (see for instance, Bolton and Dewatripont (1994); Garicano (2000), and Dessein and Santos (2006).)

[3]Related work has focused on the drivers of *real* authority in the private sector, such as the importance of local information (Aghion and Tirole, 1997), coordination (Dessein, Lo and Minami, 2022; McElheran, 2014), incentives and agent ability (Lo et al., 2016), trust (Bloom, Sadun and Van Reenen, 2012), the presence of information and communication technologies (Bloom et al., 2014), product market competition (Meagher and Wait, 2014), and how valuable the input is (Alfaro et al., 2024). This paper focuses on what determines the gap between real and formal authority rather than just the allocation of real authority, and studies this in the context of a public sector agency.

Finan and Rossi, 2013; Khan, Khwaja and Olken, 2016). This paper contributes to this literature in two ways. First, we present novel measures of what exactly regulators do as they enforce and uphold regulations, as well as show how the difference between actual regulation and regulators' implementation impacts firm outcomes. Second, the setting of this paper – environmental regulation – is an important one, as developing countries are increasingly facing tradeoffs between development and environmental quality. Prior work on environmental regulation has studied how the introduction of new environmental regulation impacts firm productivity (Fan et al., 2019; Greenstone, List and Syverson, 2012; Harrison et al., 2015; He, Wang and Zhang, 2020), while this paper focuses on how organizational reform in the environmental regulator impacts firms' outcomes.[4] While our focus is on a single reform, our results have implications for a much broader set of contexts. In the UK, for example, any firm that produces pollutants that have the potential to do harm requires an environmental permit from the Environment Agency, a regulator that employs more than 10,000 persons.[5] Under the single-medium approach in the United States, firms are often obligated to seek permits from separate agencies for each medium (e.g. air, water) they pollute (Tanaka et al., 2022). Understanding the role of authority in environmental regulation can help inform policies that seek to balance the regulator's objectives of streamlining these processes while preserving environmental quality.

2 Context

2.1 Environmental Regulation in India

India's system of environmental regulation is based on two key laws – the Water (Prevention and Control of Pollution) Act of 1974, and the Air (Prevention and Control of Pollution) Act of 1981 (Ghosh, 2019). These acts led to the establishment of the main agencies that regulate pollution in India, the national-level Central Pollution Control Board and the state-level Pollution Control Boards. These boards (equivalent to a state EPA), are in charge of implementing environmental regulations imposed on firms.

This paper studies the State Pollution Control Board in the state of Kerala. Kerala is an economically important state in India, with a population of over 34 million people (Population Census, 2011) and the 11th highest state-level GDP (Reserve Bank of India,

[4] In related work, Duflo et al. (2018) show that environmental regulators in India target inspections towards more polluting plants, and that these targeted inspections are more likely to identify serious violations relative to randomly targeted inspections. We find that senior officers also exercise discretion when deciding whether to delegate, retaining more difficult applications.

[5] `https://www.gov.uk/guidance/check-if-you-need-an-environmental-permit`, `https://www.gov.uk/government/organisations/environment-agency/about`.

2019). The Kerala Pollution Control Board administers statutes notified by the Ministry of Environment & Forest, aimed at preventing and controlling environmental pollution. Thus, their primary objective function, is ensuring compliance with environmental regulations, like the EPA in the US.[6] The Central Pollution Control Board, by contrast, operates in coordination with the state-level boards, to which it provides assistance (Bhat, 2010; Ghosh, 2019; Paranjape, 2013).[7] Critical for our study is the State Pollution Control Board's role in regulating polluting firms. In this capacity, it conducts inspections, gathers information, and is tasked with evaluating applications from firms to set up or expand operations that have the potential to pollute air or water, or release hazardous waste. The environmental permitting process serves as an instrument to uphold and monitor statutory requirements under the Water and Air Acts, ensuring that new or expanding industrial activities are consistent with environmental quality objectives (Bhat, 2010; Ghosh, 2019). All firms, except for those in a small number of non-polluting sectors, are required to apply for and receive approval from the State Pollution Control Board.[8] After approval, the Pollution Control Board is responsible for conducting routine inspections, and is able to revoke the firm's approval if it is found violating environmental regulations (Bhat, 2010; Ghosh, 2019; Paranjape, 2013).

Depending on the pollution potential of a given industry, all firms in that industry are assigned a color code – Green, Orange, or Red – that determines their regulatory burden. Red firms are the most polluting, and Green firms are the least polluting. The pollution score is a regulatory measure of pollution potential based on the expected air and water pollution levels in a given industry. It is a numeric index of the industry's pollution potential that varies between 21 and 100.[9] This score is determined by the regulator (not the firm), and varies by industry (not across firms within an industry).[10] Red firms on average pay higher fees, and must be inspected at a higher frequency.[11] They must also seek a renewal of their

[6]Their annual reports provide a detailed list of functions under the Water Act, the Air Act, and the Environment Act, all of which are focused on pollution prevention and control.

[7]The powers and responsibilities of the Central and State Pollution Control Boards, as well as their regional and district offices, are outlined in several official circulars, including PCB/T4/115/97 dated 01/03/2017 and PCB/E1/11550/2016 (2) dated 02/11/2016.

[8]New activities require a permit called Consent To Establish (CTE), while both new activities and renewals require one called Consent to Operate (CTO). We refer to these as new permits and renewals for the remainder of the paper, respectively. We observe both types of applications in our data.

[9]Firms with scores of 20 or below are classified as "White." For White firms, getting a permit to operate is not mandatory, and we do not use the small number of applications we observe in these industries (approximately 7% of the sample).

[10]Some industries are defined by size; for example, building projects receive different pollution scores and color classifications depending on whether they are greater or less than 20,000 square meters. Such applications comprise about 13.5% of the data. We discard these size-based industries in robustness checks, and show that the results do not change with this exclusion.

[11]Firms applying for permits are required to pay a fee, which varies based on the industry's pollution potential, capital investment, and the validity period of the consent. Firms in the Red and Orange categories

permit sooner (minimum every 5 years as opposed to 10 years for Orange firms and 15 for Green), and their approval requires more documentation. An inspection by the State Pollution Control Board is likely at the initial application stage, particularly for Red and Orange firms.

2.2 Organizational Hierarchy in the Regulatory Agency

There are several ranks of officer within the state's Pollution Control Board.[12] Six ranks appear as senders and receivers of the communications in our data. At the top of the bureaucratic hierarchy is the position of Chairman, followed by the position of Member Secretary. Below these officers are the Chief Environmental Engineers. For most of the duration of our data, between four and eight officers send emails with this title.

Below these three ranks are the three ranks of engineers that are central to this study. The first and most senior rank of these is that of the Environmental Engineer (EE), who is the usual first recipient for any application (approximately 98.5% of occurrences). There is usually one EE at a time for each of the fourteen districts of Kerala, and one additional EE for the industrial area of Eloor, which is treated as a district by the Pollution Control Board. We refer to the EE as the "senior" officer. Below her is the Assistant Environmental Engineer (AEE), to whom *de jure* authority over Green applications was given under the delegation reform.[13] There are generally one or two AEEs in each district at a time, though occasionally there are others.[14] We refer to the AEE as the "junior" officer. Below him and at the bottom of the relevant organizational hierarchy is the Assistant Engineer, or "AE." The AE is tasked with carrying out duties such as site inspections as directed by the AEE or EE.[15] We refer to the AE as the "subordinate" officer. Applicant firms and the record room also appear as senders and receivers in the communications data. Because the terms EE, AEE, and AE, are all similar and do not make the organizational hierarchy evident, we will show preference for our own labels of senior officer, junior officer, and subordinate officer throughout.

---

generally pay more than those in the Green categories. The fee covers administrative costs related to assessing the application and monitoring compliance with pollution control measures. This payment is required whether or not the application is approved.

[12]Our discussion here is based on the recruitment rules specified in Regn. No. KERBIL/2012/45073 dated 05/09/2012 with RNI.

[13]We adopt the pronoun conventions of the literature on principal-agent models, referring to the senior officer as "she" and the junior and subordinate officers as "he" throughout, regardless of the actual identities of the individuals in these roles.

[14]In roughly 65% of instances within district-quarter pairs, each district houses either one or two AEEs.

[15]During a site inspection, officers visit a proposed site that a firm wants to locate. For renewals, they visit the location where the firm is already operating and ensure all regulations are being followed.

When an application is made by a firm, the senior officer is supposed to check if the application is incomplete or if it is missing any required documentation.[16] Before the delegation reform, it was generally the case that the senior officer would either return the application to the firm if it was incomplete (around 2.7% of time) or forward it to the subordinate officer for further processing (around 97.1% of time). The subordinate officer did not have any decision rights. He would, however, be responsible for conducting more due diligence on the application, such as checking whether regulations regarding zoning laws (such as the firm's distance from a school) were followed, and would also be the one to conduct an inspection.

On the basis of any inspection and recommendations of the subordinate and junior officers, the senior officer would have the authority to approve the application or not. For instance, suppose a junior officer conducts a review of the application. If the application meets all requirements, he passes it on to the subordinate for further review, along with his recommendation. The subordinate then conducts a detailed review, and if he agrees with the junior officer, he forwards it to the senior along with a recommendation to approve the application. During this stage, the junior officer may direct the subordinate officer to conduct additional checks or clarifications on specific aspects of the application, resulting in several rounds of back-and-forth before the recommendation is finalized and forwarded to the senior officer. In cases where the senior agrees with the subordinate, the application will be approved. Otherwise, the senior officer overrules the subordinate and cites a reason, such as missing documentation, incorrect fees, or lack of pollution measurements. In 22% of pre-delegation period applications, senior officers overrule subordinates at least once.[17]

2.3 Delegation Reform

In July 2019, the authority to decide Green applications was delegated from the senior officer to the junior officer.[18] The policy was both announced and implemented on that date. The

[16] There are clear regulatory guidelines – such as limits on effluent and emission levels, minimum required distances from sensitive sites (e.g., schools or hospitals), and abatement requirements (e.g., stack heights) – that officers use to assess whether applications meet the necessary environmental standards (For details, see the Kerala State Pollution Control Board's Standard Operating Procedures or Distance and Siting Criteria at `https://kspcb.kerala.gov.in`). While these guidelines specify criteria, officers retain discretion in interpreting submitted materials and assessing compliance. In cases of ambiguity or uncertainty, they may request additional documentation, require resubmission, or conduct further inspections before making a final decision on approval.

[17] To calculate this, we begin by finding all approval recommendations made by the subordinate through a string search in the email text for phrases like "draft put up for approval." (these phrases were chosen as representative of a recommendation after reading through several hundred emails). We consider it a disagreement if, following the subordinate's recommendation for approval, the application is not approved within the next three emails, or if the application is resubmitted, or if the firm receives a "show cause" notification, which is a request for more information.

[18] See circular PCB/HO/EE4/Delegation of Powers/2019 dated 04/07/2019.

goal of the reform was to reduce red tape, and to "streamline the flow of applications" for firms. That is, it was intended to make processing faster. Under the delegation reform, the Pollution Control Board's *de jure* workflow rules for Green applications are as follows. After the reform, the senior officer was still supposed to be the first officer to review the file, and this practice continued in the data approximately 98.5% of the time. They are then supposed to assign applications to the junior officer for processing. The junior officer is tasked with contacting firms for clarifications, corrections, and additional documentation. If an application is resubmitted due to incompleteness, it is received by the senior officer but is then to be assigned to the junior officer immediately. The junior officer has decision rights over approving and rejecting these applications. The official policy document also includes an explicit directive against bypassing junior officers and states: "Environmental Engineers shall assign the work of Assistant Engineers only through Assistant Environmental Engineer."[19] We also reviewed all circulars published between the time period covered by our data by the Kerala Pollution Control Board to ensure there were no additional changes that might impact or interact with the delegation of authority to junior officers made in July 2019, and found none that did so.

If there is a complaint or court case relating to the application, it becomes the responsibility of the senior officer.[20] We observe this responsibility in court cases that arise from these applications. For example, the senior officer in Kottayam District represented the Pollution Control Board in court during a case in 2020, during which the manager of a tyre retreading unit sought to quash an order from the Pollution Control Board ordering the firm to cease operations between 6:00PM and 6:00 AM.[21] A different form of litigation arises when the Board approves an application but compliance is contested by affected parties. In one such case, local residents alleged that, despite the firm receiving Pollution Control Board consent to operate, the facility was violating minimum distance requirements and failing to implement adequate pollution control measures, and sought court intervention to enforce stricter compliance. In this case, the senior officer was subsequently required to revisit the decision through site inspections and compliance reporting as part of the court proceedings.[22] This obligation is one potential cost of a poorly considered decision, and helps explain why senior officers may be hesitant to delegate applications that are more risky.[23] The delegation re-

[19]See Office circular No. PCB/HO/EE4/Delegation of Powers/2019 dated 24 July 2019

[20]This responsibility is also explicitly stated in the policy document that announced the delegation reform: "All activities, action on complaint, court case on the disposed application shall be dealt with by the Environmental Engineer/Head of Office."See Office circular No. PCB/HO/EE4/Delegation of Powers/2019 dated 24 July 2019

[21]W.P.(C)No.9857 OF 2020(F).

[22]WP(C).No.32958 OF 2018(S).

[23]An officer's decisions can also have serious environmental costs. After receiving a pollution permit, a

form, availability of data on individual applications, and the communication records provide us with a unique natural experiment to examine how a change in *de jure* decision rights affects processes and communication for regulators, and how these changes shape outcomes for regulated firms.

3 Data

3.1 Environmental Permit Applications and Communication

Our primary data source is the universe of environmental permit applications and associated communication from Kerala's Consent Management System. These data should, by law, contain all firms that applied for permission to begin or renew an environmental permit in Kerala during the time period we consider. These data allow us to see successful, unsuccessful, and pending applications. We focus on applications from January 2018 (the start of the calendar year prior to the delegation reform, to reduce the possibility of other confounding policy changes) until March 2020 (the start of the coronavirus pandemic, which in addition to large macroeconomic changes, also led to multiple changes in the approval process such as relaxation of fees rules and increased permit validity period).

Throughout this time period, more than 68,000 applications were submitted, leading to the exchange of nearly half a million emails involving about 350 distinct officers. Each officer typically handles a median of 166 applications. During this duration, approximately 95.5% of the officers remain in the same rank without receiving promotions. The application contains information about the applicant firm (such as sector, color code and number of employees) and attached documents that verify this information such as the firm's location, date of submission, industry, number of workers, the anticipated capital investment for the activity that is the subject of the application, the fee paid, and the time between submission and final decision. It also contains information on the levels of pollution the firm expects to emit, which are most consistently available for wastewater discharge.[24] Note that this

firm may exceed approved emission limits, neglect conditions in its consent, or fail to treat pollutants as required by the Pollution Control Board. An example of such compliance failure is given in this newspaper article (`https://timesofindia.indiatimes.com/city/kochi/notice-issued-to-tccl-udyogamandal/articleshow/67952048.cms`) which reports that the Central Pollution Control Board (CPCB) issued a closure notice to a chemical company for breaching environmental standards. The notice cited issues such as disconnected effluent flow meters, reuse of untreated effluent, improper hazardous waste storage, and exceeding permitted waste oil levels.

[24]In the application data, firms are asked to provide information about different aspects of pollution. Data is available for both air emissions and water discharge; however, the variable that is consistently reported across various industries and time periods is the amount of effluent discharge. This is therefore our primary measure of pollution.

firm-level measure of pollution is distinct from the industry-level pollution score (discussed further in Section 3.2).[25] In instances where the color classification depends on measures of firm size or production scale (around 13.5% of the sample), it is possible that firms may strategically misreport some of these variables to obtain a lower level of regulatory burden. We will show robustness to excluding all applications in such size-based industries.

The data we use contain information on communication between regulatory officers and between these officers and applicant firms. These records are linked to each application and allow us not only to identify each officer to which the application was passed and in what order, but also the content of communication at each step. That is, for every "note" attached to the file, effectively an email, we have the sender's name and job title, receiver's name and job title, time stamp, and complete text of the email. Each email has one sender and one receiver, and so we do not need to confront issues such as multiple recipients or diverging email chains. The text of the emails allows us to measure whether a topic such as inspection has been mentioned. While most emails are in English, some are in Malayalam.[26] Even when the email content is in Malayalam, the email subject, sender's name and rank, recipient's name and rank, as well as the application's status remain in English. However, email text is important for measures such as whether an inspection has occurred. In such instances, we utilize the Malayalam equivalent of the search term to identify corresponding actions and activities.

How do these data compare to other Indian firm datasets in terms of number of firms covered and what data is collected? In comparison to other datasets on firms in India, such as the Annual Survey of Industries (ASI) or data from the Ministry of Corporate Affairs, the applications data we use cover many more firms. We have more than 50,000 unique firm names (for both new permits and renewals) in our sample that covers only the years 2018-2020 in Kerala, of which 9,150 are firms applying for a new permit. In contrast, in 2018 and 2019, about 7,500 businesses registered with the Ministry of Corporate Affairs in Kerala across all sectors (including White sectors, which do not need a permit), a significantly lower number. The number of firms reporting in the ASI for 2018–19 is around 1,994, including those that began in earlier years. The difference with the ASI is due largely to the difference in sampling frame; while the ASI only surveys firms with at least 10 employees, more than

[25] Industry definitions used to decide whether an industry is affected by the delegation reform are unique to pollution regulation in India, and comprise more than 250 categories such as "engineering and fabrication units (dry process without any heat treatment / metal surface finishing operations / painting)" or "poultry, hatchery and piggery." These are based both on the product produced and the method used to produce it, since both are relevant to the industry's pollution potential. Other regulations (such as size-based labor regulation or sector based tax regulation) do not perfectly covary with these categories.

[26] About 8% of the emails contain a Malyalam word, and approximately 16% of the applications include an email with at least one Malyalam word.

88% of firms in our data have fewer than 10 workers. Thus, our data have a much larger coverage than other Indian firm datasets. As a result, the firms in our data are much smaller than in the ASI. In Table A1, we present a comparison between our data for 2018 and the ASI sample for 2017-18. Firms in our data have fewer workers (3 at the median in our data versus 25 in the ASI), though the capital stock distribution in our data is similar to that in the ASI.

3.2 Industry-Level Pollution Score

We measure industry-level pollution scores from instructions issued to the state-level Pollution Control Boards by the national-level Central Pollution Control Board.[27] Because these instructions do not mention all industries, particularly new industries that had not been considered before 2016, this variable is missing for some applications.[28] While, according to regulation, firms with pollution scores of 21-40 should be classified as "Green," firms with scores 41-59 should be Orange, and firms with scores of 60 and above should be "Red" (CPCB, 2016), this classification is not adhered to perfectly in the data.[29]

3.3 Main Outcome Variables and Treatment Definition

The first set of outcome measures we use are delegation and rule noncompliance. Our measure of delegation is an indicator for whether the junior officer is the final officer who decides on, and hence closes, the application (described in the previous section). In these applications, the junior officer sends the last email with either one of the following accompanying actions: 'close after approval' or 'close after refusal.' The second outome is an indicator variable that takes the value 1 if an officer who outranks the individual with closing authority closes the application, and 0 otherwise. This is our measure of rule noncompliance, or *de*

[27] Central Pollution Control Board No. B-29012/ESS(CPA)/2015-16. March 7, 2016.

[28] In our main sample of applications where industry information is available, we were unable to attribute pollution potential to nearly 20% of them. We do not use this variable in the main results, and show that heterogeneity results using it are robust to imputation of this score. The probability that this information is missing is not different for industries impacted by the delegation reform post-reform (Column 1, Table A16)

[29] There are several potential explanations for this. To start, some applications could be potentially misclassified, leading to a pollution category different from the one indicated in the official documents. Additionally, as some industries undergo re-classification, applications stemming from the same industry could potentially fall under different pollution categories. Furthermore, several applications had industry type labels that were not entirely precise; some had minor variations, while in other cases, we only had textual descriptions. We assigned these applications industry type based on textual content provided in the respective field. This cleaning process is imperfect and could contribute to variations in the treatment of the same industry types. In our data, roughly 90% of applications fall into the expected category based on the pollution score. As a further check, we define pollution categories directly using the score and find the main results remain consistent.

facto treatment of applications (which may deviate from the *de jure* allocation of authority). In the case of Green applications, both for new permits and renewals, closing authority prior to the delegation reform was with the senior officer. After the delegation reform, this authority passed to the junior officer.[30]

We also consider regulatory outcomes of the applicant firms. The first such outcome measures whether the application was accepted, which is the most important outcome for the firm, since it requires the permit to operate legally. Secondly, we measure regulatory scrutiny with a binary variable that takes the value 1 if a unit undergoes a field inspection from the Pollution Control Board. Although direct access to inspection data is not available, officers do make references to inspections in the emails. Thus, our approach involves searching for specific indicators such as the phrase "conducted site inspection" within the communication data to determine whether an inspection was indeed carried out.[31] The third outcome measures time in the regulatory process, for which we use the inverse hyperbolic sine of the winsorized time to decision in days.[32] An application's color code (and therefore treatment status, since Green industries are treated and the others are not) is observed directly in the application. We describe other variables that we use to test for mechanisms and in robustness checks below as we introduce them.

3.4 Additional Measure of Decision Quality: Compliance with Siting Regulation

We combine our data on all firm applications and approvals with an intensive data collection exercise for about 200 firms to allow us to further identify changes in decision quality post-delegation. We focus on a primary aspect of regulatory compliance for these firms: the distance from particular amenities (residential buildings, healthcare facilities, educational institutions, public offices, and religious establishments). The regulations specify that firms must not be located within close quarters of any of these amenities, with a minimum allowable distance generally set at 200 meters. However, this threshold is not uniform: minimum

[30]For Orange and Red applications, authority would be with the senior officer, and in rare instances even more senior officers such as member secretary, or chairman, depending on capital intensity. Closing authority is a complex function of application color, scale, type, and industry, as outlined in Circular PCB/T4/115/97 dated 01/03/2017. This authority was not changed by the delegation reform.

[31]The inspection variable is generated based on a specific set of terms and phrases in both English and Malayalam. We examined a sample of randomly selected applications to evaluate the effectiveness of our approach in capturing actual inspections, and we found that it accurately identified inspections in all cases where they occurred in this sample.

[32]We winsorize at 1% and take a concave transformation because of the presence of outliers that take a very long time to be decided. The raw time to decision has a kurtosis of more than 17, while the winsorized inverse hyperbolic sine has a kurtosis less than 3.5. The inverse hyperbolic sine accounts for a small number of zeroes in the time to decision – roughly 2%.

distances vary by amenity type, industry, firm size, and color code. For example, small firms in the Orange category are subject to a minimum distance of 25 meters from the nearest residence and 50 meters from other listed amenities. In our analysis, we apply the relevant thresholds to each firm, based on its industry and pollution category.[33]

Alongside the field-based measure, we use communication records from all applications to directly measure officer scrutiny of siting compliance at the time of review. Since officers are required to check compliance with siting rules, we expect relevant discussions to appear in their correspondence. This approach allows us to measure officer attention to siting compliance across the full sample. We detail these measures below.

3.4.1 Supplementary Survey Data

In 2025, we conducted a survey in five districts to assess whether approved sites comply with the Kerala Pollution Control Board's siting rules. The survey focused on industries with at least 50 applications in our data, and we stratified the sample by quarter of application submission and category code, resulting in a final sample of 194 applications. For each selected firm, enumerators visited the site, recorded its GPS coordinates, and mapped all buildings within a 220-metre radius that fell into one of five categories specified by the siting criteria: residential buildings, healthcare facilities, educational institutions, public offices, and religious establishments. For each building, surveyors geocoded locations of all of these amenities that were found, allowing us to measure the precise distance from the firm to each amenity. Of the 194 firms listed, surveyors were able to successfully identify and complete this exercise for 175 firms, a 90% completion rate.[34] The goal of this exercise is to use intensive data collection for a small sample that can provide evidence that is complementary to outcomes from the applications data.[35]

3.4.2 Scrutiny of Compliance with Siting Regulation

To provide further evidence on the quality of regulatory scrutiny, we develop a measure that indicates whether officers engaged with siting requirements during their assessment of each

[33] We follow the document that lists the following restrictions: "Siting criteria for industrial units other than stone crushers, quarry, high rise buildings, hospitals, hotels, plywood industries, hollow/ solid cement bricks units, furniture, saw mill, laterite quarry and pig farm shall be as per PCB/TAC/18/2004 dated 9-8-2004.", "Siting criteria for plywood industries, hollow/ solid cement bricks units, furniture, saw mill, laterite quarry and pig farm shall be as per circular no. PCB/T4/115/97 dated 20-7-2011.", and "Siting criteria for crusher shall be as per circular no. PCB/TAC/St.Cr.Com/65/2005 dated 17-10-2007".

[34] The probability of successfully completing a siting criteria check is not different for Green industries who applied post-reform.

[35] Some of these amenities may have opened after the firm began operating, which would add measurement error to our dependent variables. This measurement error would only introduce bias if it were to change differentially for Green applications after the delegation reform.

application. Specifically, we search the text of email correspondence for references to "siting" or "distance" as evidence of discussion around these requirements. Since all industries in our sample are subject to some form of siting restriction, references to these terms provide an additional check on whether officers considered these requirements during the review process. Explicit discussion of siting criteria in email correspondence is especially common following a field inspection, when officers summarize their findings. Therefore, in the analysis, we also look at changes in the probability of such mentions among applications where a field inspection occurred. With these measures, we capture both adherence to siting rules and the scrutiny applied during review, which together inform the overall quality of regulatory decisions.

3.5 Summary Statistics

Table 1 presents summary statistics using data prior to the reform. Slightly over 60% of all applications are in the Green category (these generate almost 50% of all emails). About 94% of applications were decided above the junior officer, and some 2% were decided by the junior officer.[36] Almost no applications, about 0.7%, were decided above the rank that had decision rights for that application. That is, the rule regarding the rank of the officer with decision rights was mostly respected pre-reform. Each application generates about 9 emails on average, takes a bit more than 40 days to decide, and about 93% are accepted.[37]

4 Empirical Strategy

Our empirical strategy employs differences in differences (DID) and event study approaches. In order to estimate the impact of the reform on delegation and firm outcomes, we estimate the following event-study specification:

$$y_{aidq} = \sum_q \beta_q Green_i \times \psi_q + \delta_i + \mu_d + \eta_q + \delta_i \times q + \epsilon_{aidq}. \quad (1)$$

Because this is not a staggered design, heterogeneity in treatment effects does not cause the two-way fixed effects to be potentially biased. In equation (1), y_{aidq} is outcome y for

[36] In Table A2 we report summary statistics for the number of emails, capital, workers, land, and fees without Winsorization. We report untransformed values, natural logarithms, and the inverse hyperbolic sine.

[37] Although the overall approval rate is high, this figure masks the fact that many firms must resubmit their applications one or more times before receiving approval, as initial submissions sometimes fail to meet all regulatory requirements. This pattern suggests that the permitting process involves substantive scrutiny by regulators.

application a from a firm in industry i and in district d, submitted in year $\times$ quarter q. $Green_i$ is an indicator for whether the regulatory category for industry i is Green, an industry-level measure of whether the application is from one of the industries that was affected by the reform. β_q are separate coefficients by quarter, and ψ_q are year $\times$ quarter fixed effects. The omitted category here is Q2 of 2019, which is the final quarter in which junior officers did not have the authority to decide on Green applications.[38] Our main estimating equation also includes fixed effects for industry, δ_i, for districts, μ_d, and for year $\times$ quarter, η_q.[39] $\delta_i \times q$ are industry-specific linear time trends. We cluster standard errors by industry in our baseline estimation. We also report estimates of analogous DID specifications in which we replace the $\sum_q \beta_q Green_i$ term from (1) with $\beta Green_i \times Post_q$, where $Post_q$ is an indicator for all quarters after Q2 of 2019.

In (1), we exploit variation in how the difference in outcomes between Green and non-Green applications changes over time after the delegation reform. These changes are net of prior differences that may already vary by industry and district, and are based on comparisons of applications with different regulatory color codes submitted in the same year $\times$ quarter. We add additional controls in our robustness exercises. Although the existence of repeated firm names suggests that some firms do appear more than once in these data, this is uncommon (76% of applications come from firms that only file one application during this time). We present several additional robustness checks in Section A.1 in the Appendix.

5 Results

We present the results from the main specification in this section, and with additional robustness to specification differences, sample restrictions and other potential identification concerns in Appendix A.

5.1 Effects on Delegation

Tables 2 and 3 report the main effects on delegation and firm outcomes. The corresponding event studies are in Figure 1. Column (1) of Table 2 shows that, after the reform, a Green application became 54.2 percentage points (p.p.) more likely to be decided by a junior officer. This result is consistent with patterns in the raw data; while there was implementation of

[38]There are no other circulars issued around the time of delegation that introduce additional changes for the green category, as verified by the circulars listed on the Pollution Control Board's webpage `https://kspcb.kerala.gov.in/circulars`.

[39]We observe the industry information within the submitted applications directly and compare this information with the industrial classification provided in the "Revised Categorization of Industries" by the Pollution Control Board. Quarter is defined based on the date of submission, which we also observe directly.

the delegation reform, the delegation rate on Green applications did not jump from 3% to 100%, but instead rose to 66%. Therefore, the reform did lead to a large increase in the allocation of authority to junior officers. At the same time, we note that the reform led to incomplete delegation, whereby a third of applications were not delegated in accordance with the new rules. The policy was announced on July 4, 2019, in a circular which explicitly made decision-making authority for green applications effective that same day. As a result, any decision on a Green application made by anyone other than the junior officer would be considered a violation of assigned duties (as discussed in Section 2.3 in detail). We also reviewed all relevant circulars published between July 2019 and March 2020 on the Kerala Pollution Control Board's website to ensure there were no additional changes that might impact or interact with the delegation of authority to junior officers made in July 2019. Moreover, the persistence of the results over time suggests they are not just a consequence of early implementation problems or unawareness among senior officers. We devote Section 6 to identifying possible mechanisms driving this incomplete delegation.

Column (2) makes the incomplete delegation (rule noncompliance) clear – after the reform, Green applications became 30 p.p. more likely to be decided by an officer above the one with *de jure* closing authority, an outcome that, as Table 1 shows, was very rare prior to the delegation reform. The event study results for these outcomes in Figure 1 show a clear and sharp increase after the reform, and are estimated with considerable precision. The event studies also make it clear that the results are stable across the three quarters after the reform. Therefore, there is a sustained difference between *de jure* and *de facto* implementation of the regulation.

5.2 Effects on Firms

5.2.1 Average Effects on Firms

The fact that the allocation of authority has shifted in the organization may have implications for firm outcomes. This could happen if for instance, junior officers' ability to screen applications differs from the senior officers' ability. These include impacts on regulatory burden such as the occurrence of an inspection as well as the final decision, i.e. whether the firm gets to enter the market at all. Furthermore, since the stated goal of the reform was to streamline the application process, processing times may have changed.

The most relevant outcome from the point of view of applying firms is whether their application is accepted. We report results for this outcome in column (1) in Table 3 and Figure 1. The probability that a Green application is accepted increases after the delegation reform, by 3 p.p., about 3% relative to the mean acceptance rate.[40] This is an important change for firms, since denial of a permit implies a costly and uncertain re-application process or the inability to operate legally altogether. We also estimate the fixed effects equivalent of Equation (1), replacing $Green_i \times Post_q$ with a dummy for whether an application was decided by the junior officer, and taking $Green_i \times Post_q$ as an instrument for whether an application was decided by the junior officer. This treatment on the treated specification – for which column (1) of Table 3 is the analogous reduced form – suggests delegation raised the probability of acceptance substantially, by 5.4 p.p.. The corresponding OLS estimate is 6.4 p.p. A back of the envelope calculation shows that this causes the entry of nearly 1100 firms per year.[41]

Two other measures of particular importance to firms are the probability of an inspection and the length of time taken to decide on an application. We find no evidence in column (2) that the probability of inspection as measured by any reference to its occurrence within an email changed for Green applications relative to others after the delegation reform. The event study in Figure A2 does, however, give us reason to interpret this result with caution, as the parallel trends assumption may be violated for this outcome. [42] While Figure A2 does provide some suggestive evidence that the time to decision rose for Green applications after the reform, column (3) of Table 3 shows this to be insignificant at conventional levels and small relative to the baseline mean. Thus, the reform did not achieve its goal of increasing processing speed, but did impact firms on the most significant margin, which is the probability of acceptance, which was not, at least explicitly, cited as a goal of the reform.[43]

Is the increase in acceptance driven by any particular type of firm? We use environmental quality, proxied by application-level pollution intensity as a measure of decision quality in

[40] The number of observations in Column (1) of Table 3 does not exactly match Column (1) of Table 2. This is because we construct the measure of "accepted" in Table 3 using information from the application data, rather than the communication data used in Table 2. In the application data, a small number of cases (about 0.29% of the sample) are still listed as pending. For these applications, we use the last decision recorded by officers in the communication data to construct the measures in Table 2.

[41] There are about 4,500 Green applications per quarter, or 18,000 per year, so applying a 6 p.p increased entry rate yields 1080 firms per year. To interpret these instrumental variables results as causal would require the assumption that $Green_i \times Post_q$ is uncorrelated with the error term in the second stage. It would also require the assumption that $Green_i \times Post_q$ does not enter the second stage directly. These assumptions would imply that there is no reason other than being decided by the junior officer that a Green application would be more likely to be approved in the post-reform period that is not accounted for by the fixed effects and time trends included in equation (1).

[42] Although the likelihood of an inspection did not change, the quality or thoroughness of inspections may have. It is straightforward to verify that an inspection occurred, but more difficult to confirm that all relevant aspects were addressed. We explore this dimension in the next subsection using officer communication data.

[43] It is possible that the reform did not increase processing speed because the subordinates are now receiving more instructions from the junior officers, which increases congestion in their workflow. We do not find that the time spent by subordinates (as measured by the total time between responses for an application) increases post-reform. These results are omitted for brevity but available on request.

the next section, and test which types of firms juniors were more likely to allow to enter post-reform.

5.2.2 Impact on Decision Quality

Pollution Intensity In section 5.2.1, we show that the probability of acceptance for Green applications increases after the reform. The welfare implications of this effect depend on the decision's quality – for instance, if the policy allows more firms to enter without compromising environmental quality, it would presumably be welfare-increasing. We measure this welfare-relevant outcome using water pollution per worker, measured as the kiloliters per day of effluent per worker that the firm generates. We use data on wastewater discharge and the total number of employees to calculate water pollution per worker. Using this outcome, we test whether applications with higher costs to the environment per job created had a greater chance of being approved. While we do not have direct air pollution data, we have fuel usage information for a subset of firms. For those firms, we converted the fuel usage data into CO2 emissions using EPA greenhouse gas emission factors. A binned scatterplot is shown in Figure A3, and shows that wastewater discharge is strongly correlated with CO2 emissions calculated from fuel consumption.

In Figure 2, we study how the probability of acceptance varies with pollution per worker. The above median group represents applications that report higher pollution per worker as compared to the pre-reform industry median. Prior to the reform, when senior officers were in charge of decision-making, we find no evidence that applications from Green industries had differential trends in their acceptance rates over time in either the high-pollution or low-pollution samples. This result provides us with an indication of seniors' preferred composition of acceptance of different types of firms. However, after the reform, when junior officers were more likely to be in charge, applications with higher pollution levels became more likely to be accepted, with no change for applications with lower pollution levels.

In Table 4, Column 1, we present corresponding DID estimates and find that applications with above median pollution have 4.3 p.p. higher probability of acceptance. Indeed, the coefficient on $Green \times Post$ indicates that the entire increase in the probability of acceptance is from higher-pollution firms, with no change for less polluting firms. In Column 2, we show that results are similar if we use an even higher threshold for pollution per worker i.e. for applications that are above the 75th percentile of pollution per worker within an industry. Lastly, in Column 3, we show that these findings persist when considering total wastewater discharge instead of discharge per worker. These results suggest the increase in likelihood of approval for Green applications induced by the delegation reform can be attributed to the relatively higher acceptance of firms with more adverse environmental consequences. In column 4, we show that the acceptance probability does not vary with the number of workers, indicating that this result does not reflect junior officers prioritizing job creation *per se*, since they selectively allow more pollution-intensive firms, not firms creating more jobs.

The median discharge for Green firms in the top quartile is 2.5 kiloliters/day (with the mean being 157 kiloliters/day). The treatment cost of these effluents would be about ₹103,000 per firm for the median firm for a decentralized wastewater system, or about 21% of capital investment of the median firm.[44] Therefore, the environmental consequences of changing the allocation of decision rights is significant.

Compliance with Siting Regulation As an additional measure of decision quality, we consider compliance with siting regulation. For this, we use our field survey data to directly check whether firms are meeting the siting requirements set by the Kerala Pollution Control Board. This survey provides a field-based, ground truth measure of whether approved sites actually satisfy siting restrictions.

In Table 5, we present results using both amenity-level and application-level data. The outcome "siting violation" indicates whether there is any violation across any of the amenities that the field team recorded within the restricted distance specified by the Kerala Pollution Control Board. The "number of violations" simply counts all such violations for each firm. All columns follow the same specification as in Equation (1), except for Column 1, which additionally includes amenity-type fixed effects. We find that, overall, Green firms are more likely to have a siting violation after the delegation reform. The magnitude is sizeable: Column 1 shows that the likelihood of any siting violation for Green applications increases by 16 p.p. after the reform. This result suggests that Green applications approved after the delegation reform may have been subject to less scrutiny with respect to potential siting violations, indicating a fall in decision quality post-delegation.

To supplement this analysis, we also use a third outcome, which is from the communication data from all applications, to examine whether officers discussed siting restrictions during the application review process. Table A4 reports the estimates from this analysis. We find that mentions of siting criteria in officer correspondence decline for Green applications after the reform. Specifically, mentions of siting decrease by around 3.9 p.p. (Column 1), corresponding to 12.8% of the pre-delegation mean. For applications that received a field inspection by officers (which did not change for Green applications post-delegation), the decrease is even more substantial (Column 2). This suggests that, while the likelihood of inspection did not change, the level of scrutiny during inspections declined after the reform.

[44] We obtain these figures from the Center for Science and Environment's "Cost estimation for planning and designing of decentralised wastewater treatment system," available at `https://www.cseindia.org/cost-estimation-for-planning-and-designing-of-decentralised-wastewater-treatment-system-2073`.

One possible explanation is that, for the junior officer, monitoring whether subordinates address all relevant aspects requires greater effort than simply confirming that an inspection occurred.

Overall, in line with the higher acceptance rates for more polluting firms, the siting compliance and communication evidence indicates that Green applications faced reduced scrutiny and lower decision quality following the reform.

5.3 Other Measures of Regulatory Burden

In Table 6, we consider additional outcomes that shed light on whether other aspects of the regulatory process changed after the delegation reform. The first is the inverse hyperbolic sine of the fees charged for the permit, which is a function of capital investment. There is no evidence that the fee charged to Green applications changed. This result implies two things. First, this finding is consistent with the results showing that capital investment did not change on average after the reform, since capital investment is used to calculate these fees within an industry. Second, this result indicates that the processes around fees were not impacted by the reform.

The second measure we consider is whether the application was resubmitted, usually because the officer asked for additional documents in the application. This result suggests that Green applications were not subject to additional scrutiny regarding documentation. Third, we show that there is no evidence that the total number of emails rose on Green applications after the reform. The corresponding fixed effects coefficient is -0.034, which is small relative to the baseline mean in Table 1 and not statistically significant.

5.4 Composition of Applications

While we present most of our robustness checks in Section A.1, in the Appendix, here we address possible changes in the composition of applications. If the composition of applications submitted changed in response to the delegation reform, the impact on the probability of acceptance could be due to selection of firms applying for a permit. As shown above in Table 6, however, observable firm characteristics do not in fact respond to treatment. The firm characteristics that we consider are capital (in 00,000 rupees), land area (in acres), and labor (number of employees).[45] We show that the reported levels of capital, labor, and land for Green applications do not change relative to other applications after the reform.[46]

[45] In all three cases, winsorizing is at 1% and we use the inverse hyperbolic sine to account for zeroes and the fact that all three underlying measures are highly skewed.

[46] In Table A3, we show that the results are not driven by winsorization.

Furthermore, we check whether the environmental quality of applicants changes after the reform.

6 Mechanisms Underlying the Decision to Delegate

In the previous section, we showed that delegation significantly impacted outcomes for regulated firms and the quality of decision-making. Furthermore, while followed on average, delegation was partially implemented, with seniors withholding authority for a third of applications that they should have delegated. In this section, we use a model and empirical proxies for the model parameters to identify the mechanisms underlying the divergence between formal and informal authority.

6.1 Conceptual Framework

We outline a model that we present in detail in Appendix B. This model provides an intuitive framework in which a principal will choose not to delegate tasks that she believes the agent will perform poorly due to a lack of consequences for poor performance, high effort costs, or low ability.

The model comprises a senior and a junior, in which the senior (S) chooses to handle an application herself or delegate it to a junior (J). For either the senior or junior officer, handling an application consists of two steps. First, she (the senior) or he (the junior) has to decide whether or not to exert costly effort scrutinizing whether the application is "bad." A bad application in our context would be one that does not comply with regulations, for example violating siting restrictions such as proximity to a school, or engaging in violations not apparent from the application itself but that could be discovered after an inspection. Neither officer has complete information; an application must be scrutinized before it is revealed to be "bad," and even then its type may not be revealed. Second, if the deciding officer does not uncover that the application is "bad," he or she approves it. This second step is a simplification, but reflects the institutional role of the regulatory authority, which is to ensure that firms submit required documentation and are in compliance with the rules (for instance, around zoning and keeping pollution below permitted thresholds).

Bad applications are a proportion b of all applications, and there is a cost X to the senior if one is accepted. For the junior, this cost is Z. We interpret these costs as outcomes such as negative press, complaints, loss of reputation, and reduced future possibilities of promotion. If the senior exerts effort scrutinizing an application at a cost of c, she will discover it is bad with probability p. We interpret c broadly as a mix of effort costs and opportunity costs. p, similarly, reflects factors such as ability, contextual knowledge, the performance of the subordinate officers tasked with inspections, and the quality of the relationship the senior has with these subordinate officers (such as beliefs about their ability). If the senior delegates, the cost of effort scrutinizing an application for the junior is k and the discovery probability is q. The parameters b, X, Z, c, p, k, and q are known by both the senior and junior.

Solving this model by backward induction, we show that whether an application is delegated will depend on the parameters b, X, Z, c, p, k, and q. All else equal, the senior will prefer to delegate applications with higher Z and lower X – applications for which the costs of mistakenly accepting a bad application are high for the junior and low for the senior. The senior will also prefer to delegate applications with lower k and higher q – those for which the junior has a low cost of effort and a high probability of detecting bad applications. By contrast, the senior will prefer to delegate those for which her own effort costs are higher and her own detection probabilities are lower – those with higher c and lower p.[47] The senior prefers to delegate in these cases because the junior is more likely to exert effort, and to detect a bad application when doing so.

We will focus on empirical proxies for three of the main parameters to test predictions of what determines delegation. First, we treat pollution score as a proxy for costs of a wrongful approval to the senior (X). Second, as a measure of seniors with a higher probability of detecting bad applications (higher p), we will use the rate at which the senior overruled subordinates' recommendations to approve an application in the pre-reform period. We will additionally use a senior-subordinate pair's propensity to inspect applications during the pre-reform period as an alternative proxy for higher levels of p. Third, we will use the time-varying workload of the senior officer as a measure of the senior's effort costs c.

6.2 Senior Withholding Authority or Junior Ceding It?

As shown in Section 5.1, while delegation is followed on average, it is incomplete in that roughly one third of applications are not delegated. The conceptual framework in Section 6.1 models this lack of delegation as senior officers choosing not to delegate to junior officers, rather than junior officers yielding their decision rights to the senior officers. We use our data on communication to show that this is the case. If junior officers are included on the

[47]The prevalence of bad applications, b, plays a more ambiguous role. If the junior's costs of effort are high and his discovery probability is low, then a greater prevalence of bad applications will make the senior more wary of delegation, as he knows the junior will not exert effort detecting these applications. By contrast, if the junior's costs of effort are low and his discovery probability is high, an increased prevalence of bad applications can induce the junior to exert effort for applications he would not have scrutinized previously. This can increase delegation.

communication chain for an application but the final decision is made by a senior officer, it could reflect juniors seeking the advice or approval of seniors, or it could be consistent with senior officers consulting juniors and approving their recommendations. Failure to include juniors on the communication chain altogether, by contrast, suggests that failure to delegate is the choice of the senior officer.

To test between these possibilities, we split the binary variable that indicates if the application was decided at a level above the officer with closing authority into two outcomes. The first is an indicator variable for whether the application is decided by an officer above the officer with closing authority, but the junior is included on at least one email in the application. The second is whether the application is decided by an officer above the officer with closing authority and the junior is excluded from all emails in the application. We show results using these variables in Table 7 and Figure 3. The probability that an application is decided above the officer with decision rights and the junior officer is bypassed increases by nearly 23 p.p. On the other hand, the probability that an application is decided above the officer with decision rights and the junior officer is not bypassed increases by only 7 p.p.. These results indicate that bypassing junior officers by senior officers explains a much larger proportion, about 80%, of the lack of delegation. Incomplete delegation, then, is largely a decision made by senior officers to withhold authority from the junior officers, and not an outcome of consultation between junior and senior officers or the junior officer ceding their authority. Note that if email communication is a substitute for in-person communication, that should bias the results towards finding more delegation, since the senior officer would then follow the formal rule to delegate, but then instruct the junior verbally how to decide the application. In contrast, bypassing shows that the senior officers preferred to withhold and decide certain applications. This also supports our choice of model, which focuses on the senior's decision to delegate or not, rather than the junior deciding whether to cede his decision right.

6.3 Testing Model Implications in the Data

6.3.1 Applications with higher X (costs of wrongful approval to the senior) are less likely to be delegated

Because the pollution score on an application is an industry-specific measure of how much environmental damage an applicant may potentially cause, we treat this as a proxy for X. In Figure 6, we present two stylized facts consistent with our interpretation that senior officers treat applications with greater pollution potential as having worse consequences (X) if they are wrongfully approved. Each panel is a binscatter plot showing the mean of a given variable for each level of the discrete pollution score that we observe. First, the effort expended scrutinizing an application as measured by the number of emails attached to the application is rising in pollution score. Second, applications with higher pollution scores are more likely to be inspected. Both patterns suggest that applications with higher pollution scores involve more effort.[48]

In Column 1 of Table 8, we present heterogeneous effects by pollution score, with the corresponding event study presented in Figure 4 (Panel (a)). We define the above median pollution score within each color code. In line with the model, we find Green applications with relatively higher pollution scores are less likely to be delegated by 14 percentage points after the reform, which is a substantial proportion of the lack of delegation (25 percent). Results from the event study similarly show the differences in post-reform delegation between high and low pollution scores, with greater delegation for lower scores.

6.3.2 Senior officers with high p (detection probabilities) delegate less

In order to measure whether a senior officer has a higher detection probability p, we measure disagreement between seniors and subordinates in the pre-reform period in cases where the subordinate officer had recommended an application be approved. In particular, we code this disagreement at the level of the senior-subordinate pair. We use senior-subordinate pairs in this estimation because there is heterogeneity in subordinate officer quality, and this allows us to use senior officer fixed effects in the estimation as an additional robustness check. We have about 120 senior-subordinate pairs which we use in the estimation.

We begin by using the texts of emails sent by subordinates in the pre-reform period in order to identify cases in which the subordinate had recommended an application be approved. Based on a reading of several hundred emails, we identify a large number of regular expressions that we use to identify these approval recommendations in the full sample. Next, we pinpoint cases where the senior disagreed with this recommendation. We identify disagreement if, after the subordinate's recommendation for approval, the application is not approved in the next three emails or the application is resubmitted, closed after refusal, returned to the applicant, or if the firm is given a "show cause" notification, i.e. a request for more information. Because of the linguistic subtlety of this exercise, we cannot use the Malayalam-language emails for this coding and so lose some of the sample (around 16% of the applications).

In Column 2 of Table 8, we present heterogeneous effects by disagreement, with the corresponding event study presented in Figure 4 (Panel (b)). We define disagreement at

[48] In Figure 6, we show that this relationship remains consistent when effort is measured by the number of characters instead of the number of emails.

the senior-subordinate pair level. As the model predicts, we find Green applications with relatively higher disagreement are less likely to be delegated by 8.7 percentage points after the reform, a large fraction relative to mean delegation. Results from the event study similarly show a pattern of lower delegation by more effective senior officers.[49] In Column 1, we add the interaction of senior officer fixed effects with a "Post" dummy, while in Column 2, we add the interaction of these senior officer fixed effects with quarter fixed effects. The results are consistent with the main effects.[50]

We also consider an alternative measure of the detection probability p of each senior-subordinate pair of officers, which is whether they conduct inspections for applications that should, according to the rules, be inspected before approval. We use written inspection protocols to create measures of the expected inspection probability of each application.[51] These pre-existing rules are a function of the industry-level color code and capital investment.[52] In the pre-reform time period, nearly 31.5% of applications underwent a site inspection, with the percentage for Green applications being approximately 21.7%. We compare this predicted inspection probability with actual inspection to classify each application by whether it is "under-inspected." An application that is not inspected despite a predicted inspection probability of 50% or higher is "under-inspected." We expect that officers that are more likely to "under-inspect" are less effective, and have a lower probability of detecting a bad application (p). In our model, these officers are more likely to delegate.[53]

The results are presented in Table A5. In line with our model predictions, we find that seniors in senior-subordinate pairs who are more likely to under-inspect pre-reform are also more likely to delegate. Teams who under-inspect Red applications are 10.9 p.p. more likely to delegate post-reform, and those who under-inspect Orange and Red applications are 5.3

[49]Results are very similar if we use only within-senior variation i.e. with the inclusion of pair fixed effects. These are omitted for brevity but available upon request.

[50]Note that this is also consistent with senior officers having a more pessimistic view of the quality of the decision the junior would undertake when paired with a subordinate that is less competent.

[51]As explained in footnote 31, we measure inspections by identifying strings within the email text that indicate the occurrence of an inspection, such as "inspection took place" or "inspection was conducted." These particular strings were derived from a manual review of several hundred randomly selected applications.

[52]Officers are required to inspect certain firms that submit applications for a permit (see circular PCB/HO/Circular-01/30/2017/C on KPCB website). The guidelines for inspection state clear rules that depend on the following characteristics: a) permit type, b) whether the application is for a new permit or for a renewal, c) pollution category (red/orange/green) and d) capital investment (i.e. whether the total capital investment is under 1 million Indian rupees). We use these four variables to predict inspection probability. We compute these predicted probabilities for all the applications and then assess under-inspection by comparing these predicted probabilities with our inspection measure. Lastly, we calculate the average occurrence of under-inspection for all the pairs of subordinate and senior officers using only data from Orange and Red applications. We excluded Green applications in the last step because the model predicts that none of the Green applications should be under-inspected during the pre-reform period.

[53]An alternative interpretation, that under-inspection measures greater cost of effort (c), gives the same prediction.

p.p. more likely to delegate.

6.3.3 Officers with higher c (cost of effort) delegate more

We estimate senior officers' current bandwidth using data on application submission dates. We calculate the number of applications that have reached a senior officer's desk within the previous 120 days. The 120 day threshold is relevant because the rules stipulate that all applications must be processed within this time frame.[54] A large number of pending applications would increase the marginal cost of effort for the senior officer (c) which, according to the model, would lead to more delegation. We present results in Figure 5 and Column 3 of Table 8. In line with the model, we find that officers that have an above-median level of applications in the past 120 days delegate more. Officers with lower bandwidth are 8.4 p.p. more likely to delegate after the reform.[55]

6.3.4 Alternative Mechanism: Corruption

A possible alternative explanation of our results would be grounded in corruption – namely, if a senior officer were extracting rents from her position, she would be less willing to relinquish this source of additional income to the junior, and hence be less willing to delegate. We begin by noting that a corruption explanation is not consistent *per se* with the fact that baseline disagreement with the subordinate's recommendations for approval predicts lower delegation, nor with the fact that lower bandwidth times are times of greater delegation.

We further present two additional pieces of evidence that are contrary to this interpretation of our results. First, we show that delegation is not lower for capital-intensive applications, i.e. those for which there should be the greatest rents to extract. In Table 9, Panel (a), we show results of estimating Equation (1) while splitting the sample at the within-color median of capital investment. Regression results are presented in Column 1 of Table 9, and show that, if anything, applications with greater capital investment were *more* likely to be delegated – the point estimate shows applications from firms with above-median capital are 3 p.p. more likely to be delegated but the coefficient is not statistically significantly different from zero. This finding is inconsistent with an explanation based on

[54] This information can be found in the Standard Operating Procedure Document available on the Kerala Pollution Control Board's website at the following URL `https://krocmms.nic.in/KSPCB/SPCB_DOCUMENTS/SOP_Final.pdf`

[55] As a robustness check, we also consider two alternative measures of bandwidth – the first is whether the number of applications due for a decision in the next 15 days is above median or not, and the second is whether the number of applications due for a decision in the next 30 days is above median or not. These results are consistent with the results from the main measure of bandwidth- these are omitted for brevity but available on request.

corruption, but is consistent with the conceptual framework. Greater capital intensity is likely to increase the inspection costs c and k of both the senior and junior officers, because the rules stipulating whether a firm needs to be inspected are partially a function of capital investment. These rising costs lead to offsetting effects on delegation that could be positive on balance (but are not statistically significant).

Second, we split the sample by the prevalence of corruption in a district, measured as the number of political candidates per capita with declared criminal cases. We obtain the number of political candidates in each district with declared criminal cases according to National Election Watch's Myneta database.[56] These data are recorded for four election cycles – 2006, 2011, 2016 and 2021. We sum over the number of cases in these elections to obtain a total count for each district. Across the districts in the data, the number of cases recorded varies from 85 to 668, with a mean of 318.

To convert these numbers into per capita rates, we divide the number of cases by the population of the district recorded in the 2011 census. This measure of corruption cases per 100,000 persons varies from 4.2 in Malappuram to 26.3 in Pathanamthitta, with a mean of 14.2. Since Eloor is treated as a district by the Pollution Control Board, but not by the census, we match it to the rate of corruption cases in Ernakulam, the district that contains it. Since this measure is defined at the district level, we make the split by the state-level median. Results are presented in Column 2 of Table 9. These estimates show no evidence of either greater or lesser delegation in more corrupt districts, in either the event study or the regression results.[57]

6.4 Joint Test of Heterogeneity in the Decision to Delegate

In Table 10, we presents results from a specification that includes all interactions of the heterogeneity variables from Section 6.3, to test whether each of these explanations has separate explanatory power. The first two columns show that all the heterogeneous effects presented in this section are of the same sign as well as similar magnitude in this omnibus specification. In Column 3, we additionally control for heterogeneous effects by capital investment. In the last column, we add controls for heterogeneous effects by district-level corruption cases, and find similar results as in the other specifications. The coefficients in column (4) of Table 10 imply that a Green application after the delegation reform was 7.7 p.p. less likely to be delegated if it had a high pollution score, 13 p.p. less likely to

[56] `https://myneta.info/`. Myneta is an open data platform run by the Association for Democratic Reforms (ADR), an independent nonprofit.

[57] We also examined alternative datasets to measure the extent of corruption across districts and found no evidence that senior officers from districts with higher levels of corruption delegate less.

be delegated if senior-subordinate disagreement was above median, and 6.4 p.p. less likely to delegated if the senior officer's bandwidth was above median. Taken together, a low-pollution, low-disagreement, and low-bandwidth Green application was 27.1 p.p. more likely to be delegated in the post-reform period, when compared with one that was high pollution, high disagreement, and high bandwidth. This difference is large compared to the post-reform delegation rate for Green applications of 67.1 p.p.

Finally, we report p-values adjusted for multiple hypotheses testing in Table A20. For each table, we report the bootstrap-based unadjusted p-values, adjusted p-values based on Theorem 3.1 in List, Shaikh and Xu (2019), the Bonferroni adjustment, and p-values from Holm (1979). Any unadjusted result that was significant at the 5% level previously remains significant at the 5% level after adjustment.[58]

7 Conclusion

Our findings show that the allocation of authority to junior environmental regulators has important implications for whether firms are allowed to enter the market. Moreover, we find that this authority is retained by senior officers for riskier applications, and by officers with greater propensities for overruling subordinates' approval recommendations. This endogenously creates a knowledge hierarchy that selectively allocates these decision rights to junior officers, causing a gap between *de jure* and *de facto* regulatory enforcement. Our specific context is important, with decision rights having impacted outcomes for over 50,000 firms during our study time period alone.

More broadly, our results shed light on how agents within organizations interpret rules, delegate or withhold power, and solve problems, determining organizational outcomes and efficacy. These results can help us understand differences in *de jure* vs. *de facto* implementation of rules and regulations, as well as the mechanisms underlying the differences between them.

While the data we use are very detailed, they do not allow us to test whether, in the long term, senior officers teach junior officers how to handle applications, increasing delegation in the long run. Furthermore, the nature of the data we use makes it difficult to track the same firm over time, and data limitations prevent us from examining whether the marginal firm that is approved by the junior officer has differential productivity. These, as well as questions related to understanding whether similar differences in the implementation of rules have differential productivity implications for private sector organizations, remain interesting issues for future research.

[58]We use the *mhtreg* package provided by Barsbai et al. (2024).

References

Aghion, Philippe and Jean Tirole. 1997. "Formal and real authority in organizations." *Journal of Political Economy* 105(1):1–29.

Aghion, Philippe, Nicholas Bloom, Brian Lucking, Raffaella Sadun and John Van Reenen. 2021. "Turbulence, firm decentralization, and growth in bad times." *American Economic Journal: Applied Economics* 13(1):133–169.

Alfaro, Laura, Nick Bloom, Paola Conconi, Harald Fadinger, Patrick Legros, Andrew F Newman, Raffaella Sadun and John Van Reenen. 2024. "Come together: firm boundaries and delegation." *Journal of the European Economic Association* 22(1):34–72.

Aneja, Abhay and Guo Xu. 2024. "Strengthening State Capacity: Civil Service Reform and Public Sector Performance during the Gilded Age." *American Economic Review* 114(8):2352–2387.

Bandiera, Oriana, Michael Carlos Best, Adnan Qadir Khan and Andrea Prat. 2021. "The allocation of authority in organizations: A field experiment with bureaucrats." *The Quarterly Journal of Economics* 136(4):2195–2242.

Barsbai, Toman, Victoria Licuanan, Andreas Steinmayr, Erwin Tiongson and Dean Yang. 2024. "Information and immigrant settlement." *Journal of Development Economics* 170:103305.

Battiston, Diego, Jordi Blanes i Vidal and Tom Kirchmaier. 2021. "Face-to-face communication in organizations." *The Review of Economic Studies* 88(2):574–609.

Bergeron, Augustin, Gabriel Tourek and Jonathan L Weigel. 2024. "The state capacity ceiling on tax rates: Evidence from randomized tax abatements in the DRC." *Econometrica* 92(4):1163–1193.

Besley, Timothy, Robin Burgess, Adnan Khan and Guo Xu. 2022. "Bureaucracy and development." *Annual Review of Economics* 14(1):397–424.

Best, Michael Carlos, Jonas Hjort and David Szakonyi. 2023. "Individuals and organizations as sources of state effectiveness." *American Economic Review* 113(8):2121–2167.

Bhat, Sairam. 2010. *Natural Resources Conservation Law.* SAGE Publications Ltd.

Bloom, Nicholas, Luis Garicano, Raffaella Sadun and John Van Reenen. 2014. "The distinct effects of information technology and communication technology on firm organization." *Management Science* 60(12):2859–2885.

Bloom, Nicholas, Raffaella Sadun and John Van Reenen. 2012. "The organization of firms across countries." *The Quarterly Journal of Economics* 127(4):1663–1705.

Bolton, Patrick and Mathias Dewatripont. 1994. "The firm as a communication network." *The Quarterly Journal of Economics* 109(4):809–839.

Bolton, Patrick and Mathias Dewatripont. 2013. Authority in Organizations: A Survey. In *The Handbook of Organizational Economics*, ed. Robert S. Gibbons and John Roberts. Princeton University Press chapter 9, pp. 342–372.

CPCB, Central Pollution Control Board. 2016. "No. B-29012/ESS(CPA)/2015-16/: Modified Directions Under Section 18(1)(b) of the Water (Prevention & Control of Pollution) Act, 1974 and The Air (Prevention & Control of Pollution) Act, 1981, Regarding Harminzation of Classification of Industrial Sectors Under Red / Orange / Green / White Categories.".

Dal Bó, Ernesto, Frederico Finan and Martín A Rossi. 2013. "Strengthening state capabilities: The role of financial incentives in the call to public service." *The Quarterly Journal of Economics* 128(3):1169–1218.

Decarolis, Francesco, Leonardo M Giuffrida, Elisabetta Iossa, Vincenzo Mollisi and Giancarlo Spagnolo. 2020. "Bureaucratic competence and procurement outcomes." *The Journal of Law, Economics, and Organization* 36(3):537–597.

Dessein, Wouter, Desmond Lo and Chieko Minami. 2022. "Coordination and organization design: Theory and micro-evidence." *American Economic Journal: Microeconomics* 14(4):804–843.

Dessein, Wouter and Tano Santos. 2006. "Adaptive organizations." *Journal of Political Economy* 114(5):956–995.

Duflo, Esther, Michael Greenstone, Rohini Pande and Nicholas Ryan. 2018. "The value of regulatory discretion: Estimates from environmental inspections in India." *Econometrica* 86(6):2123–2160.

Espinosa, Miguel and Christopher T Stanton. 2022. "Training, communications patterns, and spillovers inside organizations." *National Bureau of Economic Research Working Paper No. 30224* .

Fan, Haichao, Joshua S Graff Zivin, Zonglai Kou, Xueyue Liu and Huanhuan Wang. 2019. "Going Green in China: Firms' Responses to Stricter Environmental Regulations." *National Bureau of Economic Research Working Paper No. w26540* .

Fenizia, Alessandra. 2022. "Managers and productivity in the public sector." *Econometrica* 90(3):1063–1084.

Garicano, Luis. 2000. "Hierarchies and the Organization of Knowledge in Production." *Journal of Political Economy* 108(5):874–904.

Ghosh, Shibani. 2019. The Environment. In *Regulation in India: Design, Capacity, Performance*, ed. Devesh Kapur and Madhav Khosla. Oxford: Hart Publishing pp. 203–228.

Greenstone, Michael, John A List and Chad Syverson. 2012. "The effects of environmental regulation on the competitiveness of US manufacturing." *National Bureau of Economic Research Working Paper No. w18392* .

Harrison, Ann, Benjamin Hyman, Leslie Martin and Shanthi Nataraj. 2015. "When do firms go green? Comparing price incentives with command and control regulations in India." *National Bureau of Economic Research Working Paper No. w21763* .

He, Guojun, Shaoda Wang and Bing Zhang. 2020. "Watering down environmental regulation in China." *The Quarterly Journal of Economics* 135(4):2135–2185.

Holm, Sture. 1979. "A simple sequentially rejective multiple test procedure." *Scandinavian Journal of Statistics* pp. 65–70.

Impink, Stephen Michael, Andrea Prat and Raffaella Sadun. 2020. "Measuring collaboration in modern organizations." *AEA Papers and Proceedings* 110:181–86.

Kala, Namrata. 2024. "The impacts of managerial autonomy on firm outcomes." *Econometrica* 92(6):1777–1800.

Khan, Adnan Q, Asim I Khwaja and Benjamin A Olken. 2016. "Tax farming redux: Experimental evidence on performance pay for tax collectors." *The Quarterly Journal of Economics* 131(1):219–271.

List, John A, Azeem M Shaikh and Yang Xu. 2019. "Multiple hypothesis testing in experimental economics." *Experimental Economics* 22:773–793.

Lo, Desmond, Wouter Dessein, Mrinal Ghosh and Francine Lafontaine. 2016. "Price delegation and performance pay: Evidence from industrial sales forces." *The Journal of Law, Economics, and Organization* 32(3):508–544.

McElheran, Kristina Steffenson. 2014. "Delegation in multi-establishment firms: the organizational structure of IT purchasing authority." *Journal of Economics and Management Strategy* 23(2):225–258.

Meagher, Kieron J and Andrew Wait. 2014. "Delegation of decisions about change in organizations: the roles of competition, trade, uncertainty, and scale." *The Journal of Law, Economics, & Organization* 30(4):709–733.

Paranjape, Vinay N. 2013. *Environmental Law.* Central Law Agency, Allahabad.

Pomeranz, Dina and José Vila-Belda. 2019. "Taking state-capacity research to the field: Insights from collaborations with tax authorities." *Annual Review of Economics* 11(1):755–781.

Population Census. 2011. "Census of India 2011." *Provisional Population Totals. New Delhi: Government of India* pp. 409–413.

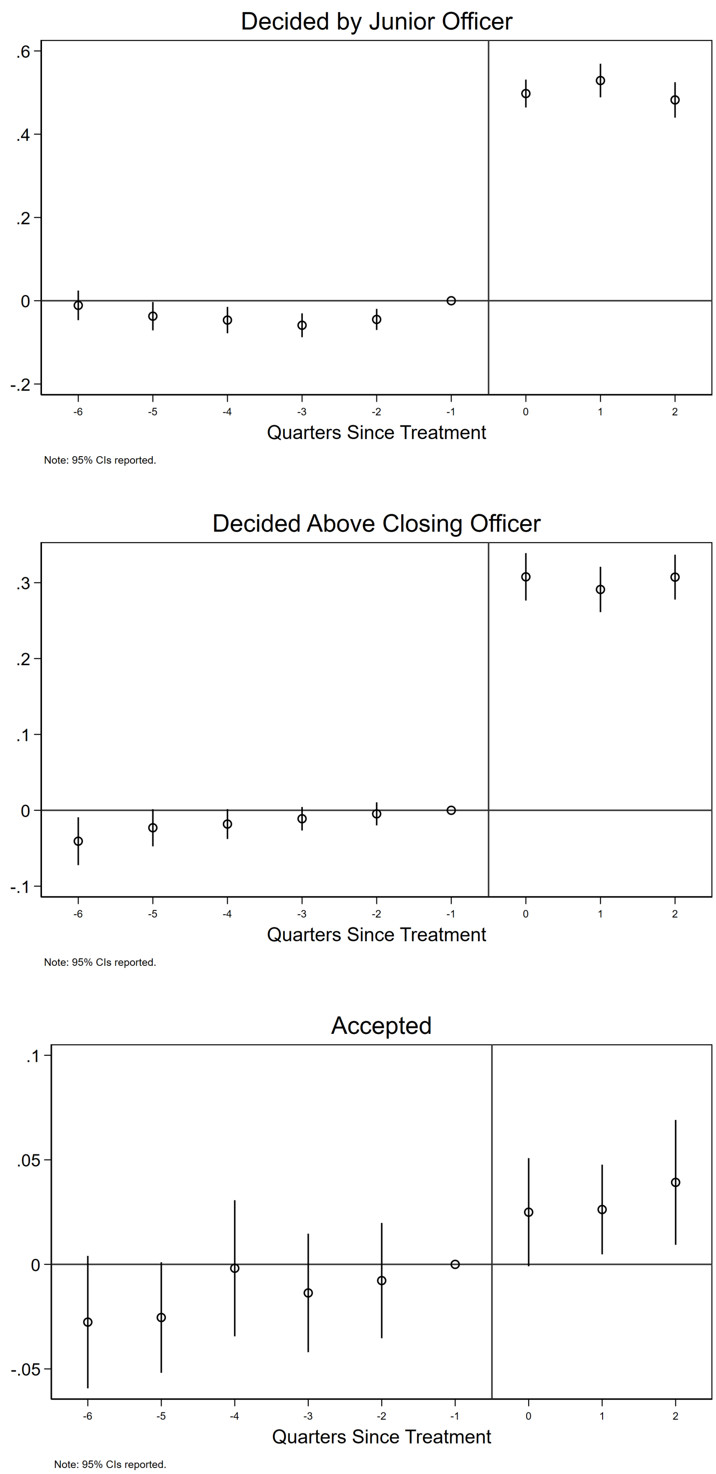
Reserve Bank of India. 2019. *Handbook of Statistics on Indian Economy 2018–19.* Reserve Bank of India, Mumbai.

Sandvik, Jason J, Richard E Saouma, Nathan T Seegert and Christopher T Stanton. 2020. "Workplace knowledge flows." *The Quarterly Journal of Economics* 135(3):1635–1680.

Schein, Edgar H. 2010. *Organizational culture and leadership.* John Wiley & Sons.

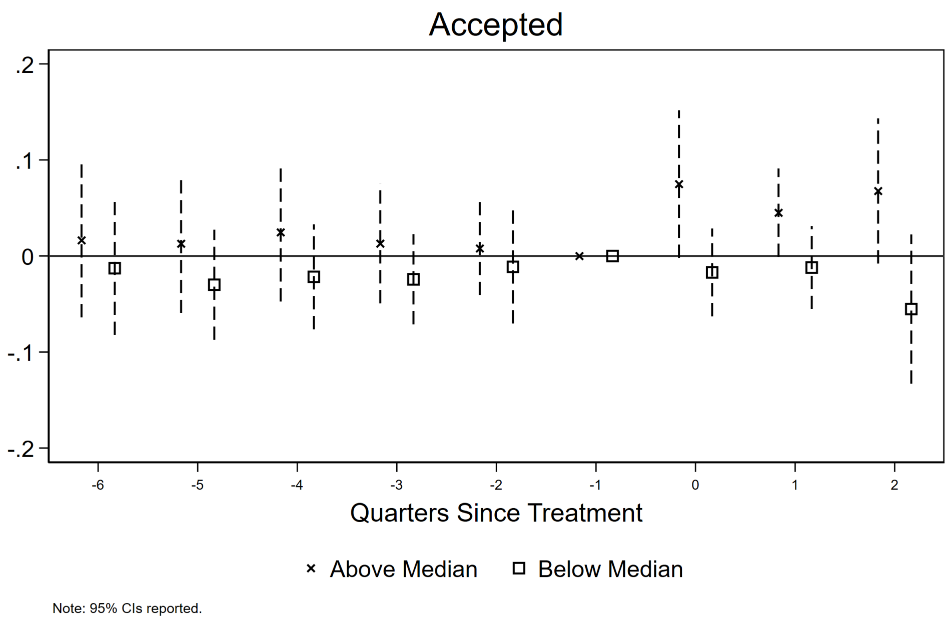
Tanaka, Paul, Michael Saretsky, Donna Ni, Maddy Foote and Matthew Smanson. 2022. *Environmental law and practice in the United States: Overview.* Thomson Reuters Practical Law.

Figure 1: Event Studies – Impact on Decision Rights and Acceptance Probability



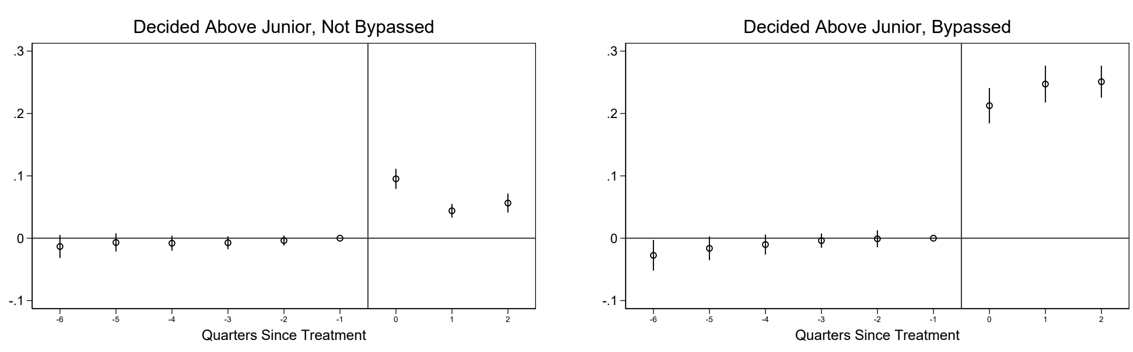
Notes: Each sub-figure presents coefficient estimates and 95% confidence intervals of equation (1). All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Outcome variables are given in sub-figure titles. All the variables presented in this figure are binary. “Junior” refers to the “Assistant Environmental Engineer”. “Above Closing Officer” is a function of application color, scale, type, and industry. See Section 5 for details.

Figure 2: Decision Quality: Heterogeneity by Pollution



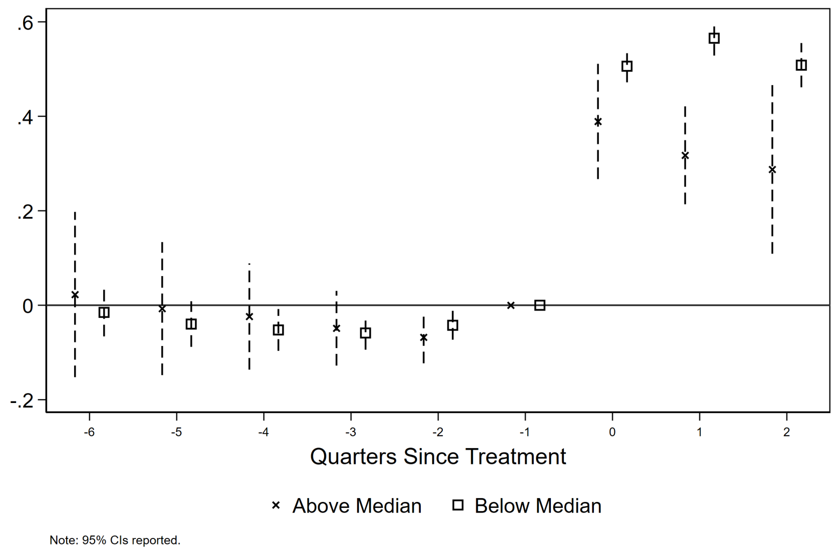
Notes: This figure presents coefficient estimates and 95% confidence intervals of equation (1) with acceptance as the outcome variable. The specification includes a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. "Above Median" is equal to 1 for those applications where pollution per worker is above the pre-reform industry median, and zero otherwise. See Section 5 for details.

Figure 3: Event Studies: Whether Junior Officer Bypassed

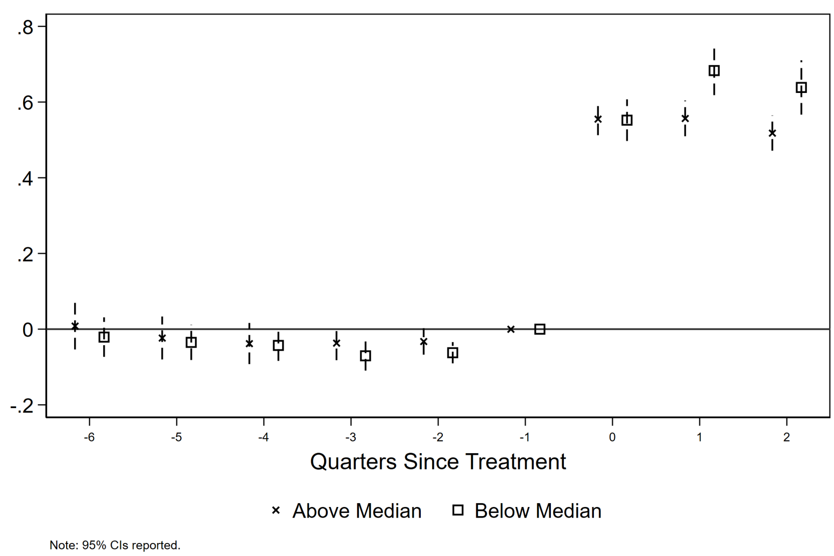


Notes: Each sub-figure presents coefficient estimates and 95% confidence intervals of equation (1). All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Outcome variables are given in sub-figure titles. "Junior" refers to the "Assistant Environmental Engineer" position. In this context, "bypass" refers to the situation where the junior officer is absent from the entire email chain. See Section 6 for details.

Figure 4: Event Studies: Heterogeneity by Application Type



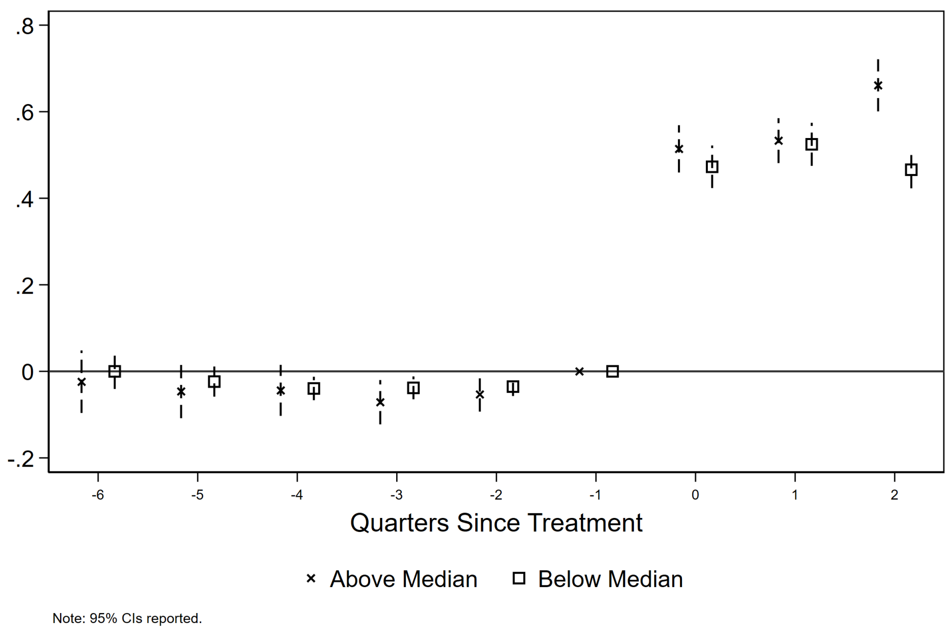
(a) Heterogeneity by Pollution Score



(b) Heterogeneity by Disagreement

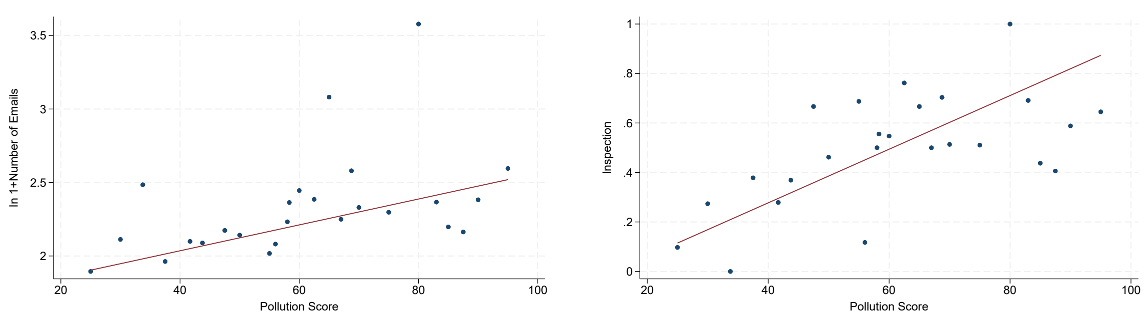
Notes: Each sub-figure presents coefficient estimates and 95% confidence intervals of equation (1). All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. The outcome variable is whether the application was decided by a junior officer. In the first sub-figure, "Above Median" signifies industries whose pollution score exceeds the median score within their respective categories. In the second sub-figure, "Disagreement" equals 1 for senior-subordinate pairs with high rates of disagreement during the pre-reform period. See Section 6 for details.

Figure 5: Event Studies: Heterogeneity by Bandwidth



Notes: The figure presents coefficient estimates and 95% confidence intervals of equation (1). The outcome variable is whether the application was decided by a junior officer. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. We determine the count of applications that have reached a senior officer's desk in the preceding 120 days. This 120-day time frame is significant as per the rules, which require all applications to be processed within this period. "Above Median" is equal to 1 if these applications are above the overall median, and zero otherwise. We also utilize data from before 2018 to calculate these measures for the initial quarters in our sample. See Section 6 for details.

Figure 6: Effort by Pollution Score



Notes: Each sub-figure shows a binned scatterplot and line of best fit representing the correlation between the application-level measure of effort on the y axis and the industry-level pollution score. The "Inspected" dummy variable is set to 1 when the email text explicitly indicates that an inspection occurred. Slopes and standard errors come from a bivariate regression with standard errors clustered by pollution score.

Table 1: Summary Statistics Using Pre-Reform Data

	Mean	SD	Min	Max	Count
Green Category	0.616	0.486	0	1	35723
Decided by Junior Officer	0.0228	0.149	0	1	35655
Decided Above Junior Officer	0.947	0.225	0	1	35655
Decided Above Closing Officer	0.00523	0.0722	0	1	34965
Accepted	0.947	0.224	0	1	35635
Inspected	0.239	0.426	0	1	35569
Winsorized IHS Time to Decision	4.151	1.423	0	6.99	35673
Decided Above Closing, Not Bypassed	0.00366	0.0604	0	1	34965
Decided Above Closing, Bypassed	0.00157	0.0396	0	1	34965
Submission Quarter	22.30	1.730	20	25	35723
Number of Emails	8.709	6.044	1	130	35723
Winsorized IHS Fee Paid	5.552	5.007	0	13.4	35722
Resubmitted	0.373	0.484	0	1	35723
Winsorized IHS Capital	2.954	1.638	0.73	9.21	35723
Winsorized IHS Labor	1.910	1.006	0.88	5.63	23487
Winsorized IHS Land	0.479	0.684	0.00100	3.42	32427
$\mathbb{1}${Industry Type has a Split}	0.128	0.335	0	1	35723
Industry Total Pollution Score	35.34	14.97	25	95	26101
Winsorized Capital (INR 100,000)	97.52	470.3	0.80	5000.6	35723
Winsorized Labour	7.533	19.16	1	140	23487
Winsorized Land (Acres)	0.853	2.151	0.00100	15.2	32427
Winsorized Fee Paid (INR)	15187.3	41127.8	0	248200	35722
1(Siting Violation)	0.103	0.304	0	1	690

Notes: Summary statistics are for the pre-reform period. In Panel A, all variables are based on the application data, except for 'Decided by Junior Officer,' 'Decided Above Junior Officer,' 'Decided Above Closing Officer,' and 'Inspected,' which are extracted from the Note History data. Additionally, 'Pollution Score' and 'Whether Industry has a split' are industry-level variables determined by matching the industry information provided in the application with the Pollution Control Board's industry listing.

Table 2: Impact of *de jure* Allocation of Authority on *de facto* Decision Rights

	(1) Decided by Junior	(2) Decided Above Closing
Green × Post	0.542***	0.300***
	(0.015)	(0.013)
Observations	53026	52118
Pre-Delegation Mean	0.023	0.005

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer" position. "Above Closing Officer" is a function of application color, scale, type, and industry.

Table 3: Impact on Firms' Regulatory Burden and Outcomes

	(1) Accepted	(2) Inspected	(3) Winsorized IHS Time to Decison	(4) Accepted
Green × Post	0.029***	-0.010	0.001	
	(0.009)	(0.027)	(0.069)	
Decided by Junior Officer				0.054***
				(0.017)
Observations	52910	52897	52960	52857
Pre-Delegation Mean	0.947	0.239	4.150	0.948
Estimator	OLS	OLS	OLS	2SLS
KP F-Stat				1354.752

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. The "Inspected" dummy variable is set to 1 when the email text explicitly indicates that an inspection occurred. Time to decision represents the number of days between the application submission date and the final decision date. We winsorize this variable at 1%.

Table 4: Heterogeneity by Pollution Per Worker and Number of Workers

	Accepted			
	(1)	(2)	(3)	(4)
Green × Post × Above Median	0.043*		0.029*	-0.005
	(0.024)		(0.016)	(0.014)
Green × Post	0.004	0.014	0.011	0.025
	(0.016)	(0.014)	(0.014)	(0.016)
Post × Above Median	-0.023		-0.025**	-0.002
	(0.019)		(0.012)	(0.013)
Green × Above Median	-0.008		-0.019*	0.002
	(0.009)		(0.010)	(0.007)
Above Median	-0.001		0.006	0.005
	(0.007)		(0.007)	(0.005)
Green × Post × Above 75th Percentile		0.049**		
		(0.024)		
Post × Above 75th Percentile		-0.033**		
		(0.015)		
Green × Above 75th Percentile		-0.006		
		(0.014)		
Above 75th Percentile		0.006		
		(0.010)		
Observations	12581	12581	19134	34340
Pre-Delegation Mean	0.959	0.959	0.947	0.957
Measure	Pollution per Worker	Pollution per Worker	Total Discharge	Number of Workers

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. This table presents coefficient estimates of equation (1) with acceptance as the outcome variable. In Column (1) and (3) "Above Median" is equal to 1 for those applications where pollution measure is above the pre-reform industry median, and zero otherwise. In Column (4) "Above Median" is equal to 1 for those applications where the total number of workers are more than the pre-reform industry median, and zero otherwise. In Column (2), "Above 75th Percentile" is equal to 1 for those application where pollution measure is above the 75th percentile of an industry, and zero otherwise. In Column (1) and (2), Pollution refers to total waste water discharge. The variation in the number of observations between the first two columns and the third column is because of missing data in the "number of workers" variable. See Section 5 for details.

Table 5: Compliance with Siting Restrictions: Survey Data

	Amenity-Level	Application-Level	
	(1)	(2)	(3)
	1(Siting Violation)	**1**(Siting Violation)	Number of Violation
Green × Post	0.161**	0.602*	1.002*
	(0.077)	(0.342)	(0.485)
Observations	970	179	179
Pre-Delegation Mean	0.103	0.417	0.583

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. This table presents coefficient estimates of equation (1). In Column (1), we also include amenity type fixed effects in the specification. The amenity-level data set has one row for each amenity type of each application. The amenity types are residential buildings, healthcare facilities, educational institutions, public offices, and religious establishments. We follow the document that lists the following restrictions: "Siting criteria for industrial units other than stone crushers, quarry, high rise buildings, hospitals, hotels, plywood industries, hollow/ solid cement bricks units, furniture, saw mill, laterite quarry and pig farm shall be as per PCB/TAC/18/2004 dated 9-8-2004.", "Siting criteria for plywood industries, hollow/ solid cement bricks units, furniture, saw mill, laterite quarry and pig farm shall be as per circular no. PCB/T4/115/97 dated 20-7-2011.", and "Siting criteria for crusher shall be as per circular no. PCB/TAC/St.Cr.Com/65/2005 dated 17-10-2007". See Section 5 for details.

Table 6: Robustness: Firm Characteristics Do Not Change

	(1) Wisorized IHS Capital	(2) Wisorized IHS Labor	(3) Wisorized IHS Land	(4) Wisorized IHS Fee	(5) Resubmitted	(6) Number of Emails	(7) Number of Applications	(8) Wisorized IHS Applications)
Green × Post	0.010	-0.001	-0.012	-0.124	-0.033*	-0.034	-0.382	-0.019
	(0.041)	(0.031)	(0.023)	(0.190)	(0.018)	(0.246)	(0.666)	(0.057)
Observations	53112	34432	48431	53111	53112	53112	8684	8684
Pre-Delegation Mean	2.953	1.909	0.479	5.553	0.373	8.708	6.195	1.744

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. We winsorize capital investment, land area, and number of workers at 1%. Apart from "Resubmitted" and "Number of Emails," all other variables were taken from the application data. The variable "Resubmitted" is a dummy variable and takes the value of 1 if a firm resubmits the application using the same application ID.

Table 7: Delegation: Bypassing Junior Officers

	(1) Decided Above Closing Not Bypassed	(2) Decided Above Closing Bypassed
Green × Post	0.070***	0.230***
	(0.006)	(0.012)
Observations	52118	52118
Pre-Delegation Mean	0.004	0.002

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. In this context, "bypass" refers to the situation where the junior officer is absent from the entire email chain. See Section 6 for details.

Table 8: Heterogeneity by Application and Officer Characteristics

	Decided by Junior		
	(1)	(2)	(3)
Green × Post × Heterogeneity Measure	-0.140***	-0.087***	0.084***
	(0.031)	(0.016)	(0.022)
Green × Post	0.575***	0.663***	0.509***
	(0.019)	(0.018)	(0.018)
Post × Heterogeneity Measure	0.019	0.031***	0.019*
	(0.015)	(0.006)	(0.011)
Green × Heterogeneity Measure	0.117***	0.026***	0.019***
	(0.038)	(0.005)	(0.006)
Heterogeneity Measure	-0.057*	0.003	-0.053***
	(0.033)	(0.005)	(0.008)
Observations	37521	44554	53026
Pre-Delegation Mean	0.020	0.024	0.023
Heterogeneity Measure	Pollution Score	Disagreement	Submissions

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. The outcome variable is whether the application was decided by a junior officer. In Column (1), "Heterogeneity Measure" is "Above Median Pollution Score" where "Above Median" means industries whose pollution score exceeds the median score within their respective categories. In Column (2), "Heterogeneity Measure" is a dummy variable that equals 1 for senior-subordinate pairs with above-median levels of disagreement in the pre-reform period. In Column (3), we use the number of submissions as a heterogeneity measure. See Section 6 for details.

Table 9: Heterogeneity: Corruption as an Alternative Mechanism

	Decided by Junior	
	(1)	(2)
Green × Post × Heterogeneity Measure	0.029	0.001
	(0.021)	(0.019)
Green × Post	0.528***	0.541***
	(0.021)	(0.020)
Post × Heterogeneity Measure	-0.009	0.023**
	(0.009)	(0.010)
Green × Heterogeneity Measure	-0.000	-0.037***
	(0.007)	(0.009)
Heterogeneity Measure	-0.005	
	(0.005)	
Observations	53026	53026
Pre-Delegation Mean	0.023	0.023
Heterogeneity Measure	Capital Investment	Corruption Cases

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. In Column (1), "Above Median Capital Investment" is equal to 1 for applications with total capital investments exceeding the median within their respective categories. In Column (2), "Above Median Corruption Cases" is equal to 1 for districts that had more cases of political candidates per capita with declared criminal cases than the overall median.

Table 10: Heterogeneity by Application and Officer Characteristics – Combined Specification

	Decided by Junior			
	(1)	(2)	(3)	(4)
Green × Post × Pollution Score	-0.065	-0.063	-0.074*	-0.077*
	(0.045)	(0.045)	(0.044)	(0.045)
Green × Post × Disagreement	-0.091***	-0.125***	-0.125***	-0.130***
	(0.020)	(0.019)	(0.019)	(0.019)
Green × Post × Submissions		0.064***	0.066***	0.064***
		(0.021)	(0.022)	(0.021)
Observations	31948	31948	31948	31948
Capital Investment	No	No	Yes	Yes
Corruption Cases	No	No	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. "Pollution Score" is a dummy for an above-median pollution score, equal to 1 for industries whose pollution score exceeds the median score within their respective categories. "Disagreement" is determined by comparing subordinates' recommendations to approve an application with seniors' decision to not approve an application. The disagreement measure is then averaged over the pre-reform period for each senior-subordinate pair. The measure in this table is in a binary form and equal to 1 if the average is above the overall median. "Submissions" is equal to 1 if these applications are above the overall median, and zero otherwise. In Column (3), we include interaction with "Above Median Capital Investment" which is equal to 1 for applications with total capital investments exceeding the median within their respective categories. In Column (4), we also include interactions with "Above Median Corruption Cases" which is equal to 1 for districts that had more cases of political candidates per capita with declared criminal cases than the overall median.

A Online Appendix Figures and Tables

A.1 Robustness of Delegation Reform Impacts

In this section, we discuss the robustness of the results regarding the impacts of the delegation reform. If the composition of applications submitted changed in response to the delegation reform, the impact on the probability of acceptance could be due to selection of firms applying for a permit. We show in Figure A1, however, that the number of applications was stable around the time of the reform, which helps mitigate this concern. We further address concerns about selection effects in several ways. First, as shown above in Table 6, observable firm characteristics do not in fact respond to treatment. Second, we show that Green firms applying for permits after the delegation reform do not report different levels of pollution per worker (Table A6, Columns 1-5). Finally, in Table A7, we further address selection by showing that our results are similar if we discard industries in which size-based rules affect an industry's color classification.

A different identification challenge would arise if firms selectively delayed submitting applications until after the delegation reform, in order to increase the chance a junior officer reviewed the file. We show in Table A8 that our results are largely unchanged discarding applications submitted 30 days before or after July 1, 2019. Furthermore, treating the number of applications in an industry × quarter × district cell as an outcome variable and re-estimating Equation (1) at the industry × quarter × district level, we find no evidence that the number of Green applications received changed relative to other applications after the beginning of the delegation reform (see Table 6).

To show that our results are not driven by differential trends by pollution potential, we control for the interaction of the pollution score with a dummy variable denoting post-reform periods in Table A9. Results are consistent with the main specification. We also report results using several alternative sets of fixed effects. First, in Table A10, we build up our to our baseline results from a parsimonious specification. We begin, in Columns (1), (4), and (7), with only color code and quarter fixed effects. In columns (2), (5), and (7), we add industry and district fixed effects. Columns (3), (6), and (9) add industry time trends, completing out baseline specification. Across columns, coefficients are stable for all our main outcomes. Second, in Table A11, we replace the district and industry fixed effects with district × industry fixed effects. Results are very similar to the main results. Third, we report a more parsimonious specification that includes only district and quarter fixed effects in Table A12. Results are again similar to the main results. We also show that our results are not driven by the comparison of Green applications to a control group that is dissimilar. We remove Red applications from the sample in Table A13, showing the results are largely unchanged.

Although only Green applications were affected directly by the delegation reform, it is possible that the increased demands on junior officers and reduced demands on senior officers led to violations of the stable unit treatment value assumption, or SUTVA. First, the fact that discarding red applications does not change our main results indicates that senior officers do not seem to have reallocated effort to high pollution potential applications.

SUTVA violations, if present, are likely to be greatest in districts that initially had a large share of Green applications, we include the triple interaction of *Green*, *Post*, and *Pre-Reform Percentage of Green Applications*, as well as all double interactions, in Table A14. This specification is analogous to a shift-share design that exploits pre-reform variation in the prevalence of green applications at the district level. While the triple interaction is significant for our delegation outcomes, the magnitude is small and the coefficient on $Green \times Post$ is unchanged. As an alternative check, we create a set of district fixed effects that take the value of 1 if the application is Green and in the same district, or if it is submitted in any other district and is not Green. This exercise restricts identification to comparison of Green applications from one district to Orange and Red applications from other districts, from which spillovers are unlikely to occur unless an application is escalated to the regional office. Results are presented in Table A15, and are similar to the main results.

Additionally, we consider the possibility that senior officers now spend more time on Red and Orange applications, and therefore become less likely to approve them, causing the net increase in acceptance. In Figure A5, we examine the time senior officers spend on different types of applications. To calculate this, we sum the time taken by senior officers to respond to each email received for an application. This descriptive evidence shows that, as expected, senior officers reduced the time spent on Green applications after the delegation reform. However, we do not observe any increase in the time spent on Red or Orange applications, suggesting that senior officers do not reallocate their efforts to non-Green applications following the reform. If anything, there is a small decrease in the time spent on non-Green applications.

Next, we consider whether missing data impact the main results. In our main sample, nearly 17% of applications do not have any information on industry. In Table A16, Column 1, we show that the pattern of industry reporting remains unaltered across color categories after the delegation reform. Within the same table, we also present our main results after including observations where industry information is missing, assigning them all the same generic industry – "missing" – for this analysis. The results are the same as our main results. It also shows that the probability an industry is missing is not different for Green industries post-reform.[59] Lastly, we test whether our results are sensitive to different definitions of industry. To do this, we use a large language model (GPT-4) to match each industry type in our data with the 4-digit industry classifications defined in NIC-2008 (National Industrial Classification). We then re-estimate our main results using both the 4-digit and 3-digit NIC categories (Table A17). The results remain unchanged.

We also present robustness checks for the results presented in Table 4. First, as mentioned previously, we rule out the possibility that firms applying for permits after the reform report different levels of pollution (Table A6, Columns 1-5). Second, we show that this result is not driven by limited availability of pollution data, as the probability of reporting does not change (Table A6, Column 6). Since we do not observe the number of workers for all firms, we show that the magnitude of the effect does not change significantly if we use imputed values for the number of workers (Table A18, Columns 2-3).[60] Lastly, in Table A18 (Columns 4-6), we show that results are not driven by splitting data at the median. Green applications with pollution per worker above the 75th percentile are also more likely to be accepted after the reform.

Furthermore, we show that the heterogeneous effects related to disagreement shown in Column 2 of Table 8 are not influenced by the characteristics of senior officers. In Table A19, we find that these results are similar if we use only within-senior variation. In Column 1, we add the interaction of senior officer fixed effects with a "Post" dummy, while in Column 2, we add the interaction of these senior officer fixed effects with quarter fixed effects. The results are consistent with the main effects.

[59] We also confirm that the probability of other important information missing on an application, such as pollution score or number of workers, is not different for Green industries post-reform. These are omitted for brevity, but available upon request.

[60] We impute the number of workers using data on capital investment and land area, while also controlling for industry, district, and firm type.

Figure A1: Number of Applications by Color Code and Quarter of Submission

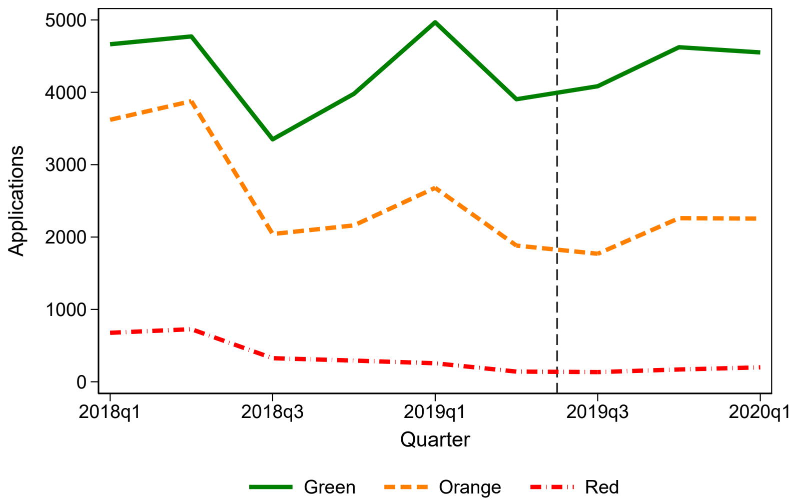
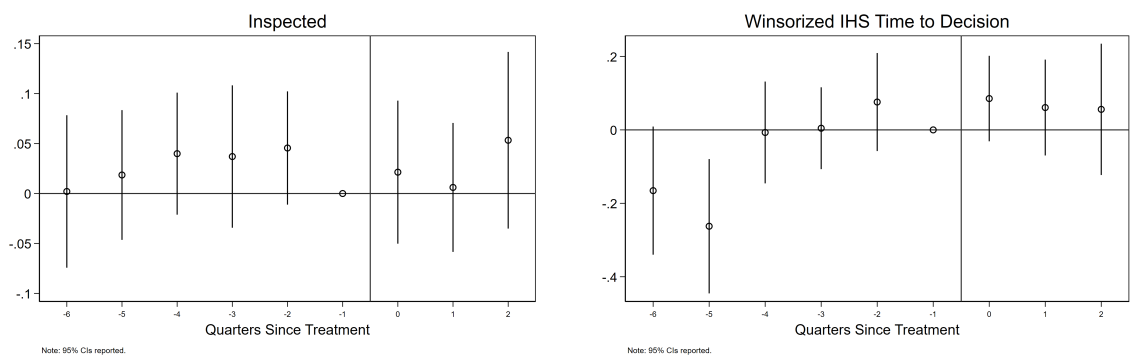
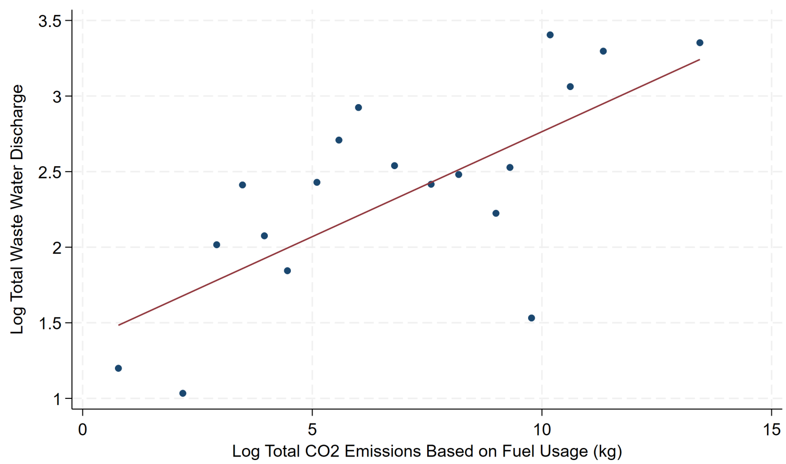


Figure A2: Event Studies – Impact on Firms' Regulatory Burden



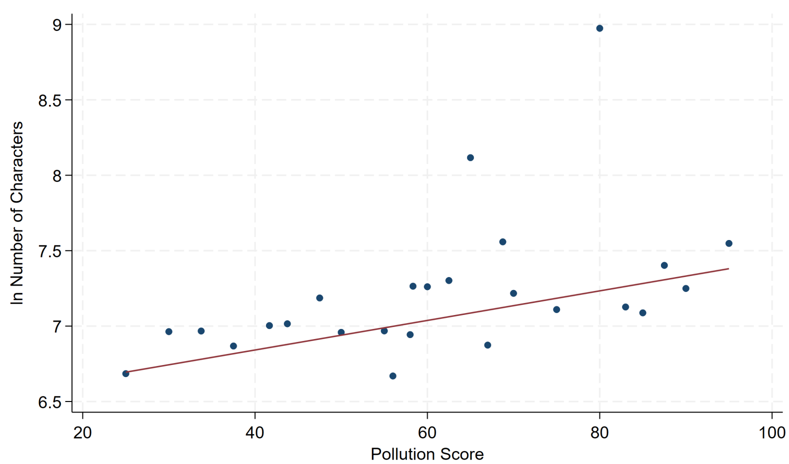
Notes: Each sub-figure presents coefficient estimates and 95% confidence intervals of Equation (1). All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Outcome variables are given in sub-figure titles. The "Inspected" dummy variable is set to 1 when the email text explicitly indicates that an inspection occurred. Time to decision represents the number of days between the application submission date and the final decision date. We winsorize this variable at 1%. See Section 5 for details.

Figure A3: Waste Water Discharge and CO_2 Emissions



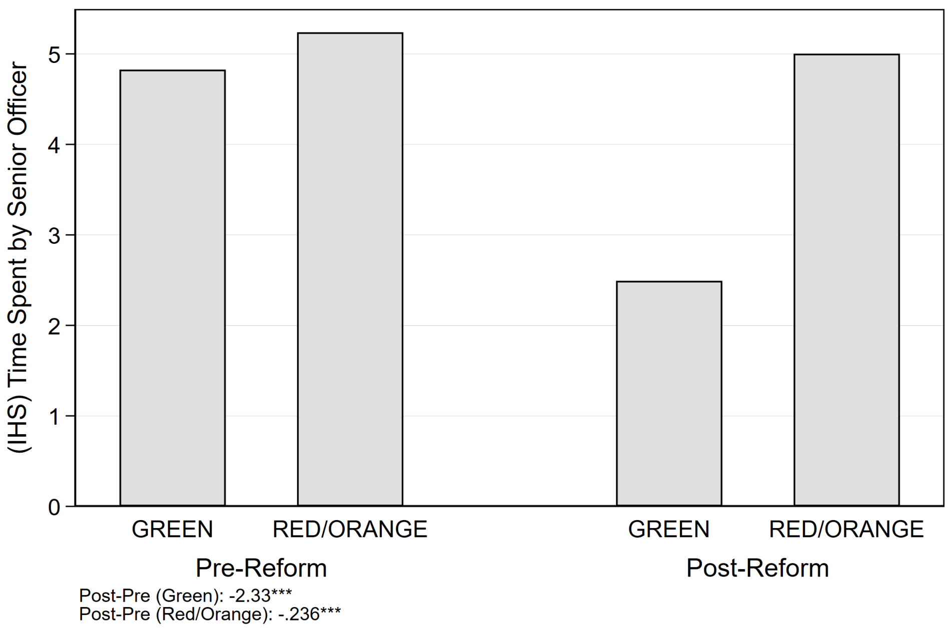
Notes: This is a binned scatterplot and line of best fit representing the correlation between the waste water discharge and CO2 emissions. The CO2 emissions were calculated by applying emission factors to fuel usage data. The emissions factors were obtained from EPA's GHG Emission Factors Hub

Figure A4: Effort by Pollution Score – Alternate Measure of Effort



Notes: This figure shows a binned scatterplot and line of best fit representing the correlation between the application-level measure of effort (log(total number of characters) on the y axis and the industry-level pollution score.

Figure A5: Time Spent by Senior Officer



Notes: This figure shows the time senior officers spent on different types of applications before and after the delegation reform. "Time Spent" is calculated by summing the time taken to respond to each email related to an application. The coefficients at the bottom of the figure represent the differences in the mean values. ***Significant at 1%, **Significant at 5%, *Significant at 10%.

Table A1: Comparison: Application Data and ASI

	Number of Employees		Capital Stock (Million Rs.)	
Percentile	Our Data, 2018	ASI, 2017-18	Our Data, 2018	ASI, 2017-18
25	2.00	9.00	3.50	1.42
50	3.00	25.00	6.75	7.72
75	6.00	107.50	26.75	39.32

Notes: ASI is the Annual Survey of Industries.

Table A2: Summary Statistics without Winsorization

	Mean	SD	Min	Max	Count
Capital	44664.4	5416495.7	0	993302591	35723
ln Capital	2.244	1.715	-4.61	20.7	35714
IHS Capital	2.962	1.689	0	21.4	35723
Labor	26.27	795.2	0	94787	23487
ln Labor	1.173	1.121	0	11.5	23260
IHS Labor	1.914	1.078	0	12.2	23487
Land	14.37	496.1	0	37616.8	32427
ln Land	-1.642	1.885	-13.9	10.5	32306
IHS Land	0.496	0.793	0	11.2	32427
Fee Paid	36992.2	1321467.1	0	200000000	35722
ln Fee Paid	9.214	1.353	3.74	19.1	20047
IHS Fee Paid	5.560	5.020	0	19.8	35722
Number of Emails	8.709	6.044	1	130	35723
ln Number of Emails	2.008	0.530	0	4.87	35723
IHS Number of Emails	2.708	0.523	0.88	5.56	35723

Notes: Summary statistics are for the pre-reform period.

Table A3: Robustness: Firm Characteristics Do Not Change (Alternative Transformation)

	(1) IHS Capital	(2) IHS Labor	(3) IHS Land	(4) IHS Fee
Green × Post	0.003	0.016	-0.014	-0.126
	(0.043)	(0.034)	(0.024)	(0.190)
Observations	53112	34432	48431	53111
Pre-Delegation Mean	2.961	1.913	0.495	5.560

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses.

Table A4: Mention of Siting Checks During Application Review

	(1) **1**(Any Mention of Siting)	(2) **1**(Any Mention of Siting)
1(Green) X 1(Post)	-0.039*	-0.065**
	(0.021)	(0.031)
Observations	44359	10977
Pre-Delegation Mean	0.303	0.400
Sample	All	Inspected Firms

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses.

Table A5: Heterogeneity by Officer Type: Inspection Behaviour

	Decided by Junior		
	(1)	(2)	(3)
Green × Under Inspection (Red) × Post	0.109***		
	(0.014)		
Green × Under Inspection (Orange) × Post		0.000	
		(0.025)	
Green × Under Inspection × Post (Orange/Red)			0.053**
			(0.021)
Observations	48878	50591	50606
R^2	0.645	0.620	0.621
Pre-Delegation Mean	0.022	0.022	0.022

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. The under inspection is determined by comparing predicted inspection with actual inspection. The inspection prediction relies on the utilization of specific variables as dictated by inspection protocols including: a) permit type, b) whether the application pertains to a new permit or renewal, c) pollution category (red/orange/green), and d) capital investment (i.e., whether the total capital investment falls below 1 million Indian rupees). The under inspection measure is then averaged over the pre-reform period for each senior-subordinate pair. The measures in this table are in the binary form and are equal to 1 if the average is above the overall median.

Table A6: Robustness: Type of Firms Applying for Permit Does not Change After the Delegation – Pollution Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Pollution per Worker	Above Median	ln Pollution per Worker	Pollution per Worker (Imputed - Predicted)	Pollution per Worker (Imputed - Median)	$\mathbb{1}\{$Pollution Data is Missing$\}$
Green × Post	-0.954	0.037	0.191	-0.957	-24.454	-0.014
	(5.531)	(0.034)	(0.133)	(3.892)	(15.128)	(0.017)
Observations	12622	12622	12622	18664	18666	53112
Pre-Delegation Mean	11.157	0.544	-2.075	12.374	21.477	0.638

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. Pollution refers to total waste water discharge. In Column (4), we estimate the number of workers for applications with missing data by employing a predictive model that utilizes information regarding capital investment and total land area. In Column (5), we fill in missing values by assigning them the median value of wastewater discharge within their respective industries during the pre-reform period.

Table A7: Robustness: Restrict sample: No size-based definitions

	(1) Decided by Junior	(2) Decided Above Closing	(3) Accepted
Green × Post	0.541***	0.298***	0.024**
	(0.016)	(0.013)	(0.011)
Observations	45886	45165	45814
Pre-Delegation Mean	0.024	0.004	0.952

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry.

Table A8: Robustness: Drop applications within 30 days of policy

	(1) Decided by Junior	(2) Decided Above Closing	(3) Accepted
Green × Post	0.582***	0.290***	0.032***
	(0.017)	(0.014)	(0.010)
Observations	49335	48494	49226
Pre-Delegation Mean	0.018	0.005	0.947

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry.

Table A9: Robustness: Control for Pollution Score × Post

	(1) Decided by Junior	(2) Decided Above Closing	(3) Accepted
Green × Post	0.515***	0.321***	0.033**
	(0.021)	(0.021)	(0.014)
Pollution Score × Post	-0.002**	0.002*	-0.000
	(0.001)	(0.001)	(0.001)
Observations	37521	36880	37449
Pre-Delegation Mean	0.020	0.006	0.951

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. Pollution Score interacted with Post is included as a further control. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry.

Table A10: Sensitivity to controls

	Decided by Junior			Decided Above Closing			Accepted		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Decided by Junior	0.611***	0.612***	0.542***	0.293***	0.287***	0.300***	0.038***	0.036***	0.029***
	(0.014)	(0.013)	(0.015)	(0.013)	(0.013)	(0.013)	(0.009)	(0.008)	(0.009)
Observations	53051	53026	53026	52141	52118	52118	52936	52910	52910
Pre-Delegation Mean	0.023	0.023	0.023	0.005	0.005	0.005	0.947	0.947	0.947
Category FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Industry FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Quarter Trend	No	No	Yes	No	No	Yes	No	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer" position. "Above Closing Officer" is a function of application color, scale, type, and industry.

Table A11: Robustness: Industry by District Fixed Effects

	(1) Decided by Junior	(2) Decided Above Closing	(3) Accepted
Green × Post	0.545***	0.292***	0.029***
	(0.016)	(0.014)	(0.009)
Observations	52504	51598	52393
Pre-Delegation Mean	0.023	0.005	0.947

***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry by district fixed effects, industry time trends, quarter fixed effects, and category code fixed effects. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry. Standard errors clustered by industry in parentheses.

Table A12: Robustness: Industry and Quarter Fixed Effects

	(1) Decided by Junior	(2) Decided Above Closing	(3) Accepted
Green × Post	0.611***	0.293***	0.036***
	(0.012)	(0.013)	(0.007)
Observations	53026	52118	52910
Pre-Delegation Mean	0.023	0.005	0.947

***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, and quarter fixed effects. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry. Standard errors clustered by industry in parentheses.

Table A13: Robustness: Drop Red Applications

	(1) Decided by Junior	(2) Decided Above Closing	(3) Accepted
Green × Post	0.540***	0.299***	0.028***
	(0.015)	(0.013)	(0.009)
Observations	50937	50163	50834
Pre-Delegation Mean	0.024	0.004	0.949

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. Red applications are excluded from the sample. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry.

Table A14: Robustness: Interact with percent Green by District in Pre Period

	(1) Decided by Junior	(2) Decided Above Closing	(3) Accepted
Green × Post	0.530***	0.311***	0.030***
	(0.015)	(0.014)	(0.009)
Green × Post × Pre Pct. Green	0.045***	-0.076***	0.011
	(0.010)	(0.011)	(0.007)
Observations	53026	52118	52910
Pre-Delegation Mean	0.023	0.005	0.947

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. In addition, all specifications control for the interaction of Green, Post, and percentage of Green applications by district in the pre-reform period. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry.

Table A15: Robustness: District × Green $\bigcup$ Any Other District × Not Green Fixed Effects

	(1) Decided by Junior	(2) Decided Above Closing	(3) Accepted
Green × Post	0.537***	0.304***	0.030***
	(0.015)	(0.014)	(0.009)
Observations	53026	52118	52910
Pre-Delegation Mean	0.023	0.005	0.947

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. In addition, all specifications control for district × Green $\bigcup$ any other district × not Green fixed effects. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry.

Table A16: Robustness: Missing Industry Information

	Application-level Outcomes				
	(1)	(2)	(3)	(4)	(5)
	=1 if Pollution Score is Missing	=1 if Industry Type is Missing	Decided by Junior	Decided Above Closing	Accepted
Green × Post	0.055	0.031	0.565***	0.294***	0.033***
	(0.062)	(0.021)	(0.019)	(0.010)	(0.006)
Observations	53137	64366	64236	63096	64091
Pre-Delegation Mean	0.269	0.194	0.022	0.007	0.944

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Apart from Column (1), all other specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. The specification used in Column (1) only include district, quarter, and category code fixed effects. All the outcome variables presented in this table are binary. Apart from Column (1), in all other specifications, we replace missing industry information with generic industry. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry.

Table A17: Robustness: Missing Industry Information

	(1)	(2)	(3)	(4)	(5)	(6)
	Decided by Junior	Decided Above Closing	Accepted	Decided by Junior	Decided Above Closing	Accepted
Green × Post	0.577***	0.287***	0.030***	0.565***	0.292***	0.030***
	(0.015)	(0.016)	(0.011)	(0.015)	(0.016)	(0.011)
Observations	37882	37263	37813	36611	36019	36544
Pre-Delegation Mean	0.020	0.004	0.951	0.021	0.003	0.952
Industry Defination	NIC-3	NIC-3	NIC-3	NIC-4	NIC-4	NIC-4

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. The specification used in Column (1) only include district, quarter, and category code fixed effects. All the outcome variables presented in this table are binary. "Junior" refers to the "Assistant Environmental Engineer". "Above Closing Officer" is a function of application color, scale, type, and industry. NIC-3 and NIC-4 refer to 3 and 4 digit industrial classification defined in NIC-2008.

Table A18: Robustness: Alternative Measures of Decision Quality

	Accepted					
	(1)	(2)	(3)	(4)	(5)	(6)
Green × Post × Above Median	0.043*	0.032	0.036*			
	(0.024)	(0.020)	(0.019)			
Green × Post × Above 75th Percentile				0.049**	0.049**	0.042*
				(0.024)	(0.020)	(0.022)
Observations	12581	18574	18577	12581	18574	18577
Pre-Delegation Mean	0.959	0.947	0.947	0.959	0.947	0.947
Imputed Missing Worker Data Imputed	No	Yes	Yes	No	Yes	Yes
Imputation Method	N/A	Prediction	Median	N/A	Prediction	Median

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. Pollution refers to total waste water discharge. In Columns (2) and (5), we estimate the number of workers for applications with missing data by employing a predictive model that utilizes information regarding capital investment and total land area. In Columns (3) and (6), we fill in missing values by assigning them the median value of wastewater discharge within their respective industries during the pre-reform period.

Table A19: Robustness: Disagreement With Senior Officer with Alternative Fixed Effects

	(1) Decided Above Junior	(2) Decided Above Junior
Green × Post × Above Median	-0.095***	-0.090***
	(0.016)	(0.016)
Green × Post	0.648***	0.652***
	(0.016)	(0.017)
Post × Above Median	0.067***	0.064***
	(0.019)	(0.018)
Green × Above Median	0.021***	0.019***
	(0.005)	(0.005)
Above Median	-0.005	-0.006
	(0.004)	(0.004)
Observations	44554	44551
Pre-Delegation Mean	0.024	0.024
Senior × Post FE	Yes	No
Senior × Quarter FE	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. All specifications include a constant, industry fixed effects, industry time trends, district fixed effects, quarter fixed effects, and category code fixed effects. Standard errors clustered by industry in parentheses. 'Disagreement' equals 1 for senior-subordinate pairs with high rates of disagreement during the pre-reform period. See Section 6 for details.

Table A20: p Values Corrected for Multiple Comparisons: Heterogeneity by Application and Officer Characteristics

	Bootstrap	List, Shaikh and Xu (2019)	Bonferroni	Holm (1979)
Table 8				
Column (1): Green × Post × Pollution Score	.01	.01	.03	.03
Column (2): Green × Post × Disagreement	.01	.01	.03	.01
Column (3): Green × Post × Submissions	.01	.01	.03	.02
Table 10				
Column (1): Green × Post × Pollution Score	.01	.01	.04	.01
Column (2): Green × Post × Pollution Score	.01	.01	.04	.03
Column (3): Green × Post × Pollution Score	.01	.01	.04	.04
Column (4): Green × Post × Pollution Score	.01	.01	.04	.02
Column (1): Green × Post × Disagreement	.01	.01	.04	.01
Column (2): Green × Post × Disagreement	.01	.01	.04	.02
Column (3): Green × Post × Disagreement	.01	.01	.04	.04
Column (4): Green × Post × Disagreement	.01	.01	.04	.03

Notes: This table presents p-values corrected for multiple comparisons for results equivalent to those in Tables 8 and 10. See Section 6 for details.

B Model

B.1 Setup

We base our conceptual framework in Section 6.1 on a simple model with two players – a senior officer and a junior officer. The senior (S) receives an application. She can deal with it herself, or she can delegate it to the junior (J). An application can be of two types, good and bad. The probability an application is bad is b. This probability is known by both the senior and junior.

If the senior does not delegate, and so retains the application (action R), she can choose to exert effort (action E) scrutinizing the application. Her cost of effort is c. If she does not exert effort (action N), she will approve the application. If she approves a bad application, its quality will be revealed and she will pay a cost X. While we assume that a bad application approved by the senior has no cost to the junior, this will have no impact on the outcome. If the senior exerts effort, there is a probability p that she will detect that a bad application is bad, and so reject it.[61]

If the senior delegates (action D), the junior can choose to exert effort scrutinizing the application (action e) or not (action n). The junior's cost of effort is k. If the junior exerts effort, there is a probability q that he will detect that a bad application is bad, and so reject it. Otherwise, he will approve it. As with the senior, this automatic choice can be understood as consistent with a positive expected return to approving an application in the absence of other information, following the imperatives of the regulator.

If the junior accepts a bad application, he will pay a cost Z and the senior will pay a cost of X. We make the assumption that the senior pays the same cost of a wrongful approval whether the application is approved by the junior or by herself. Letting there be a different cost to the senior of a decision made by the junior (say, X') would add complexity without changing the key qualitative predictions of the model.

B.2 Payoffs

We assume both the senior and junior are risk neutral. Their payoffs, then, are simply the sum of effort costs and, conditional on an action taken, the possible costs of a wrongful approval.

[61] While we model the choice to approve an application that has not been shown to be bad as automatic, this is consistent with the expected return to accepting a good application being positive in the absence of other information. For example, this could take the form of a positive return ρ to accepting good applications such that $\rho > c$. It could also be a cost of rejecting good applications κ such that $\kappa > bX$. Either would be consistent with the general interpretation that it is the job of the regulator to approve good applications and reject bad ones, rather than simply rejecting all applications in order to avoid wrongful approvals.

The senior's expected payoff (π) from not delegating (R) and from and not exerting effort (N) is given by:

$$\begin{aligned}\pi_S^{R,N} &= (1-b)\times 0 + b\times(-X)\\ &= -bX\end{aligned}$$

The senior's expected payoff from not delegating (R) and exerting effort (E) is, by contrast:

$$\begin{aligned}\pi_S^{R,E} &= (1-b)\times(-c) + bp\times(-c) + b(1-p)\times(-c-X)\\ &= -c - bX + bpX\end{aligned}$$

If the senior delegates, her payoffs will be conditional on the actions taken by the junior. The senior's expected payoff from delegating (D) if the junior does not exert effort (n) is:

$$\begin{aligned}\pi_S^{D,n} &= (1-b)\times 0 + b\times(-X)\\ &= -bX\end{aligned}$$

Instead, if the senior delegates (D) and the junior exerts effort (e), the senior's expected payoff becomes:

$$\begin{aligned}\pi_S^{D,e} &= (1-b)\times 0 + bq\times 0 + b(1-q)\times(-X)\\ &= -b(1-q)X\end{aligned}$$

Because the junior takes no action without delegation, his payoffs without delegation are irrelevant to the model predictions. It is possible, then, to assume that junior receives a payoff of zero without delegation.

The junior's expected payoff from delegation (D) if he does not exert effort (n) is:

$$\begin{aligned}\pi_J^{D,n} &= (1-b)\times 0 + b\times(-Z)\\ &= -bZ\end{aligned}$$

Instead, the junior's expected payoff from delegation (D) if he does exert effort (e) is:

$$\begin{aligned}\pi_J^{D,e} &= (1-b)\times(-k) + bq\times(-k) + b(1-q)\times(-k-Z)\\ &= -k - bZ + bqZ\end{aligned}$$

B.3 Effort Choices

Given these payoffs, it is trivial to identify the conditions under which either the senior or the junior will exert effort. We make the simplifying assumption that, for both the senior and junior, indifference leads to inaction. First, an officer indifferent between exerting effort and not will not exert effort. Second, a senior indifferent between delegation and not will delegate. While the former assumption is innocuous, the latter does change some of the model predictions, and we will return to it when we describe the equilibrium outcomes below.

Under delegation, the junior exerts effort if his payoff is greater than from not exerting effort, i.e. if $\pi_J^{D,e} > \pi_J^{D,n}$. This condition can be rewritten as follows:

$$\begin{aligned}-k - bZ + bqZ &> -bZ\\ \Rightarrow Z &> \frac{k}{bq}\end{aligned}$$

Intuitively, if the costs to the junior of wrongly accepting a bad application are high, this strengthens his incentive to exert effort, as does a higher probability of a bad application and a higher probability of detecting a bad application conditional on effort. A high cost of effort has the opposite effect.

Without delegation, the senior exerts effort if the payoff is greater than from not exerting effort, i.e. if $\pi_S^{R,e} > \pi_S^{R,n}$. This condition can be rewritten as:

$$\begin{aligned}-c - bX + bpX &> -bX\\ \Rightarrow X &> \frac{c}{bp}\end{aligned}$$

As with the junior, the senior's incentive to exert effort increases in the cost of a wrongful approval, in the probability of a bad application, and in the probability that effort uncovers a bad application. Higher effort costs weaken this incentive.

B.4 The choice to delegate

Again assuming a senior indifferent between delegation and not will delegate, the senior prefers no delegation and no effort by herself to delegation and no effort by the junior if this results in a greater payoff, i.e. if $\pi_S^{R,N} > \pi_S^{D,n}$. This condition can be rewritten as:

$$-bX > -bX$$

That is, the senior is always indifferent between delegating and not if neither she nor the junior will exert effort. By assumption, then, this indifference leads to delegation. The senior prefers no delegation and no effort by herself to delegation and effort by the junior if this leads to a higher payoff, i.e. if $\pi_S^{R,N} > \pi_S^{D,e}$. This condition can be rewritten as:

$$\begin{aligned} -bX &> -b(1-q)X \\ \Rightarrow 0 &> bqX \end{aligned}$$

In this case, it is obvious that the senior always prefers delegating if she would not exert effort but the junior would.

The senior prefers no delegation and exerting effort to delegation and no effort by the junior if $\pi_S^{R,E} > \pi_S^{D,n}$. This condition can be rewritten as:

$$\begin{aligned} -c - bX + bpX &> -bX \\ \Rightarrow X &> \frac{c}{bp} \end{aligned}$$

That is, if the senior knows the junior will not exert effort, the senior prefers not to delegate if the senior's cost from a bad application being accepted, X, is strictly greater than $\frac{c}{bp}$, which is the same value of X above which she would choose to exert effort.

Finally, the senior prefers no delegation and exerting effort to delegation and effort by the junior if $\pi_S^{R,E} > \pi_S^{D,e}$. This can be rewritten as:

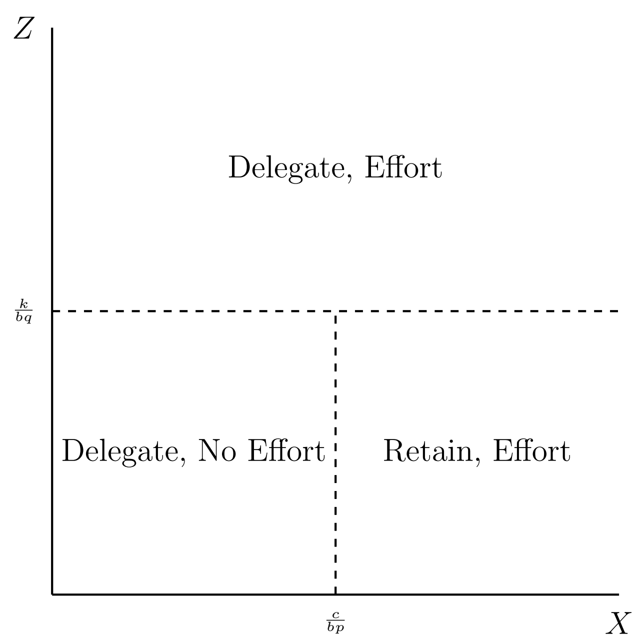
$$\begin{aligned} -c - bX + bpX &> -bX + bqX \\ \Rightarrow (p-q)X &> \frac{c}{b} \end{aligned}$$

If the senior is more effective than the junior, i.e. if $p > q$, this means that she will prefer not to delegate if $X > \frac{c}{b(p-q)}$. If $p \leq q$, she will always prefer to delegate if she knows both she and the junior would exert effort, because the junior is more likely to detect a bad application.

B.5 Equilibria

The equilibria of the model – whether the senior delegates and whether the officer who handles the file exerts effort – depend on the parameters b, X, Z, c, p, k, and q. These can be illustrated intuitively by showing these equilibria in (X, Z) space, i.e. as functions of the costs to the senior and junior of a wrongful approval. Figure B1 shows these equilibria for the case where $p \leq q$. Figure B2 shows them when $p > q$.

Figure B1: Equilibria when $p \leq q$

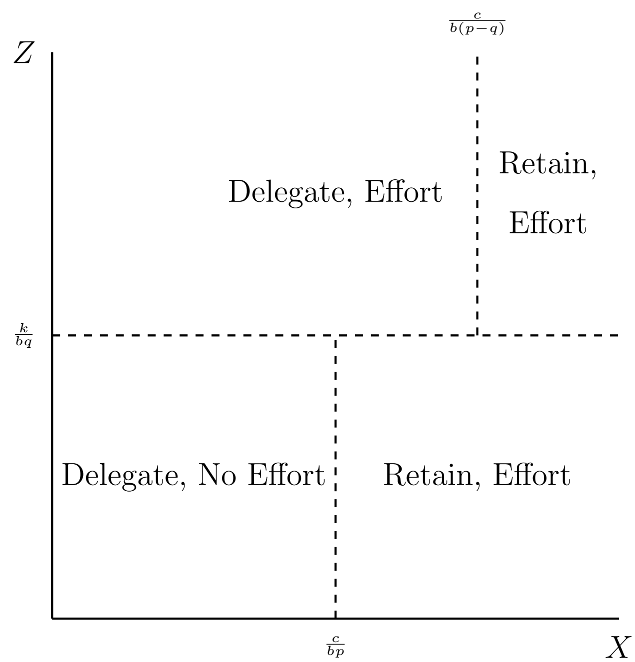


Consider first the case where $p \leq q$. In this case, the junior is at least as effective at detecting bad applications as is the senior. There are three possible outcomes. In the bottom-left corner of Figure B1, both X and Z are low, and so neither officer will exert effort inspecting an application that she or he is tasked with. The senior, indifferent between delegating and not, delegates.

Second, in the bottom right quadrant, X is high relative to Z, and Z is low relative to the ratio $\frac{k}{bq}$. That is, the costs to a junior of a wrongful approval are low enough compared to the relative costs from effort that he will not exert effort scrutinizing an application. The potential cost to the senior is, however, now high enough relative to her own relative costs from effort ($\frac{c}{bp}$) that she will now inspect an application she is tasked with. Knowing the junior will not exert effort, she does not delegate.

Third, in the top half of the figure, Z is high relative to $\frac{k}{bq}$. Now, the potential costs of a wrongful approval have risen for the junior when compared to his relative costs of effort. He will now scrutinize applications he is tasked with. The senior, knowing this, delegates.

Figure B2: Equilibria when $p > q$



In the case where $p > q$, the senior is more effective at detecting bad applications than is the junior. This situation creates an additional possible outcome in the upper right quadrant of Figure B2. Here, although the junior will exert effort, the costs to the senior of a wrongful approval are high enough that she would exert her own, more effective effort, even though it is costly, in order to reduce the chances that a bad application is approved.

We now return two simplifying assumptions made earlier. The first is that an officer indifferent between exerting effort and not will not exert effort. This will only affect what happens precisely on the boundaries separating the regions of Figures B1 and B2, and so is innocuous.

The second is that a senior indifferent between delegating and not delegates. Were we to reverse this assumption, the bottom left quadrant of both Figures B1 and B2 would become one of "Retain, No Effort." That is, knowing that neither officer would exert effort, the senior would not delegate as the ultimate probability of a wrongful approval would not change.

The exposition of the possible outcomes in (X,Z) space in Figures B1 and B2 shows how these parameters affect delegation and effort. What of b, c, p, k, and q?

If c, the senior's cost of effort, increases, both $\frac{c}{bp}$ and $\frac{c}{b(p-q)}$ shift right. This shrinks the boundaries of the "Retain, Effort" region. This is because the senior's cost of not delegating has risen.

If p, the senior's probability of detecting a bad application conditional on effort, increases, both $\frac{c}{bp}$ and $\frac{c}{b(p-q)}$ shift left. This expands the boundaries of the "Retain, Effort" region. The senior can accomplish more by not delegating.

If k, the junior's cost of effort, increases, $\frac{k}{bq}$ shifts upwards, shrinking the size of the region in which delegation occurs relative to the size of the region in which it does not. Intuitively, if the junior is less likely to scrutinize an application, the senior is less likely to delegate it.

If q, the junior's probability of detecting a bad application conditional on effort, increases, $\frac{k}{bq}$ shifts downwards, expanding the size of the region in which delegation occurs relative to the size of the region in which it does not. If $p > q$, the rightward shift in $\frac{c}{b(p-q)}$ would have the same effect. The junior can accomplish more under delegation, and is more likely to try, and so the senior is more likely to delegate.

Consider again changing the assumption that a senior indifferent between delegating and not delegates, so that instead an indifferent senior does not delegate. Now, the bottom left quadrant of both Figures B1 and B2 is an equilibrium of "Retain, No Effort." In this case, if b increases, the shift in $\frac{c}{bp}$ is now irrelevant to delegation. If $p \leq q$, $\frac{k}{bq}$ shifts downwards and the size of the region in which delegation occurs grows relative to the region in which it does not. If $p > q$, however, $\frac{c}{b(p-q)}$ also shifts leftwards, and predictions are again ambiguous.

Again under this alternative assumption about delegation under indifference, if c increases, the shift in $\frac{c}{bp}$ is now irrelevant. If $p > q$, $\frac{c}{b(p-q)}$ shifts right, increasing the size of the region in which delegation occurs relative to the region in which it does not. Again, the senior's cost of effort has risen, but this is only relevant in cases where she would rather scrutinize an application herself than allow the junior to do so, because of her relative advantage in applying effort.

Similarly, under this alternative assumption about delegation under indifference, an increase in p would lead to an irrelevant shift in $\frac{c}{bp}$ and, if $p > q$, a relevant shift in $\frac{c}{b(p-q)}$. For the subset of cases where the senior has an incentive to exert effort even knowing the junior would do the same, a rise in the senior's effectiveness in scrutinizing applications would reduce delegation.

A rise in k under this alternative assumption about delegation under indifference would still shift $\frac{k}{bq}$ upwards, shrinking the size of the region in which delegation occurs relative to the size of the region in which it does not. A rise in q would have the same impact as before, shifting $\frac{k}{bq}$ downwards and $\frac{c}{b(p-q)}$ rightwards, increasing the size of the delegation region.