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Self-enforcing contracts with persistence☆

Martin Dumav[a], William Fuchs[b], Jangwoo Lee[c,*]

[a] Universidad Carlos III de Madrid, Spain
[b] Universidad Carlos III de Madrid and University of Texas at Austin 2110 Speedway CBA 6.276, Austin, TX, USA
[c] Chinese University of Hong Kong, Hong Kong

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A B S T R A C T

We show theoretically that, in the presence of persistent productivity shocks, the reliance on self-enforcing contracts due to limited legal enforcement may provide a possible rationale why countries with the worse rule of law might exhibit: (i) higher aggregate TFP volatilities, (ii) larger dispersion of firm-level productivity, and (iii) greater wage inequality. We also provide suggestive empirical evidence consistent with the model's aggregate implications. Finally, we relate the model's firm-level implications to existing empirical findings.

1. Introduction

Many, if not most, economic interactions are carried out with very incomplete or no formal contracts at all. In their absence, to overcome the possible hold-up problems, economic agents often rely on the repeated nature of their interactions to establish relational or self-enforcing contracts. In this paper, we show how limited external enforceability coupled with persistent productivity shocks can generate several interesting empirical predictions. We show these predictions are

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* Corresponding author.
E-mail addresses: mdumav@eco.uc3m.es (M. Dumav), william.fuchs@mccombs.utexas.edu (W. Fuchs), jangwoolee@cuhk.edu.hk (J. Lee).

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consistent with both micro and macro data, and further establish a new link between a country's legal environment and its aggregate-level TFP volatility as well as its wage inequality.

We consider a repeated principal-agent game in which the principal cannot commit to bonus payments. Every period the agent first takes a costly action and the principal must then decide whether it honors its promises or holds up the agent. Concretely, we build on the model of relational contracts à la Levin (2003) by allowing for persistence in productivity and show the enforceability constraint, which captures the temptation of the principal to renege on the promised bonus, generates a multiplier effect amplifying the exogenous productivity shocks. This has three implications for economic environments where enforceability constraints are more binding:

(a) aggregate shocks are amplified, resulting in higher TFP volatilities;
(b) idiosyncratic shocks induce a larger dispersion of measured firm productivity levels;
(c) wages would be less evenly distributed.

If common persistent shocks impact all firms in economies, our model predicts that the aggregate volatility of economies with poorer legal enforcement would be greater. Consistent with our predictions, for a large sample of countries, we find a negative relationship between the dispersion of aggregate TFP growth rates and quality of law enforcement. We further address potential endogeneity concerns by exploiting exogenous variations in early settler mortality rates (Acemoglu et al., 2001) to instrument for the quality of law enforcement. The identification strategy suggests that the relationship between the legal environment and aggregate volatility is causal. Our baseline regression without any covariate suggests that one standard deviation increase in the Average Rule of Law is associated with a 0.847 percentage point decrease in the volatility of TFP growth rates.

Alternatively, if persistent idiosyncratic shocks affect firm-level productivity, our model predicts that the spread in firm-level TFP in economies with poorer legal enforcement would be wider. In line with our predictions, we document a negative relationship between the spread in firm-level TFP within a given country and the quality of the legal system in that country. These results also relate to Syverson (2011) who empirically shows large productivity differences within a given industry. Particularly, he highlights that these differences vary dramatically across countries.[1] While in the US a plant in the 90th percentile within a given industry can be twice as productive as one in the 10th percentile, for India and China differences are fivefold.

There are many possible reasons as to why these cross country differences may arise; our explanation is that it is partly driven by the fact that the US has an effective legal system that facilitates the enforceability of contracts while these institutions are much weaker in developing countries.[2] Thus, a larger fraction of business relationships in India and China are governed by relational contracts. As a result, when two firms in the US and two firms in India experience a pair of low and high exogenous productivity shocks, the spread in measured productivity in India would be larger than in the US. To see why this is the case, suppose the productivity shock does not affect the optimal level of effort. With complete contracts, there are no differences in worker effort between the two firms. As a result, the measured productivity differences in the US firms would be just given by the spread of the exogenous shocks. Instead, with imperfect enforceability, the optimal effort that can be elicited from the workers depends on the shock realization. When the shock is high, the firm can credibly promise high bonuses and, as a result, can demand high effort and become more productive. The opposite effect takes place when the shock is negative. This implies there is an extra wedge in the measured productivity of Indian firms given by the fact that the equilibrium effort also varies with the exogenous shock. Consistent with this prediction, our empirical analysis suggests that India (China) might decrease its TFP dispersion by roughly 55% (65%) if the country could improve the quality of its legal system to that of the United States.[3]

This highlights the role of persistence in productivity during bad times. When the current state is bad, the future value from maintaining the relationship is low, and the principal cannot credibly promise to make large payments. Thus, in bad times the firm cannot motivate the agent to exert high effort. This "low morale effect" is consistent with the evidence that labor productivity levels are pro-cyclical (Baily et al., 2001). We can alternatively recast the model as in Fuchs (2015) where every period the agent receives a stochastic outside option and must decide whether to leave the firm and take the outside option. In such a reformulation, when the future of the firm looks bleak, the agent would be willing to accept lower outside options. This is consistent with the findings presented by Baghai et al. (2016) which show that Swedish firms tend to lose their key talents when their financial health deteriorates. Similarly, using an online search platform, Brown and Matsa (2016) show that job applicants avoid companies with poor financial conditions.

In his review on the determinants of productivity Syverson (2011) highlights: "*... robust finding in the literature ... is that higher productivity producers are more likely to survive than their less efficient industry competitors. Productivity is quite literally a matter of survival for businesses.*" Our model's predictions are consistent with this finding, and further suggest that causality can go both ways. In particular, if a firm is more likely to survive, then it will be able to become more productive.

[1] See references therein in particular Syverson (2004) and Hsieh and Klenow (2009).

[2] See Syverson (2011) and references therein for a rich discussion of other possible factors influencing firm productivity. Collard-Wexler et al. (2011), for example, argue that these differences arise due to non-convex adjustment costs and persistence of shocks to factors of production.

[3] Since the ORBIS dataset does not contain China. India, and the US in the sample, we compute these values with the following formula: 1-exp(Regression Coefficient in Table 4. × The difference in the Average Rule of Law Between the US and the country).

Our model also has implications for wage inequality in countries with limited legal enforcement. Under imperfect enforcement, the bonus payment that the principal can credibly commit to make to the agent depends on the future value of the relationship, which in turn is shaped by productivity. Persistence in productivity therefore implies that the agent's compensation becomes more sensitive to changes in productivity relative to a contractual environment with better enforcement. Hence, our model predicts that wages would be more evenly distributed within a country as the quality of legal enforcement improves. We use the Theil index in the UTIP-UNIDO database (Galbraith et al., 2014) to proxy for wage inequality and use (Acemoglu et al., 2001)'s instrumental variable. Our baseline IV estimate suggests that one standard deviation increase in the average rule of law is predicted to decrease the Theil index by 0.49 in the logarithmic scale.

A related implication is that contracts would exhibit "rewards for luck." We say luck is rewarded since the bonuses are dependent on the realization of the shocks. Yet, the exogenous productivity shocks are perfectly observable and independent of the agent's effort. This stands in contrast to the "Informativeness Principle" (see Hölmstrom, 1979), according to which a performance measure should only affect compensation if it provides information about the agent's hidden effort. The empirical literature has documented several cases in which contracts seem to be rewarding luck. Bertrand and Mullainathan (2001) document that the compensation of executives in major US oil companies positively correlates with the price of oil, an element arguably outside the executive's control.[4] Finally, DeVaro et al. (2018) (which we discuss further below) show empirically that persistence of the state is important for "reward for luck." They also provide evidence against the capture of boards by CEOs being the main driver of the observed compensation patterns.

There is certainly additional heterogeneity and richness that is not captured by our simple model. Yet, we believe our model provides a very useful lens through which we can start to uncover how seemingly unrelated findings at the firm, industry and aggregate economy level can actually be manifestations of a natural friction economic agents must constantly deal with: namely, how to realize the gains from trade without falling prey to the hold-up problem.

Literature review

Our model belongs to the rich literature on relational incentive contracts that builds on Bull (1987), MacLeod and Malcomson (1989), and Levin (2003). Most of the papers in this literature have focused on implications at the firm level. There has been less work looking at aggregate implications.[5] Our main contribution relative to the literature is to show that a very parsimonious model can be used to simultaneously explain both micro and macro phenomena.

From a technical perspective the most closely related work to ours within this literature are Kwon (2016) and DeVaro et al. (2018). We complement (Kwon, 2016) and go beyond her analysis by characterizing the optimal relational contracts and analyze comparative statics, which our empirical analysis takes to the data. Similar to ours, DeVaro et al. (2018) offers a theoretical rationale for rewarding luck. In addition, as mentioned earlier, they complement their theoretical analysis with some corroborating evidence on CEO compensation. Although our main argument for rewarding luck is similar in spirit, our model uses a different timing of shocks vis-a-vis theirs. In our model we could have reward for luck without it implying the presence of the morale effect, while the morale effect and the reward for luck effect must always coexist in (DeVaro et al., 2018) and Kwon (2016)'s settings.[6] While this distinction is of independent theoretical interest, it is also relevant for policy debates on bonus caps. In particular, under their setting, caps on executive bonuses always decrease efficiency when reward for luck is present. By contrast, in our model, the existence of reward for luck does not necessarily imply inefficiencies when caps are introduced. Thus, the introduction of caps on bonuses might be less detrimental than what prior literature suggests. In addition to this, our main contribution relative to their work is on highlighting the "morale effect" and the related amplification of shocks that is induced by the lack of enforceability.

Other explanations have been put forward for the well-documented "reward for luck" phenomenon. Oyer (2004) argues that the shocks identified in some of the empirical studies might affect the agent's options and thus compensation must rise in good states. In Hoffmann and Pfeil (2010) and DeMarzo et al. (2012), a principal not subject to enforceability constraints needs to finance up-front an agent protected by limited liability. When productivity is high, the potential cash flows are large. Thus, the principal has stronger incentives to avoid reducing the size of the firm or triggering termination (which is the main way of providing incentives within their model). Hence, the principal must give more rents to the agent, and the "reward for luck" effect arises. DeMarzo and Kaniel (2017) show that reward for luck can also arise when agents have a strong catching up with the Joneses component in their preferences. In such a case, optimal compensation must adjust to favorable shocks to others in a way that looks like luck. None of these models allow for a "morale effect" nor can they be used to study the correlation between enforceability and output volatility.

When considering the "morale effect," Barron et al. (2018) is closely related. They study the problem of an entrepreneur which needs both: (i) to take an initial loan to finance its venture and (ii) to hire an agent to work on it. The contract between the entrepreneur and the worker is not enforceable. Thus the continuation value of the entrepreneur plays an important role in determining the extent to which the enforceability constraint binds. A highly levered entrepreneur is similar to the principal in our model that experiences a low productivity shock. In both cases, their equity value is low and thus there is a limit on how large a bonus they can credibly promise to the agent. Thus, when the firm is in poor financial

[4] For more recent works, see also Garvey and Milbourn (2006) and Ma (2019).

[5] Some exceptions are Powell (2017) and Board and Meyer-ter Vehn (2014) which we discuss below.

[6] For more details, see Remark 1 in Section 4.2.

shape, it cannot induce the worker to work hard. Their paper also provides empirical evidence supporting the mechanism in their model.

Our results on enforceability and dispersion of firm's productivity within industries are related to Powell (2017).[7] His paper focuses solely on this fact. He shows theoretically that limited enforcement combined with pecuniary effects amplify underlying permanent productivity differences and provides empirical evidence of the positive and meaningful correlation between productivity dispersion and contract enforceability. Our model, although similarly reliant on limited enforcement, allows us to look at several other implications of the theory, such as aggregate volatility and wage inequality. Also, we conduct empirical tests on these additional implications and supplement his empirical analysis with an alternative measure of productivity dispersion based on (Ackerberg et al., 2015)'s estimation method. This technique overcomes functional dependence problems raised in the literature on productivity function estimation and allows for a more precise estimation of TFP's.

Our results about macroeconomic volatility in productivity are related to Ramey and Watson (1997), Den Haan et al. (2000) and Cooley et al. (2004). Ramey and Watson (1997) develop a theory of labor contracting in which negative productivity shocks lead to costly job loss due to limited enforceability. Their model is used in Den Haan et al. (2000)'s dynamic general equilibrium analysis to illustrate a propagation effect through which cyclical fluctuations in the job-destruction rate magnify the shocks to output and make them persistent. In a dynamic general equilibrium framework, Cooley et al. (2004) characterizes the optimal long-term contracts offered by a competitive financial intermediary to an entrepreneur for investments in innovation. In this model with one-sided commitment, the entrepreneur can repudiate on the contract and this form of limited enforceability amplifies in an endogenous manner the impact of technological innovations on aggregate output. In contrast, we use a model in which neither the principal nor the agent is able to credibly commit to long-term contracts. Furthermore, an amplification mechanism obtains in our framework without any general equilibrium effects, which plays a key role in the amplification mechanism in Cooley et al. (2004)'s model.

Finally, our wage inequality result is also related to (Gradstein, 2007). Similar to our paper, his model studies the relationship between income inequality and various governance measures. The main difference is that his paper mostly focuses on 'appropriation by the state' in the tradition of (Acemoglu and Robinson, 2000), while our paper studies 'appropriation' between private entities. He also documents an empirical relationship between income inequality and rule of law, whereas we provide a correlation between wage inequality and rule of law.

We see our main contribution relative to the literature, not in being the first to point out a particular effect, but rather providing a unified model capturing multiple relevant phenomena. The existing literature so far provides distinct explanations for these facts. Instead, we offer a parsimonious rationale for all: time-varying limits to contract enforceability.

2. Setup

A principal ("she") and an agent ("he") interact repeatedly over time. Time is discrete and indexed via $t \in \{1, 2, \ldots\}$. At the beginning of every period, the principal makes the agent an offer consisting of an enforceable wage payment w_t, a schedule of non-enforceable bonus payments $\{b_t\}$ and recommends the agent take an action a_t. If the agent rejects, the game ends and both receive their outside options, which we normalize to be zero. If the agent accepts, the agent privately chooses his action $\tilde{a}_t \in [0, 1]$ incurring a cost $c(\cdot)$. We assume $c(\cdot)$ is continuously differentiable, strictly increasing and strictly convex, with $c(0) = c'(0) = 0$ and $1 < c'(1) \leq \infty$.

The firm's publicly observable output is composed of two additively separable components $\pi_t = y_t + \theta_t$. The first component takes on binary values $y \in \{0, 1\}$ and is partially under the control of the agent. Specifically, the agent's unobservable action a_t determines the probability that $y_t = 1$. On the other hand, the distribution over publicly observable state $\theta_t \in \{L, H\}$ is independent of the agent's actions. We assume $H > L > 0$ and it is worth noting that one can show that the value to the firm is weakly decreasing on the spread of the shock $H - L$. Thus, to the extent possible, firms would want to hedge this shock, our underlying assumption is that hedging cannot be done perfectly.[8] The process for θ_t follows a first-order Markov chain with a symmetric persistence parameter $\lambda := \text{Prob}\,(\theta_t = \theta_{t-1}|\theta_{t-1}) > 1/2$ for both $\theta_{t-1} = H, L$. The model could be extended to richer stochastic processes. For instance, the additive separability assumption on output can be relaxed. Yet, the additive structure provides a very clear benchmark since it implies the first best action is independent of the state.[9]

See Fig. 1 for the order of play. We assume that there is a sufficiently high utility cost of continuing the relationship with the party that has reneged before,[10] and therefore the relationship terminates the first time a party reneges on payments, or

[7] Board and Meyer-ter Vehn (2014) also argue that limited enforcement in a model with on-the-job search can explain the emergence of productivity dispersion across ex-ante identical firms.

[8] Even if θ_t is contractible, firms cannot fully hedge θ_t as long as the court (or any outside third party) cannot verify whether one party has reneged. Assume that the principal and agent write a long-term contract based on θ_t. The long-term contract would always be in effect regardless of whether a player has reneged or not. Hence, the long-term contract does not affect any party's decision to renege.

[9] If the output is additively separable, the first-best effort level a^{FB} satisfies: $\frac{\partial}{\partial \tilde{a}_t}\left(\mathbb{E}(\pi_t|\tilde{a}_t, \theta_{t-1}) - c(\tilde{a}_t)\right)\Big|_{\tilde{a}_t = a^{FB}} = 1 - c'(a^{FB}) = 0.$

[10] Alternatively, we may assume that outside options are higher conditional than when the agent exerts zero effort. However, the current formulation is more convenient for analytic purposes.

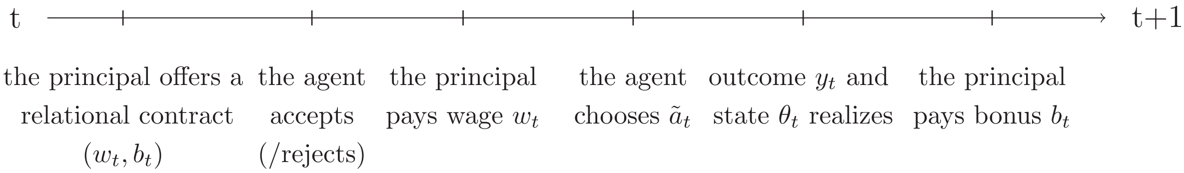


Fig. 1. Timeline.

the first-time the agent rejects a contract. Let τ denote the time when the contracting relation terminates. After termination, both players receive the value of outside option, normalized to 0.

To account for heterogeneity in contract enforcement in our empirical analysis we introduce in our model a parameter α that measures the strength of contract enforcement institutions. In particular, we assume that whenever the principal reneges on her promised payments, she can walk away with only a fraction $(1-\alpha)$ of the bonus.

Both players are risk-neutral, have a common discount factor δ, and have deep pockets. The principal maximizes the present value of the expected discounted output streams minus her payments to the agent:[11]

$$\Pi_t = (1-\delta)\mathbb{E}_t \sum_{s=t}^{\tau} \delta^{s-t}(\pi_s - w_s - b_s).$$

The agent maximizes the expected discounted payments received minus his cost of effort:

$$v_t = (1-\delta)\mathbb{E}_t \sum_{s=t}^{\tau} \delta^{s-t}(w_s - c(\tilde{a}_s) + b_s).$$

Given any public history $h^t = \{\theta_0, \theta_1, \dots \theta_{t-1}, y_1, \dots y_{t-1}, b_1, \dots b_{t-1}, w_1, \dots w_{t-1}\} \in \mathcal{H}^t$, a contract specifies the compensation mix the principal offers; whether or not the agent accepts it; and the effort and discretionary bonus payment decisions. The compensation is given by the functions of the following form: $w_t : \mathcal{H}^t \to \mathbb{R}$, $b_t : \mathcal{H}^t \times (\{L, H\} \times \{0, 1\}) \to \mathbb{R}^+$.[12]

A contract is self-enforcing if it is a perfect public equilibrium of the repeated game. There are a large number of such equilibria, but we are interested in characterizing the efficient self-enforcing arrangements that would govern this relationship. As a first step, applying the methods used by Spear and Srivastava (1987) and Abreu et al. (1990) we can conveniently summarize a given public history of the game h^t, into a pair of a continuation value for the agent v and a past state θ_{t-1}. The principal chooses the optimal current actions (a, w, b, v') based on the public history (v, θ_{t-1}). This method allows us to set up the principal's problem recursively as follows:

$$\begin{aligned}
\Pi(v, \theta_{-1}; \alpha) = \max_{a,w,b,v'} \mathbb{E}\Big[(1-\delta)(\pi - w(\theta_{-1}, v; \alpha) - b(y, \theta_{-1}, \theta, v; \alpha)) + \delta\Pi\Big(v'(y, \theta_{-1}, \theta, v; \alpha), \theta; \alpha\Big)|a, \theta_{-1}\Big]& \\
s.t.& \\
v = \mathbb{E}\Big[(1-\delta)(w + b - c(a)) + \delta v'|a, \theta_{-1}\Big]; \qquad & [PK] \\
a \in \arg\max_{\tilde{a}\in[0,1]} \mathbb{E}\Big[(1-\delta)(w + b - c(\tilde{a})) + \delta v'|\tilde{a}, \theta_{-1}\Big]; \qquad & [IC] \\
\delta\Pi(v', \theta; \alpha) \geq (1-\delta)(1-\alpha)b(y, \theta_{-1}, \theta, v; \alpha); \qquad & [DEP] \\
\Pi(v', \theta; \alpha) \geq 0; \qquad & [PCP] \\
v' \geq 0, \qquad & [PCA]
\end{aligned}$$

where [PK] is the promise keeping constraint, [IC] the incentive compatibility constraint for the agent to follow the recommended action a, [DEP] the dynamic enforceability constraint guaranteeing that the principal prefers to pay the promised bonus rather than to renege and effectively terminate the relationship, and [PC]'s the participation constraints that each party needs to be at least as well off as the outside option every period. Dependence of the solution on the strength of contract enforcement α in the economic environment is noted.

3. Basic properties of optimal markovian contracts

We start with formally defining Markovian contracts in this environment, and turn to show that it is without loss of generality to focus on this class of contracts. This definition is similar to Kwon (2016)'s history-independent contract, but the two definitions are not equivalent due to differences in timing of the shocks.

[11] More precisely, the players' payoffs should also reflect the disutility from staying in the relationship with the party that has reneged before. Yet, since the disutility is only incurred off paths, we shall drop the disutility from the payoffs.

[12] Equivalently, we could instead impose a dynamic enforceability constraint on the agent's part to guarantee that the agent prefers to pay the promised bonus rather than reneging and effectively terminating the relationship. This alternative formulation is more consistent with Levin (2003), but our formulation is also standard in the literature as well (see e.g., Fuchs, 2007).

Definition 1 (Markovian Relational Contracts)**.** A **Markovian relational contract** consists of the non-output-contingent wage $w_t = w(\theta_{t-1};\alpha)$, the output-contingent bonus $b_t = b(y, \theta_{t-1}, \theta_t;\alpha)$, and recommended action $a_t = a(\theta_{t-1};\alpha)$.

According to this definition, in a Markovian relational contract at any given period t the bonus scheme upon receiving the output y depends on the current state θ_{t-1} and the state θ_t in the next period but beyond this it does not depend on the period. As noted previously, the contract in this setting depends on the strength of contract enforcement α.

The general problem can be significantly simplified by restricting our analysis to Markovian contracts. This is analogous to the main contribution in Levin (2003) showing that it is without loss to focus on stationary contracts when shocks are i.i.d. over time, and its extension to Markovian productivity states in Kwon (2016). As we show next, this implies the Pareto frontier is linear. For notational convenience, we proceed as if the initial value of the agent is 0. Yet, if the initial value of the agent is greater than 0, it can always be delivered with a transfer in the initial period. Furthermore, we give a characterization of the optimal contract.

Proposition 1 (Optimality of Markovian Relational Contracts)**.** *There exists a Markovian relational contract such that*

(R1) *it attains maximum surplus state-by-state and it is without loss to set $v'^* = 0$; and*
(R2) *it is without loss to set $b^*(y = 0, \theta_{-1}, \theta;\alpha) = 0$.*

This result holds for any given strength α of contract enforcement. It says that for any contract that maximizes the expected total surplus we can find a Markovian relational contract that does the job. The surplus-maximizing Markovian contract also maximizes the principal's profit, because the principal can pay base wages to deliver the promised utility to the agent without affecting the total surplus. Without loss of generality, the offered base wages and bonuses are only functions of the last and current realization θ. Importantly, since beyond participation, continuation values don't play a role, we can simply focus on maximizing the current total surplus generated by the pair to characterize the optimal arrangements.

Since we have established that bonuses are only paid after success, we simplify our notation and denote the bonus payment upon success simply as $b(\theta_{-1}, \theta;\alpha)$. The only role for the base wage is to ensure that the contract delivers the right promised value to the agent. We can thus solve the problem of figuring out the effort and bonus choices that maximize surplus, which we denote by $\Pi(\theta_{-1};\alpha)$, first and then divide it between the principal and the agent by adjusting the base wages. Also note that we can drop the participation constraints since a contract that implements zero effort is always available and generates strictly positive surplus. Thus, the problem simplifies to:

$$\Pi(\theta_{-1};\alpha) = \max_{a(\cdot),b(\cdot)} (1-\delta)(a(\theta_{t-1};\alpha) + \mathbb{E}(\theta_t|\theta_{t-1}) - c(a(\theta_{t-1};\alpha))) + \delta\mathbb{E}(\Pi(\theta_t;\alpha)|\theta_{t-1}) \tag{1}$$

subject to:

$$[\text{IC}] \quad a(\theta_{t-1};\alpha) = \arg\max_{\tilde{a}} \mathbb{E}(b(\theta_{t-1}, \theta_t;\alpha)|\theta_{t-1})\tilde{a} - c(\tilde{a});$$

$$[\text{DEP}]' \quad \delta\Pi(\theta_t;\alpha) \geq (1-\delta)(1-\alpha)b(\theta_{t-1}, \theta_t;\alpha).$$

Denote the optimal effort and bonus payment by $a^*(\theta_{-1};\alpha)$ and $b^*(\theta_{-1}, \theta;\alpha)$, respectively, and resulting profit $\Pi^*(\theta_{-1};\alpha)$. The optimal bonus scheme $b^*(\theta_{-1}, \theta;\alpha)$ and the optimal effort $a^*(\theta_{-1};\alpha)$ that solves the reduced problem (1) are related as follows:

Lemma 1. *In any optimal Markovian relational contract, the optimal effort satisfies the following properties:*

(E-1) *(Monotonicity in effort) $a^*(L;\alpha) \leq a^*(H;\alpha) \leq (c')^{-1}(1) = a^{FB}$, where a^{FB} denotes the first-best level of effort; and*
(E-2) *If the optimal effort $a^*(\theta_{-1};\alpha)$ is strictly less than the first best level a^{FB}, the dynamic enforceability constraints bind for both $\theta = H, L$: $b^*(\theta_{-1}, \theta;\alpha) = \frac{\delta}{1-\delta}\frac{\Pi^*(\theta;\alpha)}{1-\alpha}$.*

The first part of Lemma 1 establishes that if there is a distortion in the effort level with respect to first best it is due only to a possible under-provision of effort. This arises due to the principal's dynamic enforceability constraint, i.e., the temptation of the principal to default on the promised bonus. As shown in the second part of the Lemma 1, when the effort is distorted the enforceability constraint must bind. Hence the principal must fully pledge the principal's future surplus (which is the maximum amount the principal can credibly commit to pay) as the bonus.[13] Since there is more surplus in high states than in low states the equilibrium effort must always be weakly lower in the low state.

Denote by $\Pi^{FB}(\theta)$ the maximum surplus that can be obtained without the dynamic enforceability for the state θ. As illustrated in Lemma 1 the dynamic enforceability constraint is the only friction precluding the first-best outcome, and the following monotonicity result obtains:

Lemma 2. *(Monotonicity in profits) In any optimal Markovian relational contract, the principal's profits satisfy $\Pi^*(L;\alpha) < \Pi^*(H;\alpha)$ and $\Pi^*(\theta;\alpha) \leq \Pi^{FB}(\theta)$ for both $\theta = L, H$.*

[13] To see this, suppose that $b^*(\theta_{-1}, \theta;\alpha) < \frac{\delta}{1-\delta}\Pi^*(\theta;\alpha)$ for some θ. The principal could then increase $b(\theta_{-1}, \theta;\alpha)$ and simultaneously request that the agent exert more effort. Since there is under-provision of effort that would improve efficiency.

4. Firm level implications

We start with presenting below in the Sections 4.1 and 4.2, the firm level implications of our model (the reward-for-luck effect and morale effect) and connect them to existing strands of empirical literature. In the subsequent Section 5, we will then show aggregate implications.

4.1. Rewarding luck

There are numerous papers (see for example Bertrand and Mullainathan, 2001; DeVaro et al., 2018; Garvey and Milbourn, 2006, and Ma, 2019) documenting empirically that variables outside of the agent's control influence compensation. Consistent with this evidence, our next result shows that when designing the optimal structure of bonus payments *an observable and contemporaneous* shock would not be filtered out, even when the realization of the shock contains no information about possible deviations by the agent in his choice of effort. Hence, it would appear as if employees are partially rewarded for luck.

Proposition 2 (Rewarding Luck). *For any contract enforcement level α there exists a threshold discount factor $\bar{\delta}(\alpha) := \frac{1-\alpha}{1-\alpha+a^{FB}-c(a^{FB})+H}$ such that, for all $\delta < \bar{\delta}(\alpha)$, the optimal bonus $b^*(\theta_{-1}, \theta; \alpha)$ increases in θ: $b^*(\theta_{-1}, L; \alpha) < b^*(\theta_{-1}, H; \alpha)$ for all $\theta_{-1} \in \Theta$.*

The principal can credibly promise to pay out larger amounts when the current shock is revealed to be favorable. This is the case because shocks are persistent. After a good realization the future prospects of the firm are better, hence the enforceability constraint of the firm is relaxed and thus the firm can credibly promise to pay more in such a state. Importantly, even though the size of the bonus varies with the persistent state θ, an element outside the agent's control or influence and with no information content, incentives are only really provided by the expected bonus. Additionally, the bonus is still only paid if the agent delivers on his part of the output. Thus, although luck determines the size of the reward these rewards are still fully driven by incentive motives. Furthermore, in economic environments with poorer contract enforcement, higher importance of future values, as measured by higher discount rates, are needed to maintain contracting relationship.

4.2. Morale effect

Our next main result shows that the dynamic enforcement constraint is more binding in the low state.

Proposition 3 (Morale Effect). *For any contract enforcement level α there exists a threshold discount factor $\bar{\delta}(\alpha) \in (0, 1)$ as given in Proposition 2 such that for all $0 < \delta < \bar{\delta}(\alpha)$, the optimal contract satisfies*

(i) $\mathbb{E}(b^*(L, \theta; \alpha)|\theta_{-1} = L) < \mathbb{E}(b^*(H, \theta; \alpha)|\theta_{-1} = H)$;
(ii) $a^*(L; \alpha) < a^*(H; \alpha)$.

There is an intuitive explanation for this result that highlights the effect of persistent productivity during bad times. When the current state is bad, the future value of the relationship is low and the principal can no longer credibly promise to make large payments. Thus, she can no longer motivate the agent to exert very high effort.

Our model thus rationalizes the "low morale effect" during firm distress, once the profitability is interpreted as a driver of financial distress. In our model, firms reduce the expected bonus payments during difficult times, to which workers respond by exerting less effort. Thus, firms' productivity is further depressed due to de-moralization of the workforce.

This mechanism resonates well with multiple labor concession episodes in the domestic steel industry during 1980s (DeAngelo and DeAngelo, 1991). DeAngelo and DeAngelo (1991) illustrates this effect with the labor problems experienced by the US steel plants in the 1980s. This was a challenging time for US steel producers as they faced stiff competition from more productive Japanese counterparts coupled with a decline in global demand.

The paper by Barron et al. (2018) has a similar mechanism at play. Although the shocks in their model are transient, their firms have different levels of leverage which generates persistence. An increase in leverage in the previous period in their model is similar to having experienced a negative persistent shock in our model and leads to a lower labor productivity. They use data on a large sample of European firms to show that indeed, an increase in leverage in year $t-1$ is followed by a decrease in year t productivity. They report that one standard deviation increase in contemporary leverage is correlated with a decrease in TFP-R equal to 9–15% of the median within firm standard deviation.

Furthermore, we can recast our model as in Fuchs (2015) to rationalize why distressed firms are more likely to lose, or less likely to attract workers. This is consistent with the empirical findings in Baghai et al. (2016), and Brown and Matsa (2016). When a negative productivity shock hits the firm, workers with high outside values would leave the company, because firms cannot promise sufficiently high bonuses to retain them.

Remark 1. Importantly, unlike related papers (DeVaro et al., 2018; Kwon, 2016), the reward-for-luck in our setup is distinct from the morale effect. In our setup, the morale effect necessarily leads to the reward-for-luck effect, but not vice versa.

To understand this observation, it is important to recall that the enforceability constraint will always be more binding when $\theta_t = L$ than when $\theta_t = H$ (see Lemma 1). When the enforceability constraint first becomes binding it implies that the principal must promise a lower bonus when $\theta_t = L$ is realized. Absent any other adjustments to the compensation, the expected bonus would decrease and thus effort would inefficiently decrease. To try to avoid this inefficiency, the principal can raise the bonus conditional on $\theta_t = H$ being realized. If the enforceability constraint does not bind in the high state, that means that the principal can fully offset the decrease in expected payments and thus keep the agent at the efficient effort level regardless of the state θ_{t-1}. This is a situation in which we have reward for luck but no morale effect. The morale effect only arises when the enforceability constraint also starts binding for $\theta_t = H$ and, as a result, the expected bonus is no longer sufficient to induce high effort. Note, that in particular, this would imply lower effort when the last period shock was low. This follows because, due to persistence, the low state is more likely to be realized again and thus the expected bonuses must be lower.

Remark 2. While Propositions 2 and 3 are stated in terms of comparative statics on the discount factor δ, one can also obtain analytic results regarding comparative statics on the enforceability parameter α as well. To see this, note that the principal's dynamic enforceability constraint can be equivalently expressed as $\Pi(\theta_t;\alpha) \geq \frac{1-\delta}{\delta}(1-\alpha)b(\theta_{t-1},\theta_t;\alpha)$. Since the right hand side of the dynamic enforceability constraint is a decreasing function of both δ and α, changes in these two parameters have similar effects on the principal's temptation to renege, and thus on bonuses and effort recommendations as well.

5. Amplification and aggregate implications

We are now ready to focus on the main contributions of the paper which is to show that this simple yet natural environment also has numerous implications that match well several empirical findings at the country level.

We provide the main theoretical results first. Weaker contractual enforcement implies:

(a) aggregate shocks result in higher TFP volatilities;
(b) idiosyncratic shocks induce a larger dispersion of measured firm; productivity levels within a country or industry.
(c) wages would be less evenly distributed within a country or industry.

We then empirically study each of these implications in turn.

5.1. Theory and main predictions

In this section, we study an economy populated by a unit mass of firms indexed by $i \in [0,1]$. Firm i is subject to some persistent shock $\theta_{i,t}$. Let us introduce some auxiliary random variables $\omega_{i,t} \overset{iid}{\sim} U[0,1]$ for each $i \in [0,1]$ and $t \in \{0,1,2,\ldots\}$ and consider two possible stochastic structures regarding the evolution of $\theta_{i,t}$:

Assumption 1. [Pure aggregate volatility without idiosyncratic volatility]

1. $\forall t$, $\theta_{i,t} = \theta_{j,t} = \theta_{1,t}$;
2. $\forall t \geq 1$, $\theta_{1,t} = (H-L) \times [1(\{\omega_{1,t} \leq \lambda, \theta_{1,t-1} = H\}) + 1(\{\omega_{1,t} \leq 1-\lambda, \theta_{1,t-1} = L\})] + L$;
3. $\theta_{1,0} = (H-L)1(\{\omega_{1,0} \leq \frac{1}{2}\}) + L$.

Assumption 2 (Pure idiosyncratic volatility without aggregate volatility)**.**

1. $\forall t \geq 1$, $\theta_{i,t} = (H-L) \times [1(\{\omega_{i,t} \leq \lambda, \theta_{i,t-1} = H\}) + 1(\{\omega_{i,t} \leq 1-\lambda, \theta_{i,t-1} = L\})] + L$;
2. $\theta_{i,0} = (H-L)1(\{\omega_{1,0} \leq \frac{1}{2}\}) + L$.

For tractability, we specialize on the quadratic cost of effort function $c(x) = \frac{1}{2}cx^2$.

We introduce these assumptions because with a combination of aggregate and idiosyncratic shocks the number of enforceability constraints is exponentially larger and does not lend it self to a tractable analytic approach. Numeric simulations show that the results of Theorem 1 are robust to more general shock structure.

We use the optimal relational contracting problem in (1) for each firm i and determine the optimal effort and the bonus scheme $a^*(\theta_{i,t-1};\alpha)$ and $b^*(\theta_{i,t-1},\theta_{i,t};\alpha)$. respectively. Using the optimal contract we denote by $I^*(\theta_{i,t-1};\alpha)$ the agent's expected compensation. By an argument similar to the one used in Proposition 3, the agent breaks even every period. Hence, the agent's expected compensation $I^*(\theta_{i,t-1};\alpha)$ is equal to the cost of effort $c(a^*(\theta_{i,t-1};\alpha))$.

Theorem 1 is the main result of our paper. It shows that weak contractual enforcement amplifies the volatility of outputs and the degree of wage inequality, mainly because weak institutions constrain the value promises the principal credibly makes.

Theorem 1.

(a) *Under Assumption 1, aggregate volatility* $\frac{\mathbb{E}(\int_0^1 y_{i,t}di \mid \int_0^1 \theta_{i,t-1}di=H)}{\mathbb{E}(\int_0^1 y_{i,t}di \mid \int_0^1 \theta_{i,t-1}di=L)}$ *decreases in* α.
(b) *Under Assumption 2, dispersion in firm-level productivity* $\frac{\mathbb{E}(y_{i,t}|\theta_{i,t-1}=H)}{\mathbb{E}(y_{j,t}|\theta_{j,t-1}=L)}$ *decreases in* α.
(c) *Under Assumption 2, wage inequality* $\frac{I^*(\theta_{i,t-1}=H;\alpha)}{I^*(\theta_{j,t-1}=L;\alpha)}$ *decreases in* α.

To illustrate the intuition behind the part (a) of Theorem 1, for simplicity, consider two extremes: (1) $\alpha = 1$, which corresponds to formal contracting which would arguably be the case in the US, and (2) $\alpha = 0$, which corresponds to self-enforcing contracting arguably in India or China. Since dynamic enforceability conditions do not bind in an environment with formal contracting, the optimal effort recommendation of US firms is always constant at the first-best level $a^*(L;1) = a^*(H;1) = a^{FB}$. This implies that, in the US, the difference between the expected aggregate output in good times (i.e., when the aggregate shock is high) and in bad times (i.e., when the aggregate shock is low) is equal to the difference in productivity shocks $H - L$. Hence, the volatility of US aggregate outputs is only given by that of the exogenous component in aggregate productivity shocks. By contrast, when business relationships are governed via self-enforcing contracts, the effort level increases in the past profitability shock due to the morale effect (Proposition 3 and the part (E-1) of Lemma 1). Hence, in this environment, the difference in the expected aggregate outputs productivity shocks becomes $a^*(H;\alpha) - a^*(L;\alpha) + H - L$, which is larger than $H - L$. As a result, the dynamic enforceability generates a multiplier effect and makes the aggregate output $a^*(\theta_{-1};\alpha) + \mathbb{E}(\theta|\theta_{-1})$ more volatile in countries as India or China.

The intuition behind part (b) of Theorem 1 is also similar. As before, let us consider two cases with $\alpha = 1$ (i.e., the US case) and $\alpha = 0$ (i.e., the India/China case). In the US, a firm always recommends the first-best effort level a^{FB} to its workers. Thus, the difference in the expected output between two US firms with different idiosyncratic shocks is simply the difference in two idiosyncratic shocks $H - L$. Hence, the cross-sectional dispersion in firms' outputs is given by the difference between the idiosyncratic productivity shocks. However, in China or India, the difference in effort policies between two firms $a^*(H;\alpha) - a^*(L;\alpha)$ further amplifies the dispersion in firm-level outputs.

Finally, the intuition behind part (c) of Theorem 1 is as follows. The agent's expected compensation $I^*(\theta_{i,t-1};\alpha)$ is equal to his cost of effort $c(a^*(\theta_{i,t-1};\alpha))$. The effort, and hence expected compensations, stays the same when $\alpha = 1$, whereas it increases in the past profitability shock $\theta_{i,t-1}$ when $\alpha = 0$. Hence, the expected compensation becomes more dispersed when $\alpha = 0$. Hence, wages in India and China would be less evenly distributed compared to those in more developed countries.

Remark 3. An alternative way to obtain the amplification at the aggregate level is to assume that a proportion $\alpha \in [0,1]$ of firms rely on the formal court of law and thus can fully enforce their commitments, while the rest rely on relational contracts with no recovery. Then, as above, the volatility of outputs as measured by $\frac{\mathbb{E}(\int_0^1 y_{i,t}di | \int_0^1 \theta_{i,t-1}di = H)}{\mathbb{E}(\int_0^1 y_{i,t}di | \int_0^1 \theta_{i,t-1}di = L)}$ decreases in α.

5.2. Empirical evidence

To show that the predictions from Theorem 1 are consistent with the data, we need to proxy for the quality of legal enforcement α. We follow the literature on incomplete contracts (Antras, 2015; Antràs and Chor, 2013; Antràs and Yeaple, 2014; Nunn, 2007; Powell, 2017) by using an indicator of the strength of contracting institutions at the country level as our proxy for α. In particular, we use the 'Rule of Law' indicators from the Worldwide Governance Index (Kaufmann et al., 2011) in our main specification. The Rule of Law variable measures the agents' confidence in contract enforceability, property rights, police, courts, and protection from crime and violence at the country level.

A potential concern is that the Rule of Law measure also includes confidence in police and protection from crime and violence, which do not have a clear connection with our theoretical model.[14] We address this issue in two ways. First, we obtain the intentional homicide rate per 100,000 people in a country from the World Bank's World Development Indicators (WDI) database in order to proxy for its overall crime rate and use it as a co-variate in many of our regressions. In addition, we also conduct robustness checks with an alternative "Rule of Law" variable from IHS Markit World Economic Service, which is available from 1996 to 2013. Despite similarity in names, this variable is only based on the level of risk associated with expropriation and contract alteration by the state and failure to enforce contracts between private entities. Hence, it measures the quality of contractual enforcement in both private and public sectors. Since the principal in our model may also be interpreted as the state and the agent as a private entity (e.g., a government procurement contractor), we believe that this measure captures the spirit of our model well. As illustrated in later sections, our results remain robust even when the crime rate is controlled for, and also when the alternative measure is used.

While, as we show below, our empirical analyses are consistent with our model, we are aware that there may be other factors at play. Unfortunately, it is difficult to entirely rule out alternative explanations. Indeed, literature discusses other channels through which rule of law affects economic outcomes at the macroeconomic level (Haggard and Tiede, 2011). While we address some of these endogeneity concerns in Sections 5.2.1 and 5.2.3 by adopting the instrumental variable pioneered by Acemoglu et al. (2001), we were not able to use a similar identification strategy in Section 5.2.2 because there is no overlap between Acemoglu et al. (2001)'s and ORBIS databases. We are hopeful that future research can utilize more granular datasets to overcome these challenges.[15]

Furthermore, since we consider stationary environments in our model, one can be naturally concerned about the set of countries used for the empirical analysis, which includes non-stationary countries. To address this concern, we re-conduct

[14] We thank the referee for bringing up this point.

[15] Ponticelli and Alencar (2016) show a promising avenue toward this direction. They use Brazilian census-level data, together with court congestion data, to establish the effect of improved legal enforcement on economic outcomes.

Table 1
Summary statistics for volatility sample.

Variable	World	Base	By Quartiles of Mortality			
			(1)	(2)	(3)	(4)
SD of TFP Growth Rates (in Percentage Points)	3.058	2.772	1.896	2.533	2.64	4.315
	(2.474)	(1.909)				
Log GDP Per Capita (PPP) in 1995	8.335	8.092	8.826	8.435	7.847	7.254
	(1.105)	(1.046)				
Average Rule of Law (WGI)	-.032	-.255	.653	-.437	-.446	-.747
	(.982)	(.871)				
Average Rule of Law (IHS)	.582	.521	.708	.482	.476	.430
	(.217)	(.192)				
Average Protection Against Expropriation Risk	7.155	6.594	7.829	6.451	6.127	5.997
	(1.758)	(1.42)				
Average Homicide Rate	7.873	12.494	6.209	21.232	12.158	6.987
	(11.59)	(15.637)				
Constraints On Executives in 1900	1.918	2.293	3.923	3.059	1.154	1
	(1.872)	(2.136)				
Constraints On Executives in 1990	3.573	3.431	4.846	2.529	3.385	3.267
	(2.409)	(2.414)				
Democracy in 1900	1.222	1.702	4.154	2.5	0.231	0
	(2.655)	(3.041)				
European Settlers 1900	31.355	16.58	29.464	27.059	9.35	0.5
	(42.56)	(25.847)				
Log European Settler Mortality 1900	n.a.	4.63	3.09	4.287	4.824	6.271
		(1.269)				
Number of Observations	108	44				

The "world" column is for the sample used in the OLS regressions. The "base" column is for the sample used in the IV regressions, which consists of former European colonies with non-missing values of European settler mortality rates. Data sources are described at the beginning of 5.2 and 5.2.1. Standard deviations are in parentheses.

our empirical analyses after excluding low-income countries (as defined by the World Bank). Our results are qualitatively similar in the restricted sample.

5.2.1. Aggregate TFP volatility and rule of law

The first part of our main theoretical result, the part (a) of Theorem 1, implies that aggregate productivity shocks can be further amplified in poor legal environments, resulting in higher aggregate TFP volatility. To test this implication, we use the latest version of the Penn World Table (PWT 10.0) to obtain aggregate TFP growth rates and merge it with WGI, WDI, and (Acemoglu et al., 2001)'s databases. After these procedures, we obtain a sample consisting of 108 countries from 1996 to 2018. Based on this sample, we measure a country's TFP volatility as the standard deviation of its annual TFP growth rates.

Table 1 reports our summary statistics. The "world" column is for the sample obtained above, whereas the "base" column is for the base sample à la (Acemoglu et al., 2001), which contains 44 former European colonies with non-missing values of the European settler mortality rate, homicide rate, and TFP volatility. We use the "world" sample in our OLS regressions, and the "base" sample in our IV regressions. Despite differences in data construction procedures, these statistics are quite comparable to those in Acemoglu et al. (2001)'s Table 1. In Table IA.1 of the Internet Appendix, we also show that (Acemoglu et al., 2001)'s results hold in our samples as well.

We first estimate:

$$VOL_c = \alpha + \beta_{OLS} AVG\_RL_c + Controls + \epsilon_c, \tag{2}$$

where VOL_c denotes country c's TFP volatility and AVG_RL_c country c's Average Rule of Law variable. Our co-variates include the absolute values of latitudes (divided by 100), continent fixed effects,[16] and average homicide rates over the sample period.

We report the OLS results in Panel A of Table 2 and graphically illustrate the baseline regression result in Panel (a) of Fig. 2 as well. As predicted by our model, the more a country relies on formal contracts (i.e., the better the legal environment is) the lower the TFP volatility it has experienced over the sample period. In particular, the baseline regression without any control variable shows that one standard deviation increase in the Average Rule of Law is associated with a 1.166 percentage point decrease in TFP volatility. Given that the volatility of TFP growth rates averages around 3.058 percentage points in our world sample, we believe that the quality of contractual enforcement has a quantitatively significant effect on TFP volatility.

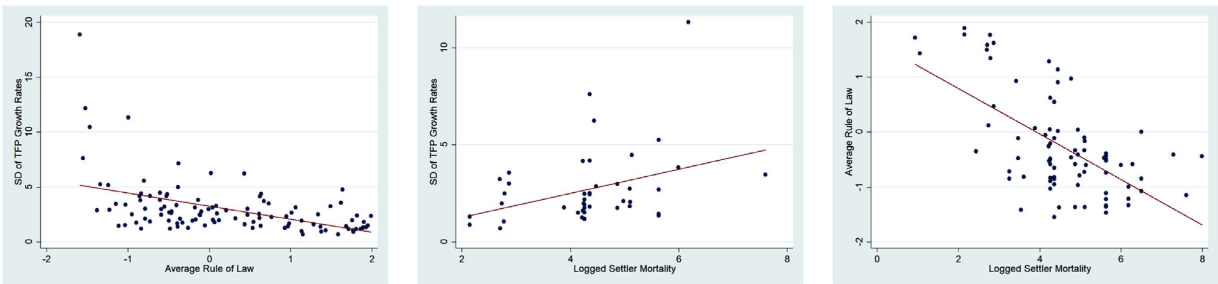
This, of course, is just a correlation. It is well documented in existing literature (Aguiar and Gopinath, 2007; Koren and Tenreyro, 2007) that developing countries' outputs are more volatile. Since contracts are more difficult to enforce in

[16] In continent fixed effect specifications, Acemoglu et al. (2001) also use the "Other continent dummy" variable, which takes the value of 1 when the country is either Australia, Fiji, New Zealand, or Malta, and takes the value of 0 otherwise. Since we believe that this particular set of countries is somewhat arbitrary, we deviate from their approach and exclude this dummy variable in our fixed effect specifications.

Table 2
Volatility Results.

Panel A: OLS Regressions						
	(1)	(2)	(3)	(4)	(5)	(6)
Average Rule of Law	-1.188***	-1.284***	-1.125***	-1.191***	-1.395***	-1.397***
	(0.300)	(0.342)	(0.319)	(0.354)	(0.409)	(0.420)
Average Homicide		-0.021		-0.011		-0.001
		(0.019)		(0.019)		(0.018)
Latitude					3.012*	3.004*
					(1.562)	(1.560)
Continent FE	No	No	Yes	Yes	Yes	Yes
Observations	108	108	108	108	108	108
R^2	0.232	0.239	0.252	0.254	0.285	0.285
Panel B: IV Regressions						
	(1)	(2)	(3)	(4)	(5)	(6)
Average Rule of Law	-0.973**	-1.023**	-1.131***	-1.232**	-1.450**	-1.490**
	(0.469)	(0.517)	(0.385)	(0.484)	(0.655)	(0.681)
Average Homicide		-0.016		-0.017		-0.018
		(0.027)		(0.026)		(0.026)
Latitude					2.399	1.897
					(2.875)	(2.484)
Continent FE	No	No	Yes	Yes	Yes	Yes
Observations	44	44	44	44	44	44
Anderson-Rubin statistics	4.20**	3.59*	7.57**	5.47**	5.04**	4.41**
Panel C: First-Stage Regressions						
	(1)	(2)	(3)	(4)	(5)	(6)
Logged Settler Mortality	-0.637***	-0.601***	-0.633***	-0.557***	-0.429***	-0.414***
	(0.095)	(0.096)	(0.114)	(0.101)	(0.130)	(0.133)
Average Homicide		-0.018***		-0.0200***		-0.016**
		(0.006)		(0.007)		(0.006)
Latitude					2.417***	1.888**
					(0.794)	(0.857)
Continent FE	No	No	Yes	Yes	Yes	Yes
Observations	44	44	44	44	44	44
R^2	0.562	0.638	0.568	0.645	0.643	0.687
F-statistics	45.17***	39.07***	30.85***	30.45***	10.85***	9.66***

Panel A reports OLS coefficients of equation (2). Panel B and Panel C report IV and first-stage estimates (respectively) of equations (3). Data sources are described in Section 5.2 and 5.2.1. Standard deviations are multiplied by 100, so that coefficients can be interpreted in percentage terms. Robust Standard errors are in parentheses. Asterisks *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively.



(a) (b) (c)

Fig. 2. OLS, IV, First-Stage Relationships for TFP Volatility. Panel (a) illustrates the OLS relationship between TFP volatility (on the y-axis) and the Average Rule of Law measure (on the x-axis). Panel (b) shows the reduced-form relationship between TFP volatility (on the y-axis) and the settler mortality rates (on the x-axis). Panel (c) shows the first-stage relationship between the Average Rule of Law measure (on the y-axis) and settler mortality rates (on the x-axis). In each panel, we also show the line of best fit in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

poor countries, even when controlling for continent fixed effects, climate, and crime rates, the OLS approach in Panel A of Table 2 cannot tease out the effects of contractual enforcement from other determinants of a country's TFP volatility.

In order to mitigate the endogeneity concern, we exploit exogenous variations in early European settler's (log) mortality rates S_c from (Acemoglu et al., 2001). Specifically, we estimate the following instrumental variable and first-stage regressions in our base sample:

$$VOL_c = \alpha + \beta_{IV} AVG\_RL_c + Controls + \epsilon_c,$$
$$AVG\_RL_c = \mu + \gamma_{FS} S_c + Controls + \eta_c, \quad (3)$$

where we use the same set of control variables as in the OLS analogues (2).

Table 3
Summary Statistics for TFP Dispersion Sample.

Variable	Mean	S.D.
Average TFP Dispersion	1.194	.463
Log GDP Per Capita (PPP) in 1995	9.294	.75
Average Rule of Law (WGI)	.973	.774
Average Rule of Law (IHS)	.793	.162
Average Protection Against Expropriation Risk	9.38	.607
Average Homicide Rate	1.793	1.58
Log European Settler Mortality 1900	92	27.689
Number of Observations	26	

Average TFP Dispersion is a country's average level of TFP dispersion.

Panel B of Table 2 shows our IV regression results. In particular, our baseline IV regression without any control variable shows that one standard deviation increase in the Average Rule of Law measure is associated with roughly a.847 percentage point decrease in TFP volatility. Other IV estimates are also quite comparable to the results from OLS regressions. In untabulated regressions, we also find that Durbin-Wu-Hausman F-tests fail to reject the null hypotheses that the IV estimates are significantly different from the OLS estimates. These results suggest that endogeneity bias may not be as severe as it seems at first.

Also, we report our first-stage results in Panel C of Table 2. Consistent with prior findings from the literature on weak instruments (Chernozhukov and Hansen, 2005; 2008), we also find that the first-stage F-statistics based on (Acemoglu et al., 2001)'s IV sometimes fall short of (Stock and Yogo, 2005)'s suggested threshold of 10 and the strength of our instrumental variable depends on the specification. To address the concern that the instrument may be too weak, we follow the recommendations from this literature and report the Anderson-Rubin statistics (Anderson and Rubin, 1949) in Panel B of Table 2. The evidence suggests that the effect of contractual enforcement remains significant (albeit to a statistically lesser extent) even when the strength of the instrument is taken into consideration.

We also graphically illustrate the reduced-form and first-stage relationships in Panel (b) and (c) of Fig. 2. From these figures, the reader may be concerned that our results may be driven by a few outliers. In untabulated regressions, we also conduct empirical analyses without outlier countries whose TFP volatility exceeds 10 and find qualitatively similar results.

In the Internet Appendix, we also conduct additional robustness checks to further validate our results. First, we use the alternative measure from IHS and report the results in Table IA.4. Second, we drop low-income countries from the sample and re-conduct the empirical analyses in Table IA.5 and IA.6. These robustness checks yield qualitatively similar results.

5.2.2. TFP Dispersion and rule of law

In the presence of idiosyncratic shocks, the same mechanism has implications for the cross-sectional distribution for firm-level TFP's. Namely, the amplification effect implies that firms in countries with poor contract enforcement have a larger dispersion of TFP's at any given point in time as well. The comparison between the findings by Syverson (2004) for the US and Hsieh and Klenow (2009) for India and China are clearly in line with our predictions. While, for the US, there is a twofold difference in productivity between the 10th and 90th percentile firm, in China and India there is a fivefold difference.

To obtain firm-level TFP estimates, we download firm-level financial statements from the ORBIS database through the WRDS platform. We closely follow (Gopinath et al., 2017)'s data construction procedure and use the STATA code *prodest* (Manjón and Mañez, 2016) to apply (Ackerberg et al., 2015)'s methodology to estimate firm-level TFPs. We refer the interested readers to our data appendix for a more detailed account.

After these procedures, we obtain 4,786,856 firm-level TFP's. For each country c and year t, we compute $TFP9010_{c,t}$ as the TFP difference (in the logarithmic scale) between the firm with the top 10% productivity and the bottom 10% firm and retain only a single observation per one country-year. Then, we merge the data with the WGI and WDI databases, and require a country-year to have non-missing values of homicide rates and the rule of law measure, so that regression coefficients can be interpreted as between-estimates. Our final sample consists of 26 countries and spans from 1996 to 2016. We report the summary statistics for this sample in Table 3. In Table IA.2 of the Internet Appendix, we find that (Acemoglu et al., 2001)'s original OLS results also hold in this sample.

We are interested in estimating:

$$TFP9010_c = \alpha + \beta_{OLS} AVG\_RL_c + Control_c + \epsilon_c, \quad (4)$$

where $TFP9010_c$ denotes the average level of the (logged) TFP difference $TFP9010_{c,t}$, and AVG_RL_c the average rule of law of country c. Since countries in our sample belong either to Asia or Europe, we only use a dummy variable "Europe" instead of continent-fixed effects. Other co-variates include a country's average homicide rates and the absolute value of its latitude (divided by 100).

We report our regression coefficients in Table 4. The basic OLS relationship without any control variable is also graphically illustrated in Figure 3. Our results show that the relationship implied by the part (b) of Theorem 1 is indeed consistent with what can be observed in the data. In particular, we find that one standard deviation increase in the Average Rule of

Table 4
TFP Dispersion OLS Results.

	(1)	(2)	(3)	(4)	(5)	(6)
Average Rule of Law	-0.527***	-0.511***	-0.534***	-0.508***	-0.583***	-0.577***
	(0.0530)	(0.0510)	(0.0542)	(0.0552)	(0.0543)	(0.0727)
Average Homicide		0.018		0.0303		0.004
		(0.026)		(0.023)		(0.030)
Europe			-0.288	-0.321	-0.442	-0.438
			(0.307)	(0.316)	(0.331)	(0.339)
Latitude					1.001**	0.948
					(0.421)	(0.565)
Constant	1.706***	1.660***	1.979***	1.930***	1.630***	1.642***
	(0.0714)	(0.105)	(0.311)	(0.320)	(0.357)	(0.373)
Observations	26	26	26	26	26	26
R^2	0.776	0.779	0.804	0.812	0.823	0.823

In all regressions, the outcome variable is a country's average level of TFP dispersion. Robust Standard errors are in parentheses. Asterisks *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively.

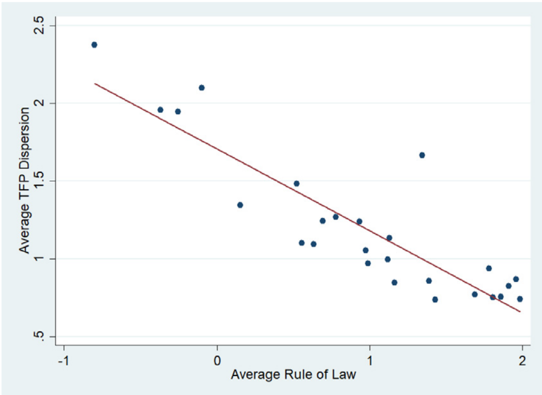


Fig. 3. Rule of Law and Average TFP Dispersion. Figure 3 illustrates the OLS relationship between log-TFP differences between the firm with the top 10% productivity and the bottom 10% firm (on the y-axis) and the Average Rule of Law measure (on the x-axis) for 26 sample countries. Above the plot is the line of best fit in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Law would decrease the productivity gap between the top 10% most productive firm and the bottom 10% firm by 0.407 in a logarithm scale. This translates into a reduction in the productivity gap by 33.4%.

We also conduct various robustness checks in Table IA.7. First, we report the results based on the IHS measure in Panel A. Second, in Panel B and C, we exclude low-income countries from the sample and repeat the empirical analyses. These robustness checks yield qualitatively similar outcomes.

We could not conduct IV regressions in this subsection because there are zero overlaps between countries in the ORBIS database and those in Acemoglu et al. (2001)'s data set. In the ORBIS universe, only European countries and a small group of Asian countries contain financial statement information required to estimate firm-level TFP's, but none of these countries are former European colonies. We are hopeful that future research can use higher-quality datasets to overcome this issue.

5.2.3. Wage inequality and rule of law

In the last part of our empirical analyses, we relate the amplification mechanism to pay inequality. To proxy for wage inequality, we use the (logged) Theil index for industrial wage-inequality from the UTIP-UNIDO database (Galbraith et al., 2014).[17] After merging the database with WDI, WGI, and (Acemoglu et al., 2001)'s databases, we only retain observations with non-missing values of the Theil indices, Rule of Law, and homicide rates so that we can use between-estimators in our empirical analyses. The sample period is between 1996 and 2015. The summary statistics for this sample are reported in Table 5. In Table IA.3 of the Internet Appendix, we also replicate (Acemoglu et al., 2001)'s main results in this sample and find similar results.

We first estimate:

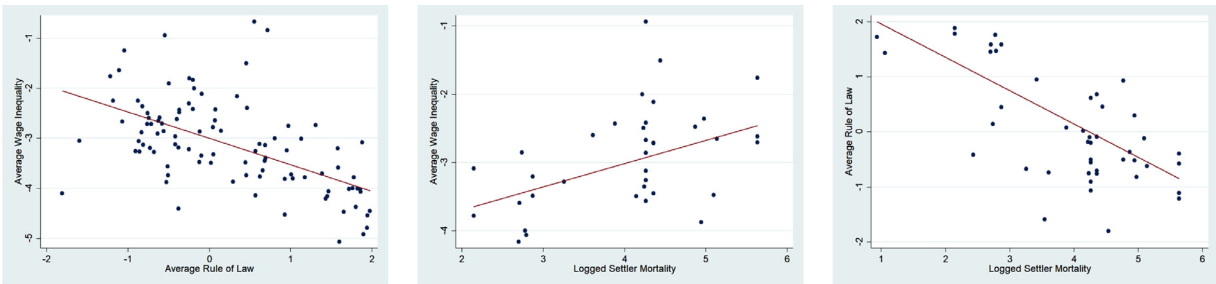
$$AVG\_Log\_Theil_c = \alpha + \beta_{OLS} AVG\_RL_c + Control_c + \epsilon_c,$$

[17] To the best of our knowledge, other popular inequality indices (e.g., Gini indices) are only available for *total income*, but not for *labor income*. Since we believe our model is more relevant for labor income, we use Theil indices from the UTIP-UNIDO database.

Table 5
Summary Statistics (Inequality Sample).

Variable	World	Base	By Quartiles of Mortality			
			(1)	(2)	(3)	(4)
Average Pay Inequality	-3.126	-2.921	-3.581	-2.749	-2.749	-2.605
	(.896)	(.732)				
Log GDP Per Capita (PPP) in 1995	8.645	8.467	9.696	8.197	8.464	7.658
	(1.051)	(1.051)				
Average Rule of Law (WGI)	.247	.041	1.344	-.395	-.222	-.466
	(.982)	(.871)				
Average Rule of Law (IHS)	.648	.595	.841	.528	.529	.446
	(.982)	(.871)				
Average Protection Against Expropriation Risk	7.765	7.097	8.697	6.635	6.568	6.449
	(1.529)	(1.338)				
Average Homicide Rate	7.324	12.791	5.859	12.964	34.109	9.979
	(13.584)	(20.109)				
Constraints On Executives in 1900	2.333	2.765	4.714	2.714	3.5	1
	(2.216)	(2.4)				
Constraints On Executives in 1990	3.778	3.588	6.429	2.286	2	4.111
	(2.619)	(2.583)				
Democracy in 1900	1.841	2.583	6	1.786	4	0
	(3.256)	(3.596)				
European Settlers 1900	42.119	23.097	50.938	19.857	15.25	6.878
	(46.17)	(30.866)				
Log European Settler Mortality 1900	n.a.	4.027	2.64	4.102	4.358	5.152
		(.963)				
Number of Observations	99	36				

The “world” column is for the sample used in the OLS regressions. The “base” column is for the sample used in the IV regressions, which consists of former European colonies with non-missing values of European settler mortality rates. “Average Pay inequality” is a country’s average level of the (logged) Theil indices. Other data sources are described at the beginning of 5.2 and 5.2.1. Standard deviations are in parentheses.



(a) (b) (c)

Fig. 4. OLS, Reduced-Form, and First-Stage Relationships for Wage Inequality. Panel (a) shows the OLS relationship between wage inequality (on the y-axis) and Average Rule of Law (on the x-axis). Panel (b) shows the reduced-form relationship between the standard deviations of country-level TFP growth rates (on the y-axis) and the logged morality rates of early European settlers (on the x-axis). Panel (c) shows the first-stage relationship between the Average Rule of Law measure (on the y-axis) and the mortality rates (on the x-axis). In each panel, we also show the line of best fit in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

where $AVG\_Log\_Theil_c$ denotes the average level of our wage inequality measure (i.e., logged Theil index) for country c. We also use the same set of control variables as previous analyses.

We report the OLS estimates in Panel A of Table 6 and also graphically illustrate the OLS relationship in Panel (a) of Fig. 4. We find that the relationship implied by the part (c) of Theorem 1 is indeed consistent with the data: countries with better contract enforcement have, on average, less dispersed wages than those with weaker contract enforcement. One standard deviation increase in the average rule of law is predicted to decrease the average level of the wage inequality measure by 0.49. We believe that this is quantitatively large, given that the standard deviation of the wage inequality measure is about 0.896. Furthermore, the R-squared value suggests that variations in the average rule of law would account for 29.9% of variations in country-level dispersion in wage inequality.

As in Section 5.2.1, we adopt (Acemoglu et al., 2001)’s instrumental variable approach and estimate:

$$\begin{aligned} VOL_c &= \alpha + \beta_{IV} AVG\_RL_c + Controls + \epsilon_c, \\ AVG\_RL_c &= \mu + \gamma_{FS} S_c + Controls + \eta_c, \end{aligned} \tag{5}$$

where we use the same set of control variables as in previous analyses.

Table 6
Wage Inequality Results.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: OLS Regressions						
Average Rule of Law	-0.499***	-0.493***	-0.391***	-0.359***	-0.311***	-0.299***
	(0.0770)	(0.0829)	(0.0864)	(0.0975)	(0.0924)	(0.0988)
Average Homicide		0.001		0.005		0.003
		(0.004)		(0.004)		(0.004)
Latitude					-1.032**	-0.989**
					(0.468)	(0.485)
Continent FE	No	No	Yes	Yes	Yes	Yes
Observations	99	99	99	99	99	99
R^2	0.299	0.300	0.369	0.375	0.403	0.404
Panel B: IV Regressions						
	(1)	(2)	(3)	(4)	(5)	(6)
Average Rule of Law	-0.504***	-0.521***	-0.465***	-0.495***	-0.490**	-0.499**
	(0.113)	(0.122)	(0.129)	(0.145)	(0.194)	(0.201)
Average Homicide		-0.004		-0.006		-0.006
		(0.00375)		(0.005)		(0.005)
Latitude					0.188	0.0286
					(0.937)	(0.918)
Continent FE	No	No	Yes	Yes	Yes	Yes
Observations	36	36	36	36	36	36
Anderson-Rubin statistics	16.44***	15.36***	12.08***	11.00***	8.33***	8.30***
Panel C: First-Stage Regressions						
	(1)	(2)	(3)	(4)	(5)	(6)
Logged Settler Mortality	-0.727***	-0.696***	-0.707***	-0.657***	-0.608***	-0.596***
	(0.100)	(0.0904)	(0.111)	(0.0930)	(0.145)	(0.133)
Average Homicide		-0.011***		-0.014***		-0.013**
		(0.004)		(0.005)		(0.005)
Latitude					1.056	0.688
					(0.888)	(0.907)
Continent FE	No	No	Yes	Yes	Yes	Yes
Observations	36	36	36	36	36	36
R^2	0.584	0.638	0.591	0.666	0.612	0.675
F-statistics	52.62***	59.20***	40.75***	49.91***	17.62***	20.13***

Panel A reports OLS coefficients of equation (2). Panel B and Panel C report IV and first-stage estimates (respectively) of the sytem of equations (3). The outcome variable in Panel A and Panel B is "Average Pay inequality," which can be obtained from the UT-UNIDO database. Other data sources are described in Section 5.2 and 5.2.1. Robust Standard errors are in parentheses. Asterisks *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively.

We report the IV estimates in Panel B of Table 6 and the first-stage estimates in Panel C of Table 6. Also, we show the reduced-form and first-stage relationships graphically in Fig. 4. The IV estimates are quite comparable to the OLS estimates, and the first-stage statistics suggest that the inclusion restriction is likely to be satisfied.

As in previous empirical analyses, we report the results of various robustness checks in the Internet Appendix. First, we use the IHS measure and repeat the empirical analyses in Table IA.8. Second, we report the results after excluding low-income countries in Table IA.9 and Table IA.10. These robustness checks yield qualitatively similar outcomes.

6. Conclusion

We have presented a parsimonious model combining two very natural premises: limited enforcement and persistent productivity. Despite its simplicity, time-varying limits to contract enforceability generate a rich set of testable implications both at the micro and macro levels. The empirical findings (both by others and our own) are consistent with our model. In particular, we provided a new set of empirical results showing that cross country differences in contract enforceability can have important implications for aggregate TFP volatility, cross-sectional dispersion in firm-level TFP's and wage inequality.

Declaration of Competing Interest

None.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.jmoneco.2022.03.010.

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