Quality Provision through Regulation and Reputation

Theory and Evidence from the Environmental Impact Assessment Industry

Yucheng Quan

The University of Hong Kong

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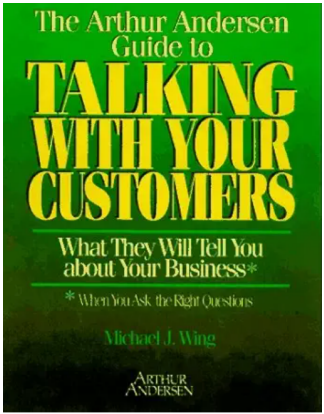
- Reputation, as a market mechanism, plays a similar role in mitigating quality problems.
- **Key puzzle**: How does entry regulation interact with market-based reputation mechanisms to affect service quality and social welfare?

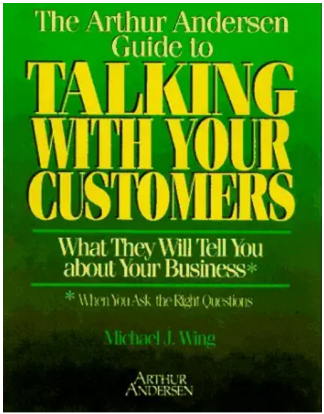
Consequences of Low-quality Provision

- Environmental Impact Assessment (EIA): required by 93% of UN member states

Reputation Mechanism



Reputation Mechanism



Enron scandal

From Wikipedia, the free encyclopedia

The **Enron scandal** was an accounting scandal sparked by American energy company Enron Corporation filing for bankruptcy after news of widespread internal fraud became public in October 2001, which led to the dissolution of its accounting firm, Arthur Andersen,

Regulatory Flip-flops

- No consensus on entry regulation in service industries has been reached:
  - Post-Enron auditing reforms (the Sarbanes-Oxley Act of 2002):
    - Strengthened administrative entry barriers: Public Company Accounting Oversight Board (PCAOB) registration, state-level permits, CPA-licensed auditors
  - China's 2019 EIA deregulation reform
    - Abolished the licensing system of EIA agencies and reduced the minimum requirements for certified staff

Regulatory Flip-flops

Original Articles

Deregulation of professional accounting services in the United Kingdom: integrating marketing and accounting

Victoria L. Crittenden, Larry R. Davis, Daniel T. Simon & Gregory Trompeter

RESEARCH ARTICLE | DECEMBER 01 2005

Twenty-Five Years of Audit Deregulation and Re-Regulation: What Does it Mean for 2005 and Beyond?

William R. Kinney, Jr., Professor

This Study I

1. Empirical facts:
   - investigates the Environmental Impact Assessment industry in China
   - **Question I**: How does an entry deregulation reform affect market outcomes (number of new entrants, service quality and externalities on other stakeholders)?
   - **Question II**: How do customers respond to reputation changes?
2. Illustrative model:
   - incorporates market power, quality uncertainty and reputation formation
   - **Question III**: How do reputation dynamics change the effect of entry regulation on quality?

This Study II

3. Empirical model:
   - develops a dynamic oligopoly model with Moment-based Markov Equilibrium (Ifrach and Weintraub, 2017)
   - estimates the model using EIA industry data
   - conducts policy simulations (pending)
   - **Question IV**: What determines optimal intensity and timing of entry regulation when reputation matters?

Context: Environmental Impact Assessment

- Incentive: Authorities penalize customers with over-polluted projects.
- High-quality service is important:
  - Ensures **clients** comply with environmental regulation
  - Informs regulators and citizens of the environmental impact
- **Quality is unverifiable prior to construction.**

Empirical Fact I: Effect of Entry Deregulation on Market Outcomes

The sharp entry deregulation reform in 2019 increased the # of EIA agencies by fivefold and reduced average service quality by approximately 43% in a typical province.

- Proxy for quality using penalty in the EPA law enforcement process
- Regress market outcomes on the # of agencies
- IV strategy: pre-deregulation EIA trade patterns

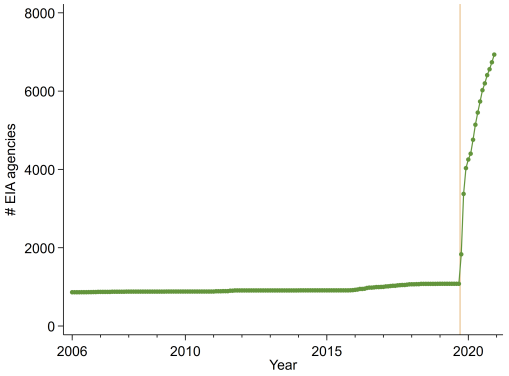


Figure: Changes in the # of EIA Agencies

Empirical Fact II: Market Response to Reputation Shocks

Firms experiencing a penalty disclosure event saw their market shares decline by nearly half.

- Staggered adaptation design: EPA systems regularly disclose penalties for low-quality reports through multiple channels.
- Implications: reveals the severity of information asymmetry and the sensitivity of firm reputation to credible quality signals

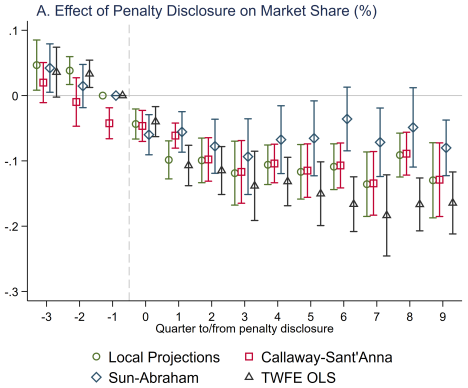


Figure: Event Study Estimates

Illustrative Model

Question III: How do reputation dynamics change the effect of entry regulation on quality?

Model Setup

- In period 0, entrants observe their productivity $\gamma \in \{\gamma_L, \gamma_H\}$ and decide whether to enter the market and pay the entry cost c_e common to all entrants. After observing the number of successful entrants, firms decide the quality to maximize their EDV.
- Then, in each of period 1 and 2, customers and firms (and the regulator) play the following subgame:
  1. Forward-looking firms choose the price level.
  2. Customers form reputation based on observed penalties and the demand is realized.
  3. The law enforcement is realized.

Customer Demand

- Demand is determined by the price and the expected penalty:

$$s_j(\boldsymbol{p}_t, \tilde{\boldsymbol{q}}_t) = a - b(p_{jt} + h\hat{P}(\tilde{q}_{jt})) + \sigma \sum_{k \neq j} (p_{kt} + h\hat{P}(\tilde{q}_{kt})). \quad (1)$$

- The parameters governing own-price elasticity (b) and the cross-price elasticity (σ) are common to all firms' services.
- h: fine amount and thus $h\hat{P}_{jt}$ captures the expected fine.

Reputation of Quality

- Reputation is modeled as the beliefs about quality, which are updated with new quality signals (Shapiro, 1985; Board & Meyer-ter-Vehn, 2013).
- The quality signal (penalty probability) evolves as: $P = \alpha_0 - \alpha_1 q + \nu$, $\nu \sim N(0, \sigma_\nu^2)$ (law enforcement process)
- Model dynamic reputation-updating process using Bayesian learning.
  - Assume that customers perceive the law enforcement process correctly.
  - The perceived quality in period 2: $\tilde{q}_2 = (1-\delta)\bar{q} + \delta\frac{\alpha_0 - P_1}{\alpha_1}$ with $\delta \equiv \frac{\sigma_{\bar{q}}^2}{\sigma_\nu^2 + \sigma_{\bar{q}}^2}$ being the speed of reputation updating.

Effect of Entry Regulation on Service Quality

- Entry regulation is defined as an increase in the entry cost c_e.

Proposition (Effect of Entry Regulation on Service Quality)

There exists $\tilde{c}_e$ in the set of all possible entry costs c_e such that for all c_e above $\tilde{c}_e$, only entrants of γ_H enters and below $\tilde{c}_e$, all entrants enter. The service quality $\bar{q}$ is higher when the entry cost c_e is above $\tilde{c}_e$ relative to when the entry cost c_e is below $\tilde{c}_e$.

- Intuition: Entry regulation preserves only high-productivity firms and increases the relative return to quality investment *vs.* short-term profit harvesting.

Reputation-Regulation Interaction

Proposition (Role of Reputation on Quality and Entry Regulation Effect)

The average quality $\bar{q}$ increases with the reputation updating speed δ, informativeness of the signal (α_1 and $-\sigma_\nu$); the difference between the quality with above-threshold entry cost and below-threshold entry cost decreases in them.

- Reputation mechanism increases the average quality; reputation weakens the effect of entry regulation.
- Intuition: High-productivity firms in an unregulated market will seize the opportunity to show their reputation to grab clients from the hand of low-productivity firms in period 2. In a regulated market, this incentive disappears.

Dynamic Oligopoly Model

Question V: What is the welfare effect of entry regulation when reputation matters?

Model Setup

- Dynamic oligopoly model *à la* Ericson and Pakes (1995).
- Equilibrium concept: moment-based Markov equilibrium (Ifrach and Weintraub, 2017)
  - One EIA market comprises hundreds of agencies.
  - Tighter entry regulation shifts firms from the fringe to dominant positions.
- The moment-based industry state $\hat{\mathbf{s}}$ includes the fringe moment (sum of fringe firms' reputation terms $\theta(\tilde{q})$) and the dominant firm state d.

Measurement

- A continuous measure of quality
  - Plagiarism is the major issue identified by regulatory authorities.
    "Engineers often exert less effort in drafting reports, resorting instead to copying content from existing reports." — Ministry of Ecology and Environment, 2020
  - A corpus of EIA reports: sourced from disclosure forums and government websites; valid reports total 40k
  - A plagiarism detection system: segment reports by paragraphs and calculate cosine similarity btw text embeddings (Word2Vec) Go
- Reputation (beliefs about quality)
  - Use the revealed preference and beliefs approach
  - $v = \text{revenue} - \text{price} - \text{Penalty}; \text{Penalty} = f(\text{reputation}, \text{law enforcement})$. Go

Estimation

- Use the two-stage estimation algorithm similar to that of Bajari, Benkard, and Levin (2007).
- First-stage estimation: static parameters, transition parameters, transition processes, and policy functions.
  - Static parameters include demand parameter b, marginal cost c, and transition parameter δ and α.
  - Instrument for price using the average quality of other firms; estimate the demand function; recover expected quality as the residual.
  - Estimate the fringe moment transition (AR(1)) and fringe-dominance transition processes, then discretize them.

Estimation

- First-stage estimation: static parameters, transition parameters, and policy functions.
  - Estimate quality, entry, and exit policy functions using spline regressions.
  - Use forward simulation to recover perceived value functions $\widehat{V}_i(\hat{\mathbf{s}}; \hat{\boldsymbol{\sigma}}; \theta)$.
- Second-stage estimation: dynamic parameters.
  - Dynamic parameters: the distribution of quality fixed cost c_q, exit value ϕ, and entry cost c_e.
  - Use the Laplace-type MCMC minimum distance estimator to recover $G(c_q)$ and $G(\phi)$.
  - Recover the distribution of entry cost:
    $\Pr\left(\chi_e\left(\hat{\mathbf{s}}, \nu_e\right) = 1\right) = G_e\left(\beta \mathbb{E}\left[V\left(\hat{\mathbf{s}}'; \boldsymbol{\sigma}\right) \mid \boldsymbol{\sigma}, \hat{\mathbf{s}}, \chi_e = 1\right]\right)$

Estimates

Table: Estimating Reputation Transition Process

	(1)	(2)	(3)
	AR(1) process		Linear index model
	Original quality	Discretized quality	Discretized quality
Quality_{t-1}	0.079***	0.087***	
	(0.013)	(0.013)	
Reputation_{t-1}	0.984***	0.977***	
	(0.003)	(0.003)	
Probability of outside shock (δ)			0.453***
			(0.114)
Reputation's Sensitivity to quality (α)			1.522***
			(0.036)
Mean Dep Var	7.394	7.394	7.394
Adjusted R^2	0.993	0.993	
Observations	3,747	3,747	3,747

Economic significance: Increasing quality from the lowest to the highest level in the data implies a 95% higher probability of increasing reputation, which has the same effect as reducing price by an amount equal to marginal cost.

Estimates

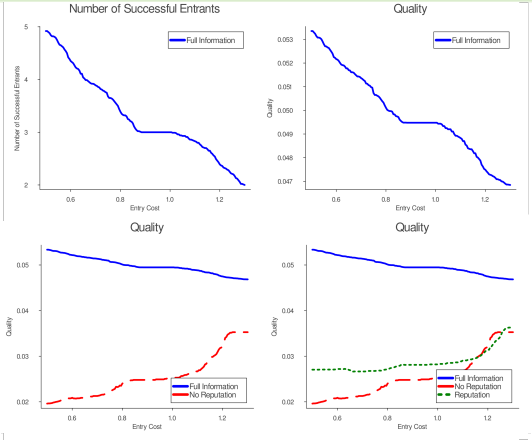
Table: Model Parameters

	(1)	(2)
Parameter	Estimate	SE
Panel A. Static Parameters		
Sensitivity to price (b)	2.675	(0.427)
Marginal cost (c, mCNY)	0.723	
Probability of outside shock (δ)	0.453	(0.114)
Reputation's Sensitivity to quality (α)	1.522	(0.036)
Panel B. Dynamic Parameters (mCNY)		
Quality fixed cost		
Mean (μ_ξ)	-0.549	(0.094)
Standard deviation (σ_ξ)	0.412	(0.065)
Exit value		
Mean (μ_ϕ)	33.029	(6.491)
Standard deviation (σ_ϕ)	24.849	(4.869)
Sunk entry cost		
Lower bound (c_{el})	16.440	(2.166)
Upper bound (c_{eh})	29.698	(8.082)

Policy Counterfactual

- Practice I: How do information asymmetry and reputation change the optimal stringency of entry regulation?
  - Full info: individual state = quality
  - Asymmetric info: individual state = industrial avg quality
  - Reputation: individual state = reputation
- Practice II: Importance of regulatory timing
  - Constant regulation, delayed regulation, loosened regulation, Laissez-faire
- Practice III: Complementarity between entry regulation and reputation-enforcement policy

Policy Simulations: Decompose Effect of Entry Regulation on Quality



- Full info case: entry regulation oligopolizes the market and lowers quality.
  - aligned with Spence (1975): price competition and quality competition are complementary.

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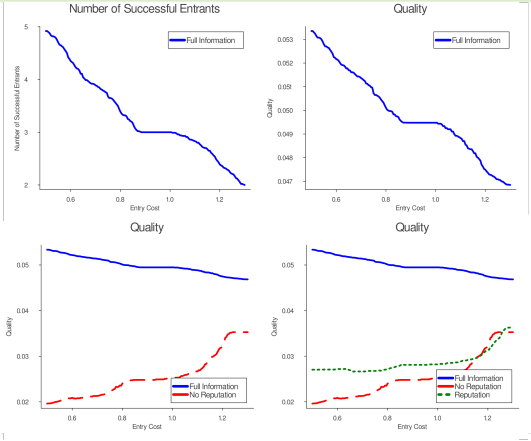

- Asymmetric info case: the effect of entry regulation on quality is reversed.
  - Pigouvian view: entry regulation lowers the difficulty of quality inference.

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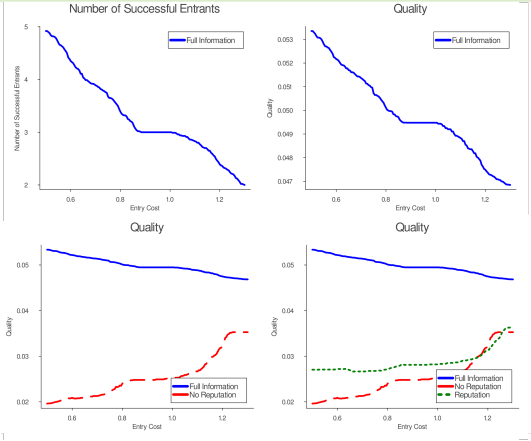
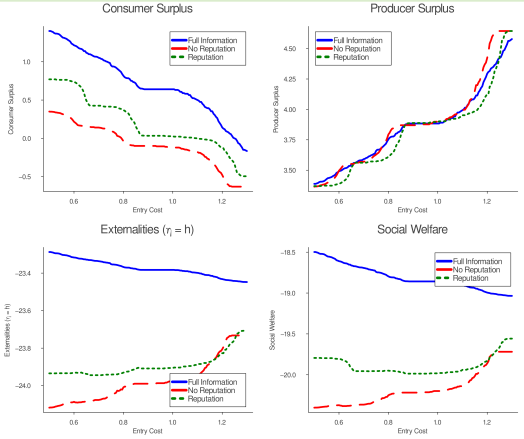


- Reputation formation case: the quality turns to be higher due to the mitigation of information asymmetry (Proposition II)

Policy Simulations: Decompose Effect of Entry Regulation on Quality



- Deregulation becomes much less damaged: CS ↑; positive externalities ↑

Takeaways

- The entry deregulation reform in China's EIA industry intensifies competition but induce lower service quality.
- Information asymmetry makes entry regulation more attractive in terms of quality and social welfare; reputation formation reduces the attractiveness by substituting the function of entry regulation in the LR.
- Further steps: Finish counterfactual analysis; The SR choice of regulation level is pending for research.

Thank you!

Comments and Suggestions:

ycquan@hku.hk

Assessment Quality: Context

- Lack of a quality measure: multi-dimensional; penalties are sparse indicators of extremely low quality.
- Plagiarism is the major issue identified by regulatory authorities.
  "Engineers often exert less effort in drafting reports, resorting instead to copying content from existing reports."
  — **Ministry of Ecology and Environment, 2020**
- Example 1. The EIA report for the Shenzhen Bay Waterway Dredging Project mistakenly referenced "Zhanjiang" 35 times.
- Example 2. Fraudsters in a EIA plagiarism case admit that an EIA report can be compiled in 30 min.

EIA Report Corpus

A corpus of EIA reports

- Reports sourced from disclosure platforms and government websites
- Extract project information using GPT-3.5 Turbo and match with project data
- Valid reports total 40k

Assessment Quality: Methodology

Develop a plagiarism detection system:

- Adopt TF-IDF (Kelly et al., 2021) and Word2Vec (Mikolov et al., 2013; Li et al., 2018; Acemoglu et al, 2022) as the benchmark text vector model.
- The quality measure of report r is the sum of section-level similarity scores:

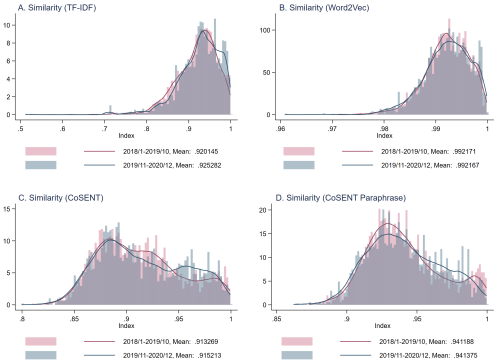
$$\text{Sim}_r = \sum_{s \in \mathcal{S}^{(r)}} w_s \text{sim}_s \tag{2}$$

- The section-level similarity score is the maximum of the similarity score of section s to sections belonging to the set of potential plagiarized reports $\mathcal{P}^{(r)}$:

$$\text{sim}_s = \max_{l \in \mathcal{P}^{(r)}} \text{similarity}(s_f, s_l) \tag{3}$$

Assessment Quality

Distribution of Similarity Indices



Back

DiD Estimator

- The TWFE OLS specification is:

$$Y_{jt} = \alpha \text{PenaltyDisclosure}_{it} + \delta_j + \omega_t + \varepsilon_{jt} \tag{4}$$

- Y_{jt}: market share in province-year-quarter (j, t).
- $\text{PenaltyDisclosure}_{it} = 1$ if the penalty on agency i is disclosed in year-quarter h, with $h \leq t$.
- δ_j and ω_t capture treatment-cohort FEs and year-quarter FEs.
- Sample: All agencies penalized for less than or exactly once (in 2020–23Q3).

TWFE OLS Estimates

Outcome	(1)	(2)	(3)
	Market share (%)		
		Market size	
Sample	Whole sample	Large	Small
Penalty Disclosure	-0.176***	-0.252***	-0.122***
	(0.038)	(0.063)	(0.029)
Adjusted R^2	0.051	0.041	0.144
Dep. Var. Mean	0.132	0.121	0.339
Observations	278,562	264,741	13,821

Sensitivity Test

- Change the number of entrants as 3/10 instead of 5
- Change the effect of quality reduction on externalities η and check the sensitivity of welfare effect wrt η
- Change the entry regulation as the minimum quality standard instead of an increase in entry cost

Between-Quarter-Agency *vs*. Within-Quarter-Agency Quality Differences

Variance Decomposition

- Quality measure decomposition:

$$\text{var}\left(q_{i,jt}\right) = \underbrace{\text{var}_j\left(\bar{q}_{jt}\right)}_{\text{Between-agency-quarter dispersion}} + \underbrace{\sum_{jt} \omega_{jt} \times \text{var}_i\left(q_{i,jt} \mid i \in jt\right)}_{\text{Within-agency-quarter dispersion}} \tag{5}$$

- report i; agency j; year-quarter t.
- $\omega_j t$: Report share of agency-quarter jt in the corpus.

Between-Quarter-Agency *vs*. Within-Quarter-Agency Quality Differences

Results

Quality Index	(1) Between-agency-quarter Variance	(2) Within-agency-quarter Variance	(3) Total Variance
Benchmark			
Similarity (Word2Vec)	0.0015	0.0007	0.0020
Robustness			
Similarity (TF-IDF)	0.0058	0.0039	0.0088
Similarity (CoSENT)	0.0007	0.0003	0.0010
Similarity (CoSENT paraphrase)	0.00012	0.00004	0.00015
Readability (avg. length of sentences)	201.928	107.749	286.496
Readability (# of prep./conj.)	0.037	0.018	0.051
Readability (Fog)	51.244	27.312	72.679
Sentiment	29181.695	12219.688	38013.801

- Between-agency dispersion dominates overall quality dispersion.

Demand

- Use the revealed preference and beliefs approach: infer parameters of preference and beliefs using the customers' choice data.
- The customers minimize the loss by choosing which agency to purchase the EIA service. The revenue from agency j for customer i of type θ in period t is given by: $v_{ijt} = -bp_{jt} - bh_\theta \tilde{P}_{jt} + \varepsilon_{ijt}$
- The expected penalty depends on the penalty amount h_θ and the expected likelihood of penalty occurrence $\tilde{P}_{jt} \equiv \alpha_0 + \alpha_1 \tilde{q}_{jt}$.
- ε follows a type I extreme value distribution with variance as 1. Back