Dual and common agency issues in international contracting

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Abstract

With the help of a theoretical model we analyze an international team production setting of a foreign headquarter firm and a domestic production facility in which the local government faces a commitment problem in providing non-contractual public goods that support the joint enterprise (infrastructure, the rule of law, abstaining from corruption, etc.). The commitment problem arises when the government ex post does not care for the revenues of the foreign firm. We show that to overcome this dual agency problem the foreign firm leaves higher rents to the local firm, so as to provide stronger incentives for the government to supply public goods. However, when multiple foreign firms enter in joint production arrangement with local firms a double moral hazard problem arises in which the externality causes underprovision of incentives and underprovision of public goods. Hence, when the dual moral hazard problem is severe, stringent local content requirements may actually improve the profit levels of the foreign firms conducting foreign investment, since such rules internalize the common pool problem. We test the trade-off between local public goods and ownership shares across 31 Chinese provinces to find support for our mechanism.

Key words: Dual agency, common agency, local public goods, foreign investment

JEL codes: F23, L14, L22, L23, O14

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1. Introduction

Becoming engaged in international trade is crucial for poor countries to develop. Since domestic demand for products with high value added is absent, income growth relies on external demand. Clearly, many small and medium sized enterprises in developing countries cannot get access to world markets for final goods directly. However, in practice they cooperate with multinational enterprises to become part of the value chain. For example, supplying intermediate inputs to foreign producers is the most important activity for many Chinese and Indian firms.

In the relationship between foreign and domestic firms, the local government often plays an important role in supporting the partnership. For example, public agencies and officials need to improve infrastructure, abstain from corruption, and police contract adherence. Often, however, private parties complain about insufficient public services. Such undersupply can be explained by using two sets of arguments. First, privately motivated public officials may have limited incentives, because individual financial rewards for “good governance” are absent. Even stronger, pay-offs may actually come from diverting funds earmarked for infrastructure, engaging in rampant corruption, and assisting in discretionary rulings in favour of cronies. A second reason for undersupply of public services is that benevolent, socially motivated public officials care only for the revenues of local suppliers. Hence, they do not internalize the benefits of public goods and services to foreign producers. Moreover, public goods and services often need to be supplied after the relationship of the domestic and foreign producers is in place, so that such limited incentives ex post create a commitment problem for local governments.

In this paper, we set up a theoretical model to study how contracts between foreign and domestic firms deal with limited incentives of public officials. In a principal-agent relationship between the foreign producer (the principal) and the local supplier (the agent), the local government acts as a dual agent of whom the actions cannot be contracted directly. However, when the revenues of the local supplier are positively correlated with the public official’s pay-offs, leaving more rents to the local supplier (partly) solves the incentive and commitment problem of its government.

By adding public interests, our model extends the knowledge of efficient international contract design in some non trivial ways. First, in designing contracts, multinationals face a trade-off between ownership and the quality of public services. Hence, this results in a higher ownership share for local producers than would have been predicted by traditional models. Second, there may be a positive relation between the opportunity costs of public goods to policy makers and the shares of local producers in total profits. The reason is that to induce policy makers with such high costs to supply public goods, the foreign producer leaves more rents to the local supplier. Last, when FDI is high, local content requirements make more sense. If foreign producers free ride on each others’ provision of incentives for policy makers, then public goods supply will be too low. In that case, forcing firms to leave more rents to local suppliers alleviates this negative externality.

A few examples may illustrate that multinationals care about local governments’ incentives. To take advantage of low labour costs, Advanced Micro Devices (AMD) has set up various production plants across China. In order to get government supports in local production, AMD has an interest in maintaining a good relationship with the Chinese government. This means that AMD sometimes has to do things which may run against its short run interest. As a case in point, with respect to AMD’s research cooperation with one Chinese local computer chip producer, an
AMD general manager points out: “This is a potential competitor for AMD, but we are still doing that... This is the commitment of AMD to the Chinese government. If you want to do business here in China, you have to grow with China together”.

In the Liquefied Natural Gas (LNG) industry, Shell deals with state owned Oman Liquefied Natural Gas (OLNG). Since public investment in infrastructure is essential in the natural resource sector, Shell has to make concessions to OLNG, so as to please the government of Oman. In a Sale and Purchase Agreement (SPA) between Shell Western and OLNG in 2002, Shell agreed to replace its ships by the fleet of OLNG from 2004 onwards. Clearly, this comes at a cost of Shell in terms of value added. An important reason for Shell to agree is to maintain a good working relation with the government of Oman. According to Oman Liquefied Natural Gas (LNG)’s General Manager and Chief Executive “Originally our customers (including Shell) had been supplying their own ships for these long-term contracts, while we found an increasing need to secure some shipping capacity ourselves. This also follows the aspiration of the government of Oman to build its own fleet of LNG ships to be provided to OLNG”.

Surrendering shipping rights to Oman may also increase the future bargaining power of OLNG in future deals. Leaving rents is not always bad in our model and Shell’s experience in Russia illustrates this point, where it failed to pay enough attention to providing incentives for local producers. Recently, in a very dubious way Shell lost its stake in 20 billion dollars Sakhalin-2 scheme. Since Russia in the 1990s was unable to invest in own production capacity, according to Russian officials, Shell grabbed all rents. By contrast, BP participated in Russian Tyumen Oil Company (TNK) and built Russian owned production capacity. So far, BP has had little problems with ‘Russian rule of law’. The different stories of Shell and BP indicate that the outcomes of legal rulings in Russia may be closely related to the bargaining power of Russian firms and the Russian government. Or, as the chief of Business Week’s Moscow bureau notes, “Foreign investors in Russian energy have already learned the painful lesson that only investments with the direct blessing of the Kremlin have a hope of success. That’s likely to favour investments in tandem with either Gazprom or Rosneft (two major Russian oil companies)”.

Our model roots in the literature on optimal contracting in international relations, as summarized in for example Helpman (2006). The general idea in this literature is that contracting across borders involves imperfections. One underlying motivation for such imperfections may be that contract cannot be enforced in foreign courts, whereas they can under domestic law. To our knowledge, no other paper in this literature has endogenized foreign government decision making. Commitment problems of governments are a common theme in the international trade literature, for example in setting tariffs and export taxes. Clearly, a government would like to commit to low trade taxes so as to attract foreign direct investment. As obvious commitment devices are lacking, this is an important reason to enter into binding agreements such as the WTO, see Bagwell and Staiger (2001). Close to the spirit of our paper is Tirole (2003), who analyzes the commitment problem of governments in international finance. He shows that ex ante inefficient taxes on capital inflows may serve as an ex post efficient commitment devise for good domestic policies. His (and our) result echoes older and more general findings in the common agency literature that restrictions on the agent’s behaviour may improve efficiency by alleviating the common pool problem, see e.g. Bernheim and Whinston (1997).

\[2\] There is also a small but growing empirical literature that analyzes the connection between institutions and trade flows, see Levchenko (2004) and Nunn (2006) for pioneering studies.
The paper commences as follows. In section 2 below we present the dual agency model which highlights the most important trade-offs. Section 3 then analyzes the dual agency commitment problem and its effects. After that, section 4 investigates extensions: (i) The common pool problem when there are multiple foreign investors and the way in which local content requirements may alleviate agency problems; and (ii) the effects of corruption. Section 5 presents evidence for China for the trade-offs. Section 6 concludes.

2. The model

Consider the unit production of a final good \( z \) for which the price in the world market depends on the quality of the inputs. Production takes place in a partnership between a final goods producer and a specialized component producer. In line with most of the literature, suppose that there are two private inputs: the quality of headquarter services \( h \) and that of the component \( m \). In the following we also include public inputs \( a \) into the production process, which can be considered as public goods (schooling, infrastructure, etc.) that raise quality of the inputs. We assume that revenues of selling \( z \) are \( R = R(x) \) where \( R(x) \) is the vector of inputs. \( R(x) \) is strictly concave in all its arguments and all third derivatives are close to zero. In contracts of foreign investment, it is obviously that the two private inputs \( m \) and \( h \) are complementary to each other. Hence, for the second derivatives of the vector \( R(m, h) \), we have

\[
R_{mm} < 0, R_{mh} < 0, R_{hm} = R_{hh} > 0.
\]

Throughout the paper subscripts denote (partial) derivatives and we suppress superscripts when possible. Extended to the three variables situation \( R(m, h, a) \), there is an additional condition \( R_{aa} < 0 \). Since the public goods support the partnership between the component supplier and the final goods producer, it is reasonable to assume that the marginal revenues of private inputs increase with the public investment \( R_{ma} > 0, R_{ha} > 0 \). Furthermore, in order to capture each input’s own reaction to outside changes, we assume that the mixed second-order derivatives (\( R_{mh} \), \( R_{ma} \), and \( R_{ha} \)) are sufficiently small. The costs to supply quality of each input are captured by the cost function \( C^*(x) \) that is strictly convex. In the case of public inputs, these costs measure social opportunity costs. Clearly, the first-best is a forcing contract on the quality of the inputs that maximizes profits \( \Pi = R(x) - \sum x C^*(x) \), so that from the first-order conditions \( R_i(x) = C^*_i x \).

**Team production and incentives**

To introduce the most important building blocks of the model, we start by evaluating some specific cases. Consider the situation where quality is non-contractible so that incentives have to be provided. There may be various reasons to consider this set up. For example, the quality depends on unobservable effort and can not be verified before the final sale. Then, a contract cannot specify the quality of the input nor effort and relies on tying the rewards of the input producer to total revenues. It may also capture the case where there is some uncertainty in the contracting stage how high the

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3 For example, suppose the public good is education investment by the government, the marginal revenues of the private inputs could increase with \( a \). This is because high educated customers prefer and can afford high quality goods.

4 The same assumption is applied in Anderson (2007).
price will be in the world market for a given quality. Also in that situation it may be optimal to design a bonus scheme that relates rewards of the input producer to the revenues in the world market when the input suppliers have observed the price-quality relation before they maximize profits. Further, when renegotiation is possible in the stage when the inputs have to be put together, then forcing contracts may simply not be credible. Lastly, forcing contracts may give rise to well-known multiple equilibria when financial sanctions are non-enforceable.

To provide a benchmark, suppose that the contract specifies the pay-off for each input supplier in the following way:

\[ \Pi(x) = \beta^x R(x) - C^x(x) \]  

(1)

where \( \beta^x \) is the bargaining power for the supplier of input \( x \). Suppose the two inputs \( x = h \) and \( x = m \). In stage 1, the social planner decides on bonus structure to maximize joint pay-offs. In stage 2, the firms choose \( h \) and \( m \). To satisfy the budget constraint, the bonus is \( \beta^m = \beta \) for the supplier of \( m \) and \( \beta^h = 1 - \beta \) for that of \( h \).

The first-order conditions for choosing the optimal quality of inputs (symbolized by star) are:

\[ \beta R_m(m^*, h^*) - C_m(m^*) = 0 \]  

(2)

\[ (1 - \beta) R_h(m^*, h^*) - C_h(h^*) = 0 \]  

(3)

where \( dm^*/d \beta > 0 \) and \( dh^*/d \beta < 0 \). It is evident that both firms under invest in the quality compared to the first-best outputs. In stage 1 the social planner maximizes the joint profits \( \Pi = R(m^*, h^*) - C(m^*) - C(h^*) \) by choosing the optimal incentives \( \beta \).

The first-order condition that maximizes \( \Pi \) is:

\[ \frac{d\Pi}{d \beta} = \frac{dm^*}{d \beta} (R_m - C_m) + \frac{dh^*}{d \beta} (R_h - C_h) \]  

(4)

Clearly, the envelope theorem does not apply, as in the eyes of the social planner in stage 2 there are no optimal incentives. The choice of the optimal \( \beta^* \) captures the trade-off that a higher \( \beta \) gives more incentives for the supplier of \( m \) (which is good) and weaker incentives for the supplier of \( h \) (which is bad). Incentives for the supplier \( m \) are increasing in his importance in the production of the final product's quality and decreasing in his marginal cost.

**Optimal contracts in a principal-agent set-up**

Suppose there is an additional payment \( s \) (such as the upfront fee) specified in the contract. The profits function becomes:

\[ \Pi(x) = \beta^x R(x) + s^x - C^x(x) \]  

(5)

Holmstrom (1982) on team production and Grossman and Helpman (2004) in an outsourcing setting show that in the absence of a third party, first-best incentives (the outcome of the forcing contract) can not be implemented if the social planner
decided on revenue allocation. To see why, in a setting where the fixed payment by a third party is not feasible \((s = 0)\), the first-order conditions result in \(\beta^x R_x - C_x s = 0\). Hence, the first-best is only obtained when \(\beta^x = 1\). However, this clearly breaks the budget constraint.\(^5\)

It may come as no surprise that in a principal-agent set up the first-best can be obtained when the final goods producer decides on the bonus structure and can commit to the first-best \(h^F^B\). Suppose that in stage 2 the component producer maximizes pay-off according to (5). When setting incentives, the final goods producer has to take into account of the participation constraint:

\[
\Pi^m = \beta R + s - C(m) \geq \Pi
\]

where \(\Pi\) denotes the outside option. The pay-off to the final goods producer is:

\[
\Pi^h = (1 - \beta)R - s - C(h)
\]

Suppose the outside option is zero, substituting the participation constraint (6) with equality \((s = -\beta R + C(m) + \Pi < 0)\) into the pay-off function of the final goods producer gives the profits function:

\[
\Pi^h = R - C(m) - C(h)
\]

Maximizing the profits function (8) results in two first-order conditions \(R_h - C_h = 0\) and \(R_m - C_m = 0\). The two producers could commit to provide the first-best outputs in stage 2. Since \(s < 0\), this first-best outcome is equivalent to giving full incentives \((\beta = 1)\) to the component producer and accruing all the total surplus back to the final goods producer. In this case, instead of deciding on incentives in stage 1, the downstream firm sets the amount \(s\) paid by component supplier in the contract.

**Liquidity constraints**

When the contract can not specify the desired payments from the component supplier to the final goods producer - and there are many practical and legal reasons to take this case seriously - then the liquidity constraint \(|s| < |\tilde{s}|\) binds and we have condition \(\tilde{s} = -\beta R + C(m) + \Pi\). In this case, the final goods producer does not commit to provide the first-best output. This introduces a trade-off for the final goods producer in setting incentives. Increasing incentives for the component producer increases the supplier's quality of which he also benefits. However, these stronger incentives induce higher payments ex-post to the component supplier, which puts a dent in the profits of the final goods producer. In the second stage, the firms produce based on the first-order conditions:

\[
\beta R_m(m^*, h^*) + s_m(m^*, h^*) - C_m(m^*) = 0
\]
\[
(1 - \beta)R_h(m^*, h^*) - s_h(m^*, h^*) - C_h(h^*) = 0
\]

\(^5\) When a third party can collect an up-front bond, then full incentives can be given to each input supplier without breaking the budget constraint.
Since the payment \( s \) is set to alleviate the underinvestment problem, we assume \( s_m < 0 \) and \( s_h < 0 \). In the first stage the final goods producer chooses incentives \( \beta \) so as to maximize his own profits. By using the envelope theorem, and assuming that the participation constraint for the intermediate goods producer is always fulfilled, this gives the first-order condition:

\[
\frac{d\Pi^h}{d\beta} = -R + \frac{d m^*}{d\beta} [(1 - \beta^*)R_m - s_m] = 0
\]

(11)

As discussed above, the optimal incentives trade off the costs of a lower share in the profits and stronger incentives for the component producer.

A special case is when \( s = 0 \). In the first stage, the final good producer design the bonus structure based on the first-order condition:

\[
\frac{d\Pi^h}{d\beta} = -R + \frac{d m^*}{d\beta} [(1 - \beta^*)R_m] = 0
\]

(12)

Comparing (11) and (12), it is clearly that the positive argument is smaller if there is no payment to the final goods producer at all. Intuitively, the final goods producer would like to give stronger incentives for the component producer, if he can get more back by the fee paid by the supplier. For simplicity, we set \( s = 0 \) in the following parts of the paper.

3. The commitment problem in public investment

As we have discussed in the introduction, public investment in infrastructure is important to attract private investment. In this section we investigate the interaction between incentives in foreign investment contracts and public investment. We may depict a multinational that is engaged in foreign production to a local export processing zone in a developing country. The multinational is a large player for the local government that manages this zone. The management realizes that when the government has to implement public works after the multinational has agreed to cooperate with local suppliers, this government faces a commitment problem if it only cares for the profits of the local inputs producers. This commitment problem will be anticipated by giving the local suppliers a larger share of the cake. Further, we will show that lobbying by local producers for public investment reduces their incentives and hence, their production level. For this reason, capture of local policy makers increases investment level, but at the expense of a lower share in the profits the local producers and higher social cost of public investment.

From the start, to give our analysis bite, we assume that the liquidity constraint binds, so that the pay-off functions for the two firms are given by:

\[
\Pi^m = \beta R(m, h, a) - C(m)
\]

(13)

\[
\Pi^h = (1 - \beta) R(m, h, a) - C(h)
\]

(14)

The government’s objective function maximizes the pay-off of the local supplier subject to the social costs of public investment:
The timing of events is as follows. In stage 1 the multinational decides on incentives $\beta$ for the local supplier; In stage 2 the government decides on the level of public investment $a$; In stage 3 the firms set production levels $h$ and $m$ and share the profits according to the rule set in stage 1. We solve for subgame-prefect equilibria. In the third stage, the two firms set production levels to maximize (13) and (14). Given the level of public investment $a$ chosen in stage 2 this program gives:

$$\frac{\partial \Pi^m}{\partial m} = \beta R_m(m^*, h^*, a) - C_m = 0$$

(16)

$$\frac{\partial \Pi^h}{\partial h} = (1 - \beta)R_h(m^*, h^*, a) - C_h = 0$$

(17)

**Lemma 1:** $dm^*/d\beta > 0, dh^*/d\beta < 0$ and $dm^*/da > 0, dh^*/da > 0$

Lemma 1 implies that public investment may have a direct effect of revenues, but also may increase the marginal returns to the private inputs. Investment in both local and foreign inputs is more efficient with higher level provision of public goods.

In stage 2, the government realizes that public investment will increase the revenues of both firms, but it only cares for those of the local supplier. Hence, it sets public investments to satisfy:

$$\frac{dG}{da} = \beta R_u(m^*, h^*, a^*) - C_u + \frac{dh^*}{da} \beta R_h(m^*, h^*, a^*) = 0$$

(18)

where we have used the envelope theorem to get rid of the effects on marginal profits of the production of the local producer. When compared to first-best public investment ($R_u(m, h, a) = C_u$), the first two terms indicate the underinvestment of the public goods. The third term shows that (to some extend) such weak incentives for public investments are mitigated by the fact that the government wants to induce higher inputs from the foreign producers, so as to increase the profits of the local supplier.

**Lemma 2:** $da^*/d\beta > 0$

The reason is that increasing $\beta$ gives the local supplier a higher share in the profits and, hence, its government a stronger incentive to provide public goods. An interesting side-result is that an unbiased social planner would conduct a higher level of public investment than the first-best level when the team structure of production provides too weak incentives for the firms. Such a social planner would maximize:

$$G = R(m, h, a) - C(m) - C(h) - C(a)$$

(19)

As the envelope theorem does not apply, this gives:

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6 Based on the proof for Lemma 3, $da^*/d\beta$ increases with $R_h$ and $R_a$. when the underinvestment in public goods is larger ($R_h$ and $R_a$ are larger), the government is more sensitive to the incentives tool.
\[
\frac{dG}{da} = R_a - C_a + \frac{dm}{da} (R_m - C_m) + \frac{dh}{da} (R_h - C_h) = 0 \tag{20}
\]

Since the last two terms are positive, incentives for investing public goods may be higher than in the first-best.

When we return to our main argument, in the first stage the final goods producer is confronted with the liquidity constraint of the local supplier, so that the optimal \( \beta \) maximizes (14), which (using the envelope theorem) gives:

\[
\frac{d\Pi^h}{d\beta} = -R(m^*,h^*,a^*) + \frac{da^*}{d\beta} (1 - \beta^*) R_e(m^*,h^*,a^*) + \frac{dm^*}{d\beta} (1 - \beta^*) R_m(m^*,h^*,a^*) = 0 \tag{21}
\]

**Proposition 1:** Government commitment causes higher local rents for the local supplier than in the first-best case.

Equation (21) reveals that there are four arguments why the commitment problem forces incentives for the local supplier to be stronger than in the absence of it. Before we go over the arguments, recognize that \( m, h, \) and \( a \) are higher when there is no commitment problem and so is \( R \). The first term shows that revenues \( R \) are lower than in the absence of the commitment problems, so that giving incentives at the margin is less costly. The second term is positive and shows that the final goods producer has an incentive to push the government to increase public investment, which in turn increases the revenue of the foreign producer. By the third term, when production of \( m, h, \) and \( a \) is lower due to the commitment problem, the marginal productivity of the supplier is higher, which raises the rewards of providing incentives. Lastly, the fourth (positive) term reveals that higher incentives further raise the investment by the local supplier through the encouragement of the increased public goods investment. Totally differentiating equation (21) more directly shows the change of profits distribution in the level of public investment.

Intuitively, since the government only cares about the local supplier’s benefits, leaving more rents to the local supplier also generates incentives for the local government in public goods investment. The two-fold gains from higher incentives for both the local supplier and government increase the total revenues and the payoffs to the foreign producer. Hence, when public services are low-level because of high opportunity costs, foreign producers would like to encourage public investment by giving local suppliers stronger incentives.

As a corollary, crony capitalism and lobbying by local suppliers (reducing the costs of public investment to the policy maker) may result in weaker incentives for local suppliers. When \( a \) is higher, so will be \( m, h \) and \( R \). In equation (21) this means that the first, third, and fourth terms unambiguously work towards weaker incentives for the local supplier. For the second term, since \( R_e \) is decreasing in \( a \) but increasing in \( m \) and \( h \), for mild assumption on the importance of public investment in generating revenue this term also works towards lower incentives. Before lobbying by the local supplier, the foreign producer has to exchange the share of the profits for public

\footnote{Furthermore, \( dm*/d\beta \) increases with \( R_e \) based on the proof for lemma 1 in Appendix.}
goods. While after getting the demanded government services due to lobbying, the foreign producer losses the motivation to leave strong incentives for the local supplier.

4. Extensions

**Free Riding**

From the perspective of country incentives, a common agency problem emerges. Actually, common agency problem is a translation of dual agency problem from the side of firms’ managerial choices to the local government’s behavior. Suppose \( N \) foreign firms engage in international team production. They split the market which is occupied by a single firm in the baseline model. The gross production and revenues keep unchanged. Local government which provides public goods is a common agency of all production teams. The optimal level of public investment depends on the overall incentives offered by all firms. Since \( N \) is large, firms can not individually affect the level of public investment.

As the local government is the common agency to provide non-rival and non-excludable public goods, at least some foreign producers intend to provide weak incentives for local suppliers, because they can free ride on public goods generated by other foreign producers’ lost rents. When the local government only cares about local suppliers’ benefits, however, it invests less in public goods given lowered profits. In other words, common agency and free riding result in dual moral hazard of both the local government and foreign firms, which cause underprovision of public goods and underprovision of incentives for local firms. The local government’s objective function is

\[
G = \sum_{i=1}^{N} \Pi_i - C(a)
= [\beta_1 R(m_1, h_1, a) - C_1(m_1) + \ldots + \beta_N R_N(m_N, h_N, a) - C_N(m_N)] - C(a)
\]

(22)

When all firms are symmetric, it is reasonable to assume homogeneous revenues and costs. Thus to reach the same level of public goods in the baseline model each final goods producer should set the optimal incentives at \( \beta^* \). However, when the number of foreign producers is sufficiently large, every firm has incentives to deviate from providing \( \beta^* \). Instead, they share the amount of public goods \( a^* \) by leaving nothing to their partners. When foreign producers free ride simultaneously, the local government’s profits become trivial and therefore the local government does not invest in public goods. Negative externalities of common agency and free riding give rise to production efficiency loss. Therefore, when the public goods are so scarce, foreign firms have incentive to encourage the local government to improve the level of public investment. This leads to:

**Proposition 2**: In the presence of a common agency problem, local content requirements may raise profits levels of foreign firms.

**Corruption**
Doing business in developing countries (and not only developing countries) means
dealing with corruption of public officials. Multinational firms shield themselves
against corruption practices by adopting codes of conduct, however, with limited
success - see the recent troubles at Siemens. Although multinationals can shield
themselves, local suppliers may not be so lucky. For example, the son of the former
President of Bangladesh as well as the daughter of Suharto in Indonesia, were known
as “mister and misses 10 percent”, for this is the fee that they asked for any local
economic activity. Hence, in making contract with outside suppliers, multinational
firms have to take account of the fact that these local partners are subject to extortion
by their policy makers. In this section we analyze how this affects incentives in
contracts.

The timing of events is as follows. In stage 1 the multinational decides on
incentives $\beta$ for the local supplier; in stage 2 the government sets the fee to be paid
by local suppliers as a percentage $r$ of the local supplier’s profits; in stage 3 the firms
set production levels $h$ and $m$ and share the profits according to the rule set in stage 1.
The government collects $r\Pi^m$. To motivate the set up, the reason that corruption is
placed before the production stage is to capture the fact that production will
commence after the corruption environment is known to the firms. The fact that
incentives are set before the corruption stage is to capture imperfect knowledge of the
multinational firm about local environment, for which the potential local supplier can
not send a credible signal. The pay-offs are given as:

$$\Pi^m = (1-r)[\beta R(m, h) - C(m)]$$

$$\Pi^h = (1-\beta)R(m, h) - C(h)$$

For simplicity, the government’s objective function maximizes the rents only:

$$G = r[\beta R(m, h) - C(m)]$$

The government’s objective function is not monotonically increasing in the
level of corruption $r$, for the policy maker has to discount the effect of corruption on
the production of the local and foreign producer - and, in a different set up than ours
(that does not use liquidity constraints) also on the participation constraint of the local
supplier.

In stage 3, the first-order conditions for maximum profits of the firms are:

$$\frac{\partial \Pi^m}{\partial m} = (1-r)[\beta R(m^*, h^*) - C(m^*)] = 0$$

$$\frac{\partial \Pi^h}{\partial h} = (1-\beta)R(m^*, h^*) - C(h^*) = 0$$

In stage 2, the government sets $r$ according to:

$$\frac{dG}{dr} = \beta R(m^*, h^*) - C(m^*) + \frac{dh^*}{dr} r^* \beta R(m^*, h^*) = 0$$

Lemma 3: $dm^*/d\beta > 0, dh^*/d\beta < 0, dm^*/dr < 0, dh^*/dr < 0$
The underlying reason of the last two comparative static effects above is that giving more rents to the policy maker leaves fewer payoffs to the local producer, and small gain from the production makes the local supplier pay less attention to the quality of the inputs produced. In the same time, lower quality of input $h$ follows the lower quality $m$, in line with the complementarities in the production function.

In equation (28) we see that the third term represents the costs of extorting rents $r[\beta R(m,h) - C(m)]$ from the local supplier. It shows that corruption reduces incentives for the foreign final goods producer to supply $h$, which reduces the profits of the local supplier. Hence, the cost of raising the payments of the local supplier in the stage 2 is that this distortion effect reduces the ability to collect rents in stage 3.

**Lemma 4:** $\frac{dr^*}{d\beta} > 0$

The reason is that increasing incentives for the local supplier also raises the incentives for the local government to set a higher level of corruption. Let us proceed to the first stage of the game. The final goods supplier maximizes (24) with respect to incentives $\beta$, which (using the envelope theorem) gives the first-order condition:

$$\frac{d\Pi^h}{d\beta} = -R(m^*,h^*) + \frac{dm^*}{d\beta} (1 - \beta^*) R_m(m^*,h^*) + \frac{dr^*}{d\beta} \frac{dm^*}{dr} (1 - \beta^*) R_m(m^*,h^*) = 0 \quad (29)$$

**Proposition 3:** Under mild assumptions, corruption of local policy makers raises the share of the local supplier in the profits of the partnership.

When compared to the situation in which there is no corruption, start by recognizing that both $m$ and $h$ are lower. Hence, there are two reasons to give stronger incentives for the local supplier. First, the first term shows that the foregone profits of giving incentives are lower in the case of corruption, which raises the optimal incentives for the local supplier. The second term also works towards a higher share in total profits to the local supplier, as the marginal revenue $R_m$ is higher in the case of corruption. The last term is negative, as a higher share in the profits for the local supplier increases the marginal returns to corruption. However, under mild assumption about the impact of increasing incentives on corruption rate ($\frac{dr^*}{d\beta}$), this argument cannot be dominant. Totally differentiation result of equation (29) presents the impact of corruption on incentives for the local supplier. Intuitively, when there is corruption, the foreign producer would like to raise the investment level of the local supplier which is reduced by the corruption, at the cost of leaving more rents.

5. Empirical support: the case of China

To test the existence of the government commitment problem and its impact on foreign investment relations, we use data on the investment of foreign funded

---

*Based on the proof for Lemma 3, this positive term $\frac{dr^*}{d\beta}$ decreases with $R_m$. The intuition is that when the distortion of corruption is larger ($R_m$ is larger), the corruption of the government is more or less restricted.

*First, the second-order effects are minor. Moreover, $\frac{dm^*}{d\beta}$ increases, while $\frac{dr^*}{d\beta}$ decreases with the degree of corruption.
enterprises (FFE) across 31 Chinese provinces between 1995 and 2006. Foreign funded enterprises in China are of three types: contractual joint ventures, cooperative ventures, and solely foreign funded enterprises. The last type is excluded from our sample because it is irrelevant to the contracting setting. To analyze the provincial data we (heroically) assume homogeneous “with-province” and heterogeneous “between-provinces” time-varying rents to local suppliers. Hence, $N_i$ denotes the number of symmetric foreign funded enterprises which invest in province $i$ ($i = 1, \ldots, 31$) and in year $t$. In line with our theory, with commitment local governments respond to rents-sharing scheme of joint ventures in public goods provision. Level of public goods is expected to increase with local contains in this case. In other words, no impact of local rents on public goods provision should be found when the government commitment is absent.

We measure local rents by the ratio of local capital in total registered capital. Using local share of total revenues helps us to exclude the case that local governments are corrupted and bought by rich foreign investors to provide public services. Denote total registered capital of foreign funded enterprises as $TC$ and capital invested by foreign investors as $FC$ (in 100 million USD), incentives for local producers ($Localrents$) then are:

$$Localrents = 1 - \frac{FC}{TC}$$

Two remarks are in place. First, we assume that the division of surplus is determined by capital contribution. Second, China sets no upper limit to the proportion of foreign capital in total registered capital.

We measure local public goods by a provincial infrastructural factor derived from variables on transportation and communication, which include length of city road, area of city road, capacity of freight, length of railways, length of highways, length of inland waterways, capacity of telephone exchanges (long-distance, local, and mobile phone), and the length of cable lines. Number of foreign funded enterprises is useful to capture free riding and its externality. Provincial GDP per capital is added to control for the possible positive correlation between infrastructure and local development. To capture the enforcing effect of FDI on local public goods, we include total amount of money invested by FFE. Year dummy are used to correct for the time trend. Table 1 presents summary and correlation of level and first-differenced variables. Then the commitment problem can be formulated by the model below:

$$Publicgoods_{it} = \lambda_1 Publicgoods_{it-1} + \alpha_1 Localrents_{it} + \alpha_2 Localrents_{it-1} + \theta NumberFFE_{it} + \delta_1 CV_{it} + \delta_2 CV_{it-1} + \epsilon_{it}$$ [1]

The dependent variable is the level of public goods such as investment in local infrastructure and $CV$ represents control variables. A dynamic setting is proper since public goods provision is usually persistent over time. Lag one is selected based on $t$-statistics to account for autocorrelation. A positive $\alpha_1$ indicates that local governments invest more in infrastructural items if foreign investors leave more rents to local producers, which therefore proves the existence of the commitment problem.
Moreover, a possible solution to the commitment problem can be shown by the following model when foreign investors take into account the role of local governments in rents-sharing structure design:

\[
Local\text{rents}_{It} = \pi_1 Local\text{rents}_{It-1} + \pi_2 Local\text{rents}_{It-2} + \gamma_1 Public\text{goods}_{It-1} + \\
\gamma_2 Public\text{goods}_{It-2} + \theta Number\text{FFE} + \rho_1 CV_{It} + \rho_2 CV_{It-1} + \nu_{It} \tag{2}
\]

To capture the dynamics of local rents, the optimal order of the lag length is selected to be two. We are interested in previous public goods instead of the contemporary variable for two reasons. First, in our theoretical model local government provides public goods after the contract has been signed. Foreign investors are not acknowledged of the amount of public goods they can consume when they choose local rents. Second, past public goods can be viewed as a referenced baseline. If investors are satisfied with the existing level of infrastructure, zero \( \gamma_1 \) and \( \gamma_2 \) are expected because the commitment problem is not relevant in this case. However, if the accessible public goods are insufficient, negative \( \gamma_1 \) and \( \gamma_2 \) mean that foreign firms provide local rents to stimulate local governments in public investment.

Panel unit roots tests in Table 2 show that all the level variables are integrated at order one and first differencing yields stationary series. Meanwhile, first differencing helps to eliminate regional specific time-invariant characteristics. Therefore, econometrics models are transferred into the first-differenced form. Both error terms are tested to be serial independent, however, it is possible that the error structure is heteroskedastic and correlated between the groups (panels). Since the first-differenced lagged dependent variables are endogenous by specification, lagged two level variables are used as instrumental variables as proposed by Anderson and Hsiao (1981).

Table 3 shows some evidence of government commitment and free riding. The first five columns illustrate static and dynamic estimation results of model [1]. First, coefficients of local rents across panels are statistically significant positive. Based on results of IV, local governments raise the infrastructural factor by 0.20 percentage point if foreign investors leave one percent more rents to local partners. Hence, local governments do invest more when domestic producers can benefit more from public goods.

Static results imply that the number of foreign firms has no direct effect on local public goods provision conditional on total investment and local rents. In line with our theory, local governments under invest public goods because of insufficient local rents. So when free riding is not the case (unchanged local rents), local governments are insensitive to the number of foreign firms in providing public goods. However, it is also likely that such insignificance is caused by model misspecification, as based on our model [2] local rents are supposed to be endogenous when previous public investment is omitted. Results of a dynamic setting in Column (2) show two possible mechanisms on how the number of foreign firms affects public investment. First, in the case of free riding, foreign investors reduce local rents which are important in public goods provision. Hence, increasing the number of foreign firms has an indirect effect on public goods through local rents. Second, even free riding is absent a larger number of foreign firms with constant local rents may cause the undersupply of public goods. Normally, when more foreign firms participate in local production, local governments would expect to see more local rents and total investment. This gives local governments incentives to attract new investing firms.
Without raised local rents, the benefit of involving more foreign direct investment is marginal. Therefore, a failure to realize local governments’ expectation results in weakened incentives in public investment. Different from the indirect impact through local rents, this negative effect of increasing the number of foreign firms on public services comes directly from government commitment. We try to specify the direct and indirect impact of the number of foreign firms by controlling for local rents in Column (4). The difference between the magnitudes of the number of FFE variable in Columns (2) and (4) can be viewed as the indirect effect working through local rents, while the coefficient in Column (4) shows the direct effect conditional on local rents. Furthermore, a turning point of increasing investing firms is illustrated by the positive squared term in Column (3) and Figure 1. Given these two channels of the number of foreign firms changing public investment, the rebound of public goods provision may result from two reasons. On the one hand, it is an indicator that negative externalities of free riding can be internalized. Foreign investors may realize such efficiency loss and increase local rents. When the level of public goods hits the bottom due to free riding, at least some of the foreign investors seem to stand out to alleviate the inefficiency. Alternatively, local governments may exert local content requirements. With minimum amount of local rents requested, foreign investors are forced to give local governments some incentives in public investment. On the other hand, lack of infrastructure extensively harms local producers, which makes the share of total profits no longer the priority of local governments. When the competition between increased foreign investors for reduced public goods makes joint production unlikely to be conducted, the local profits lost from the impeded production can be larger than missing local rents. This motive of public investment seems significant in Column (5) testing for direct effect of increasing the number of firms.

Regression results of model [2] in Columns (6) to (7) confirm that foreign investors strategically respond to public goods provision. In provinces with one unit lower infrastructural factor, foreign investors share 4.9 percent more rents with local producers there. Therefore, when more public goods are needed (e.g. low level of existing infrastructure), foreign investors deal with the commitment problem by offer stronger incentives to local producers and local governments. In addition, the significant negative impact of the number of foreign funded enterprises on local rents implies that foreign investors do free ride. With more opportunities to consume public goods for free when more investors are involved, foreign investors have incentives to reduce the part of local rents originally allocated for encouraging infrastructure investment. Figure 2 demonstrates the existence of foreign investors’ opportunistic behavior. Foreign investors free ride on each other’s rents to local producers and therefore local content decreases with the number of foreign funded enterprises.

Finally, we extend the definition of public goods to include institutional quality of local governments, which is important for the efficiency and effectiveness of foreign investment. A provincial level NERI index (National Economic Research Institute index, scaling 0 - 10) of marketisation is used to show the quality of local institutions. This index covers dimensions of government and market, development of non-state enterprises, development of commodity market, development of factor market, and development of market intermediaries and legal environment. Based on estimation results in Table 4, we can conclude that the government commitment problem plays a role even when local governments provide non-physical public goods. Since it is foreign investors who benefit more from good institutions, local governments are reluctant to provide rule of law when local contains are large. Such
finding provides some explanation for the inability of local governments to commit to abstain from corruption, or their limited incentives to supply the rule of law.

6. Concluding Comments

This paper has investigated the dual and common agency problems in international investment strategies of multinational firms. So far, papers that discuss the interaction between the headquarter firm and the production facility have taken government behavior as given. This is an important omission, since the role of the (local) government is a potential important source of the contract imperfection. We model such a contract imperfection explicitly by introducing a dual agency problem. We show that the headquarter firm may leave more rents to the production facility’s management to induce its government to behave well. Although it is difficult to isolate these effects in a macro-political environment, we do present some evidence for China on the trade-off between foreign rents and local government incentives.

By endogenizing government behavior we may speculate on an additional set of results when the model is slightly enriched. First, we have set up the model in the managerial incentives tradition, which highlights the moral hazard problem in production. Alternatively, we may consider a set up where re-negotiation takes place after the initial production stage. Our work on such a set up indicates that this would not alter the basic intuitions presented in the present paper. Moreover, is such a setting we may model government effort as enforcement of private contracts. In that case an intriguing result arises in that the local government may strategically under invest in the rule of law, so as to induce higher rents for the domestic firm.

What we have not done is to make the now standard connection to the literature on firm heterogeneity. As is well known, differences in firm productivity may cause differences in internationalization strategy. Clearly, taking up government incentives may affect the choice over FDI or outsourcing. To speculate, it may well be that the dual agency problem inflicts a bias towards outsourcing. The reason is that outsourcing contracts – in contrast to FDI - can easily be cancelled in the short run, so that they discipline the government in providing public goods.

Lastly, our discussion on local content requirements may open up to a broader discussion on the merit if trade barriers. For example, Ornelas and Turner (2008) investigate the effects of trade protection when firms enter in imperfect contracts. They show that when tariffs increase the rewards to domestic factors of production, they may also raise the rents to domestic firms in vertical relationships, and for that reason may increase social welfare. For this reason, in our set up a government may strategically raise trade barriers so as to credibly commit to good policies and hence higher income for domestic workers.
References

### Table 1: Summary and correlation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs.</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local rents</td>
<td>369</td>
<td>0.3586</td>
<td>0.0978</td>
<td>0.1111</td>
<td>0.5524</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>371</td>
<td>-0.0303</td>
<td>0.9896</td>
<td>-1.3168</td>
<td>4.5063</td>
</tr>
<tr>
<td>GRPPC (ln)</td>
<td>369</td>
<td>8.9721</td>
<td>0.6709</td>
<td>7.3479</td>
<td>10.9629</td>
</tr>
<tr>
<td>FFE total investment (ln)</td>
<td>369</td>
<td>13.9207</td>
<td>1.5716</td>
<td>9.5670</td>
<td>17.2937</td>
</tr>
<tr>
<td>Number of FFE (1000 units)</td>
<td>369</td>
<td>7.4813</td>
<td>11.1217</td>
<td>0.051</td>
<td>61.999</td>
</tr>
<tr>
<td>NERI Index</td>
<td>371</td>
<td>4.9709</td>
<td>1.9921</td>
<td>0.1</td>
<td>10.41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>L~rents</th>
<th>Infra~</th>
<th>GRPPC</th>
<th>Investment</th>
<th>No. FFE</th>
<th>NERI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local rents</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>-0.3620</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>GRPPC (ln)</td>
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<td>0.6218</td>
<td>1.0000</td>
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<td>FFE total investment (ln)</td>
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<td>0.7476</td>
<td>0.6877</td>
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<td></td>
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<tr>
<td>Number of FFE (ln)</td>
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<td>0.7300</td>
<td>0.4943</td>
<td>0.7373</td>
<td>1.0000</td>
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<tr>
<td>NERI Index</td>
<td>-0.6706</td>
<td>0.7375</td>
<td>0.7841</td>
<td>0.8673</td>
<td>0.6620</td>
<td>1.000</td>
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</table>

### Table 2: Panel unit root tests

(Hadrilm test with Heteroskedastic error)

<table>
<thead>
<tr>
<th>Variable</th>
<th>p-value</th>
<th>Level</th>
<th>Order</th>
<th>p-value</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local rents</td>
<td>0.0000</td>
<td>1 (1)</td>
<td></td>
<td>0.8298</td>
<td>I (0)</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>0.0000</td>
<td>1 (1)</td>
<td></td>
<td>0.3928</td>
<td>I (0)</td>
</tr>
<tr>
<td>GRPPC (ln)</td>
<td>0.0000</td>
<td>1 (1)</td>
<td></td>
<td>0.4534 (no trend)</td>
<td>I (0)</td>
</tr>
<tr>
<td>FFE investment (ln)</td>
<td>0.0000</td>
<td>1 (1)</td>
<td></td>
<td>0.9965</td>
<td>I (0)</td>
</tr>
<tr>
<td>Number of FFE (ln)</td>
<td>0.0000</td>
<td>1 (1)</td>
<td></td>
<td>0.9989</td>
<td>I (0)</td>
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<tr>
<td>NERI Index</td>
<td>0.0000</td>
<td>1 (1)</td>
<td></td>
<td>0.6350</td>
<td>I (0)</td>
</tr>
</tbody>
</table>

Note: the null hypothesis of Hadrilm test is that all time series in the panel are stationary processes.
### Table 3: Estimation results

<table>
<thead>
<tr>
<th></th>
<th>Static</th>
<th>Dynamic (IV)</th>
<th>Static</th>
<th>Dynamic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>ΔInfrastructure,1</td>
<td>0.952***</td>
<td>0.937***</td>
<td>0.955***</td>
<td>0.941***</td>
</tr>
<tr>
<td></td>
<td>(0.108)</td>
<td>(0.108)</td>
<td>(0.108)</td>
<td>(0.108)</td>
</tr>
<tr>
<td>ΔInfrastructure,2</td>
<td>0.168*</td>
<td>0.209*</td>
<td>0.200*</td>
<td>0.014***</td>
</tr>
<tr>
<td></td>
<td>(0.095)</td>
<td>(0.118)</td>
<td>(0.117)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>ΔLocal rents,1</td>
<td>0.143</td>
<td>0.042</td>
<td>0.035</td>
<td>0.174</td>
</tr>
<tr>
<td></td>
<td>(0.203)</td>
<td>(0.144)</td>
<td>(0.143)</td>
<td></td>
</tr>
<tr>
<td>ΔLocal rents,2</td>
<td>0.044</td>
<td>-0.071***</td>
<td>-0.045</td>
<td>-0.062**</td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
<td>(0.029)</td>
<td>(0.041)</td>
<td>(0.027)</td>
</tr>
<tr>
<td>ΔNumber squared</td>
<td>0.013</td>
<td>0.012</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.009)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔGRPPC (ln)</td>
<td>0.337***</td>
<td>0.338**</td>
<td>0.340**</td>
<td>0.336**</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.145)</td>
<td>(0.146)</td>
<td>(0.147)</td>
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<tr>
<td>ΔGRPPC,1</td>
<td>0.244*</td>
<td>-0.065</td>
<td>-0.060</td>
<td>-0.069</td>
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<tr>
<td></td>
<td>(0.124)</td>
<td>(0.167)</td>
<td>(0.166)</td>
<td>(0.170)</td>
</tr>
<tr>
<td>Δinvestment (ln)</td>
<td>0.010</td>
<td>0.092***</td>
<td>0.078**</td>
<td>0.087***</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.029)</td>
<td>(0.032)</td>
<td>(0.028)</td>
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<tr>
<td>Δinvestment,1</td>
<td>0.031**</td>
<td>-0.006</td>
<td>-0.011</td>
<td>-0.004</td>
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<td>(0.014)</td>
<td>(0.010)</td>
<td>(0.011)</td>
<td>(0.011)</td>
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<td>IV first-stage</td>
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<td>p-value = 0.0000</td>
<td>p-value = 0.0000</td>
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<tr>
<td>Test H0: exogeneity</td>
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<td>p-value = 0.0000</td>
<td>p-value = 0.0000</td>
<td>p-value = 0.0000</td>
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<tr>
<td>Joint significance</td>
<td>p-value = 0.0047</td>
<td>p-value = 0.0044</td>
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<td>No. of observations</td>
<td>308</td>
<td>308</td>
<td>308</td>
<td>308</td>
</tr>
</tbody>
</table>

Note: regression controls for year dummy; since provinces may interact with each other, standard errors are corrected for cross-provincial (spatial) and temporal dependence. Robustness tests show contemporary infrastructure is insignificant in columns (6) to (7).

### Table 4: Institutional quality and local rents

<table>
<thead>
<tr>
<th></th>
<th>ΔNERI index</th>
<th>ΔLocal rents</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔNERI index,1</td>
<td>-0.635*</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>(0.330)</td>
<td>(0.016)</td>
</tr>
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</table>

Note: static models with no dynamic factors are estimated; number of observations = 308; regression controls for year dummy, GRPPC, and total FFE investment; standard errors of pooled OLS are robust to cross-provincial and temporal dependence.
Table 5: List of Regions

<table>
<thead>
<tr>
<th>Number</th>
<th>Province</th>
<th>Number</th>
<th>Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beijing</td>
<td>17</td>
<td>Hubei</td>
</tr>
<tr>
<td>2</td>
<td>Tianjin</td>
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<td>Hunan</td>
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<td>Hebei</td>
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<td>Guangdong</td>
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<tr>
<td>4</td>
<td>Shanxi</td>
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<td>Guangxi</td>
</tr>
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<td>5</td>
<td>Inner Mongolia</td>
<td>21</td>
<td>Hainan</td>
</tr>
<tr>
<td>6</td>
<td>Liaoning</td>
<td>22</td>
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</tr>
<tr>
<td>7</td>
<td>Jilin</td>
<td>23</td>
<td>Chongqing</td>
</tr>
<tr>
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<td>Heilongjiang</td>
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<td>Shandong</td>
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<tr>
<td>16</td>
<td>Henan</td>
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</tr>
</tbody>
</table>

Figure 1: Negative externality of free riding

Figure 2: Existence of free riding
Appendix

**Lemma 1:** \( \frac{d m}{d \beta} > 0, \frac{d h}{d \beta} < 0 \) (when the crossed effects \( R_{mh} \) and \( R_{hm} \) are sufficiently small.)

Starting with totally differentiating equation (2) and (3) in the paper, we get the following functions:

\[
\begin{align*}
R_{mh} \frac{d \beta}{d m} + \beta R_{mm} d m^* + \beta R_{mh} d h^* - C_{mm} d m^* &= 0 \\
R_{hm} \frac{d \beta}{d h} + (1 - \beta) R_{hh} d h^* + (1 - \beta) R_{mh} d m^* - C_{hh} d h^* &= 0
\end{align*}
\]

Based function set [1], we solve for \( \frac{d m}{d \beta} \) and \( \frac{d h}{d \beta} \):

\[
\frac{d h^*}{d \beta} = \frac{(1 - \beta) R_{mm} d m^* - R_{hh} \frac{d \beta}{d m}}{C_{hh} - (1 - \beta) R_{hh}}
\]

Substituting \( d h^* \) in the first equation of [1], we get \( \frac{d m}{d \beta} \):

\[
R_{mh} \frac{d \beta}{d m} + \beta R_{mm} d m^* + \beta R_{mh} \frac{d h}{d m} \frac{d h^*}{d \beta} C_{hh} - (1 - \beta) R_{hh} - C_{mm} d m^* = 0
\]

[2]

Similarly, we get

\[
\frac{d m}{d \beta} = \frac{[C_{hh} - (1 - \beta) R_{hh}] R_{mm} - [C_{hh} - (1 - \beta) R_{hh}] R_{mm} - \beta R_{mh} R_{hh} - \beta (1 - \beta) R_{mh}}{C_{hh} - (1 - \beta) R_{hh} R_{mm} - \beta (1 - \beta) R_{mh}}
\]

For the vector-valued revenue function \( R(m, h) \), we know that second-order partial derivatives \( R_{mm} = R_{hh} \) because of the symmetry property of the Hessian matrix. To make sure the revenue function has a maximum, it is necessary to get the conditions below based on the second partial derivative test: the determinant of the Hessian matrix is larger than zero \( M = R_{mm} R_{hh} - R_{mh}^2 > 0 \). Therefore the denominator \( [C_{hh} - (1 - \beta) R_{hh}] R_{mm} - R_{mh} R_{hh} - \beta (1 - \beta) R_{mh} \) of both expressions is positive. Because \( R_{mh} \) is quite small by assumption, we get \( \frac{d m}{d \beta} > 0, \frac{d h}{d \beta} < 0 \).

Further, \( \frac{d m}{d \beta} > 0, \frac{d h}{d \beta} < 0, \frac{d m}{d a} > 0, \frac{d h}{d a} > 0 \) (when the crossed effects \( R_{mh} \) and \( R_{hm} \) are sufficiently small). Since the value of the public goods \( a \) is chosen in stage 2, in the first stage, we turn back to the two variables situation and the proof is the same as in Lemma 1. Given incentives \( \beta \) set in stage 1, totally differentiating equation (2) and (3) yields functions:
\[ \beta R_{aw} dm^* + \beta R_{aw} dh^* + \beta R_{aw} da - C_{aw} dm^* = 0 \]

\[ (1 - \beta)R_{bh} dh^* + (1 - \beta)R_{aw} dm^* + (1 - \beta)R_{aw} da - C_{bh} dh^* = 0 \]  \[\text{(2)}\]

Then we solve for \( dm^*/da \) and \( dh^*/da \):

\[
\frac{dh^*}{da} = \frac{(1 - \beta) R_{aw} dm^* + (1 - \beta) R_{aw} da}{C_{bh} - (1 - \beta) R_{bh}}
\]

\[ \beta R_{aw} dm^* + \beta R_{aw} (1 - \beta) R_{aw} da + \beta R_{aw} (1 - \beta) R_{aw} da + \]

\[ [C_{bh} - (1 - \beta) R_{bh}] R_{aw} dm^* + \beta (1 - \beta) R_{aw} R_{bh} \]

\[ \frac{dm^*}{da} = \frac{\beta [C_{bh} - (1 - \beta) R_{bh}] R_{ma} + \beta (1 - \beta) R_{aw} R_{bh}}{[C_{bh} - (1 - \beta) R_{bh}] [C_{nn} - \beta R_{nn}] - \beta (1 - \beta) R_{nh}^2} \]

Similarly,

\[ \frac{dh^*}{da} = \frac{(1 - \beta) [C_{nn} - \beta R_{mn}] R_{ha} + \beta (1 - \beta) R_{ma} R_{nh}}{[C_{hh} - (1 - \beta) R_{hh}] [C_{nn} - \beta R_{mn}] - \beta (1 - \beta) R_{nh}^2} \]

It has been proved that the denominator of both terms is positive. Because \( R_{ma} > 0 \) and \( R_{ha} > 0 \) by assumption, we get \( dm^*/da > 0, dh^*/da > 0 \). Furthermore, as all the third derivatives are zero, it is easy to show that the values of \( dm^*/da \) and \( dh^*/da \) are constant.

**Lemma 2:** \( da^* / d \beta > 0 \)

Assuming zero third-order conditions and sufficient small cross second-order conditions, totally differentiating equation (18) \( \frac{dG}{da} = \beta R_a - C_a + \frac{dh^*}{da} \beta R_b = 0 \) gives:

\[ G_{aw} da + G_{aw} dm^* + G_{aw} dh^* + G_{aw} d \beta = 0 \]

\[ da^* = \frac{G_{aw} dm^* - G_{aw} dh^* - G_{aw} d \beta}{G_{aw}} \]

\[ \frac{dG}{da} > 0 \]

\[ G_{aw} < 0, G_{aw} = G_{aw} = 0 \]

\[ G_{aw} = R_a + \frac{dh^*}{da} R_b > 0, (R_a > 0, R_b > 0, dh^*/da > 0) \]

\[ \frac{da^*}{d \beta} > 0 \]

**Proposition 1:** \( d \beta / da < 0 \)

Totally differentiating equation (21), we get
By assuming that the cross second order effects are sufficiently small, we have

\[
\frac{d\beta}{da} = \frac{-R_\beta \frac{dm}{d\beta} \frac{dh}{d\beta} \frac{da}{R_\alpha} + \frac{dm}{d\beta} (1 - \beta^*) \frac{dm}{d\beta}}{\frac{dm}{d\beta} + \frac{dm}{d\beta} (1 - \beta^*) \frac{dm}{d\beta} + \frac{dm}{d\beta} \frac{dm}{d\beta} \frac{dm}{d\beta}} = 0
\]

(\text{Assume zero third-order conditions})

\text{Lemma 3:} \quad \frac{dm}{d\beta} / d\beta > 0, \frac{dh}{d\beta} / d\beta < 0, \frac{dm}{dr} / d\beta < 0, \frac{dh}{dr} / d\beta < 0 \quad \text{(when the crossed effects \( R_{mh} \) and \( R_{nm} \) are sufficiently small)}

Based on the profits functions (23) and (24), the first order conditions can be represented by equation (2) and (3). Therefore, we derive \( \frac{dm}{d\beta} / d\beta > 0, \frac{dh}{d\beta} / d\beta < 0 \) directly.

Totally differentiating equation (26) \( 1 - r \) \([\beta R_{n}(m^*, h^*) - C_n(m^*)]\) with respect to \( r \), we get:

\[
(C_n - \beta R_\alpha) \frac{dm}{dr} + (1 - r)(\beta R_{nm} \frac{dm}{dm} + \beta R_{nm} \frac{dm}{dh}) = 0
\]

\[
(C_n - \beta R_\alpha) \frac{dm}{dr} = \beta R_{nm} \frac{dh}{dr}
\]

From the equation above, it is obviously that \( \frac{dm}{dr} \) and \( \frac{dh}{dr} \) have the same sign. From equation (28):

\[
\frac{dG}{dr} = \beta R(m^*, h^*) - C(m^*) + \frac{dh}{dr} \frac{dh}{dr} \beta R(m^*, h^*) = 0
\]

To make the corruption problem relevant, we need to assume \( \beta R - C(m) > 0 \). Then to set the optimal corruption level, it is necessary to have \( \frac{dh}{dr} / d\beta < 0 \). Otherwise the government will choose the corner solution and always steal all the profits. If so, the design of the corruption level is independent of other factors, which is obviously not our interested question. Finally, because of the same sign, we prove \( \frac{dm}{dr} / d\beta < 0 \).

\text{Lemma 4:} \quad \frac{dr}{d\beta} > 0
Assuming zero third-order conditions and sufficient small cross second-order conditions, totally differentiating equation (28) gives

\[ G_r \cdot dr^* + G_m \cdot dm^* + G_h \cdot dh^* + G_r \cdot d \beta = 0 \]

\[ \frac{d \beta^*}{d \beta} = \frac{-G_m \cdot \frac{dm^*}{da} - G_h \cdot \frac{dh^*}{da} - G_r \cdot d \beta}{G_r} \]

\[ G_r < 0, G_h = 0 \]

\[ G_m = 0 \text{ (envelope theorem)} \]

\[ G_r \cdot \beta = R^* + \frac{dh^*}{dr} \cdot R_h > 0 \text{ (Given by equation 28)} \]

\[ \frac{d \beta^*}{d \beta} > 0 \]

**Proposition 3**: \( \frac{d \beta}{dr} > 0 \)

Assuming zero third-order conditions and sufficient small cross second-order conditions, totally differentiating equation (29) gives

\[ \Pi_h \cdot \beta^* d \beta^* + \Pi_m \cdot \beta \cdot dm^* + \Pi_h \cdot \beta \cdot dh^* + \Pi_h \cdot \beta \cdot d \beta^* = 0 \]

\[ \frac{d \beta^*}{d \beta} = \frac{-\Pi_m \cdot \frac{dm^*}{dr} - \Pi_h \cdot \frac{dh^*}{dr} - \Pi_h \cdot \beta \cdot d \beta}{\Pi_h \cdot \beta \cdot \beta} \]

\[ \Pi_h \cdot \beta \cdot \beta < 0, \Pi_m \cdot \beta = -R_m < 0, \Pi_h \cdot \beta \cdot h = -R_h < 0 \]

\[ \Pi_h \cdot \beta \cdot r = -R_m \cdot \frac{dm^*}{dr} - R_h \cdot \frac{dh^*}{dr} > 0 \]

\[ -\Pi_m \cdot \frac{dm^*}{dr} - \Pi_h \cdot \frac{dh^*}{dr} - \Pi_h \cdot \beta \cdot r < 0 \cdot \frac{dm^*}{dr} < 0, \frac{dh^*}{dr} < 0 \]

\[ \frac{d \beta^*}{d \beta} > 0 \]