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On the gains of committing to inefficiency: Corruption, deforestation and low land productivity in Latin America

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Abstract

We present a new explanation and empirical evidence showing that rural subsidies to large farmers tend to be associated with low land productivity and excessive deforestation. We develop a lobbying model where wealthy farmers trade bribes or political contributions to government politicians in exchange for subsidies; farmers are able to tilt the terms of the bargaining game with policy makers in their favor by pre-committing to an inefficient choice of semi-fixed inputs. Government proneness to accept political contributions or bribes and its willingness to provide subsidies cause farmers to adopt inefficient modes of production as a mechanism to capture such subsidies. Our predictions are consistent with stylized facts on land use in Latin America, and suggest that subsidy schemes have been counterproductive—distorting and constraining development, and triggering excessive depletion of natural resources. We validate some of the predictions of the model through econometric analyses using a new data set for nine countries in Latin America.

Keywords: Corruption; Subsidies; Cattle ranching; Inefficiency; Low agricultural productivity; Tropical deforestation

1. Introduction

Government subsidies to resource-intensive industries are ubiquitous. For example, global farm subsidies exceed \$500 billion per annum [33], subsidies to fishing are estimated at between \$15 billion and \$21 billion [31] and subsidies to the energy and coal sector approximate \$245 billion per annum [21]. Subsidies are generally considered economically inefficient as they tend to distort prices and trade patterns, and are a blunt instrument to address social or economic objectives.

This paper provides a rigorous explanation for the persistence of mainly perverse subsidies. By developing a lobbying model, where producers can 'purchase' subsidies by bribing or by providing political campaign

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contributions or other less tangible benefits to elected politicians, this paper provides a formal analysis of the political economy aspects of subsidy provision. We theoretically and empirically show that a greater government's proclivity to provide (non-social) subsidies leads producers to choose more extensive modes of production thus lowering resource or land productivity. Producers thus have the ability to pre-commit to extensive (often inefficient) modes of production, which in agriculture means over-investing in land, as an instrument to attract public subsidies when governments are corrupt or prone to exact political contributions. Large land holdings play not only a productive role but also constitute a signal by producers to government that they can obtain greater benefits from government subsidies and, consequently, are willing and able to pay greater bribes or to support incumbent politicians campaigns to remain in office.

While the subsidy and pre-commitment issue is global in scale, and our analysis applies to a much wider set of subsidized resource-based industries, the motivation and focus of this paper is on agricultural subsidies in Latin America, where agriculture often expands onto forested areas. These countries inherited institutions that benefit elite groups at the expense of the majority of the population [11,35]. About 50% of the total rural government expenditures in Latin America are subsidies to private goods instead of expenditures related to the provision of public goods [28,1,23]. These include subsidized public credit to selected producers, grants directed to particular activities, marketing promotion targeting specific crops, free irrigation services financed with public monies directed mainly to a small number of often wealthy producers, fertilizer subsidies and so on [11]. Findings suggest that these subsidy schemes have been counterproductive—distorting and constraining development, lowering productivity, and triggering excessive expansion of farmland and possibly depletion of forests and other natural resources.

We validate some of the predictions of the model through econometric analyses using a new panel data set for nine countries in Latin America over the period 1985–2000. In particular, our empirical analyses show that: (i) More corrupt governments tend to spend more in (non-social) subsidies mainly directed to wealthy producers to the detriment of public and social goods; (ii) Government subsidies to the rural sector significantly reduce agricultural land productivity; and (iii) Government subsidies, *ceteris paribus*, promote the expansion of the agricultural land area and induce more deforestation.

This application of the model to Latin America is of general economic and policy significance for at least two reasons. First, the analysis provides a novel political economy explanation of the widely documented 'inverse farm size-productivity' relationship in developing countries that has been considered to be particularly relevant to Latin America [9]. Our model suggests that this phenomenon is consistent with income maximizing behavior of subsidized industries and rent-seeking policy makers. While it is often argued that rural subsidies are necessary to stimulate development in backward regions, our results suggest that the effect may be the opposite of what is intended—subsidies can contribute to rural stagnation. Second, extensive agricultural systems have led to excessive expansion of agricultural land into forested areas and other environmentally sensitive ecosystems [18,10]. The resulting external costs are likely to spill over beyond the region, and have global repercussions.

Some authors have argued that low agricultural yields lead to greater deforestation pressures as farmers would need more land to sustain their income, providing an incentive to convert forest land into agriculture. Others have pointed out that low yields mean low returns to land (and low land values) and, therefore, reduced incentives to deforest. A consensus has recently emerged in the sense that the first argument applies mostly to poor subsistence farmers whose main objective is to survive while the second argument is more relevant for commercial profit maximizing operators [25,4]. We show that the relationship between these two endogenous variables, deforestation and agricultural yields, critically depends on the underlying processes causing their changes. We show that low agricultural yields are likely to be associated with more deforestation even for profit-seeking commercial farmers if subsidies are guided by political economy and corruption.

The paper is organized as follows. In Section 2 we sketch the existing literature and stylized facts on land use in Latin America. In Section 3 we develop the lobby model and in Section 4 we present the main results. Section 5 presents the econometric estimates that support much of the theoretical results. Finally Section 6 concludes.

2. Low agricultural productivity: stylized facts and related literature

Some studies have tried to explain low productivity by appealing to "structural problems" associated with a high concentration of wealth and land. Land ownership would be a means to save taxes, speculate on appreciation of land prices, or exploit imperfections in credit and other markets, rather than merely a factor of agricultural production [9,7]. Another view is that agriculture tends to be excessively extensive because the sector has been discriminated against, especially through biased trade policies and exchange rate overvaluation that resulted in low prices for agricultural commodities [24]. While several countries have implemented land reform and/or eliminated much of the above macroeconomic distortions, policy reforms have rarely led to major increases in land productivity despite or, we argue, because many of the input subsidies have remained in place.[1]

An interesting illustrative case is the cattle industry in the Amazon. Early studies argued that large-scale cattle ranching was ecologically unsustainable and unprofitable [12,20]. More recent studies regard cattle as an economically attractive venture for small and large producers alike [30,2,16,38]. Yet governments implemented large subsidy programs. Also, if farmers rationally raise cattle for profit, why do not they exploit the many apparently profitable investments to intensify production and increase profits? Intensification investments have lagged behind the levels recommended by agronomists and economists, depressing profits even during the subsidy decades [22]. Low input strategies may be partly explained by expectations about land appreciation [34], but this provides only part of the explanation [16]. Moreover, while slow adoption of new technologies by smallholders may be the result of capital constraints and market imperfections [38], this explanation does not go for the large farmers (the focus of this study) which are unlikely to lack access to capital and new technologies.

We suggest that in order to shed light on these issues it is helpful to invoke a lobbying model. It is plausible that groups lobby for support by offering bribes or political contributions to government officials as emphasized, for example, in [11,16]. We abstract from many considerations that complicate land use in Latin America (including encroachment by squatters or other sources of tenure insecurity),[2] and present a new hypothesis for low land productivity in agriculture. We postulate that competition for government input subsidies accessible through lobbying provides a consistent explanation for low productivity and rapid land expansion into frontier areas. In order to secure subsidies, farmers credibly commit to an inefficiently extensive mode of production. Large land farm size and, concomitantly, an overly extensive mode of production signals two things: (1) That the value of government-provided inputs to large-scale farmers using extensive methods is larger than for those that have already more intensive production systems. (2) That farmers owning a lot of land and using extensive methods are more able and willing to provide bribes, political campaign contributions and/or political influences in favor of incumbent government politicians in exchange for greater government contributions than small and intensive farmers. As a result, large-scale extensive farm operators are able to monopolize most of the public subsidies. We show that as a consequence of the extensive farming system with under provision of private inputs both government officials and farmers gain compared to a situation without bribes or political contributions and a socially optimal input-land mix.

3. The lobbying model

The ensuing model explains why subsidies are in the interest of government officials and farmers, and why fiscal incentives might constrain rather than promote development and efficient resource usage. The model is in the tradition of Grossman and Helpman [19] (hereafter GH), where private parties might purchase 'favorable' policies from the government in exchange for bribes or political contributions. The outcomes in

[1] An important feature to keep in mind is that agricultural input subsidies are generally captured by a small subset of the large farmers, *mostly* those that have the lowest land productivity.

[2] It is often argued in the literature that putting land to use implies securing tenure rights in the Amazon [3]. Tenure insecurity thus provides an important alternative explanation for very extensive production patterns—if landowners care about maintaining landownership rather than profits from agricultural production per se (perhaps for speculative reasons), then some extensive form of management might be rational. But note that it is unclear why extensive patterns of land use to fend off encroachment would qualify for public support through subsidies. Which explanation is more apt requires an extensive empirical analysis and is left for future work.

these models are locally truthful, implying that the size of the bribe is related to the gain associated with the new policy.[3]

Here we extend the GH [19] framework by adding a commitment mechanism in an extra stage of the game. Certain investments are in semi-fixed inputs such as heads of cattle, land, and pasture quality. The level at which such inputs are supplied is unlikely to change in the short run because of considerable transaction costs—purchasing land requires formal procedures. This implies that farmers can credibly commit to either an intensive or extensive style of production by selecting the appropriate combination of such inputs. For example, by clearing extensive tracts of forest for (natural) pasture and choosing low stocking rates, farmers can signal that they will employ an extensive production pattern. Semi-fixed inputs are then combined with 'variable inputs' to produce output. Thus, we can use a three-stage lobbying model: (1) The farmer chooses land (hectares) and the intensity of land use (investment in pasture productivity, stocking rates); (2) The government optimally chooses the level of public support for farmers by maximizing a weighted average of social welfare and bribes/transfers; (3) The farmer combines inputs (public and private) to maximize profits.

Governments have typically employed several fiscal mechanisms to promote agricultural development [10,16]: (i) direct financial support through shareholder participation and grants, (ii) exemptions (reductions) of duties, sales and income taxes, (iii) reinvestment of a considerable fraction of the income tax of the original project in the form of capital increases and (iv) subsidized credit. In other words, a substantial share of the government support took the form of providing farmers with private goods (such as cash or investment funds) that are near perfect substitute for private investment funds and savings. Another important set of support measures are public investments in infrastructure, marketing or other services.

Rather than model the effects of each particular subsidy scheme, we adopt a more general approach and assume that government assistance takes the form of provision of government-supplied inputs that are perfect or good substitutes for privately purchased inputs.[4]

Assumptions on the production technology: Turning to the formal model, farm output Q is described by the following production function:

$$Q = f(Y, A, h, g^h), \tag{1a}$$

and

$$Y = y + \phi(g^y), \tag{1b}$$

where $f(\cdot)$ is total production. As arguments in the production function we include a variable input Y, semi-fixed privately provided factors h, a government-provided semi-fixed input g^h, and land, A. The variable input Y, may either be purchased privately, y, or could be supplied by the government, $\phi(g^y)$, where $\phi(g^y)$ is the government-provided variable input in efficiency units with $\phi' > 0$, $\phi'' < 0$. Consistent with the observation that subsidies for variable inputs are typically provided in the form of subsidized short-term credit, we assume that private and public variable inputs are perfect substitutes. Define Condition B on the production technology:

Condition B. *The production function is*: (1) *strictly increasing and concave in its arguments*; (2) *Homothetic*; (3) *the marginal productivity of each input is increasing in the level of other inputs. Thus* (*with subscripts denoting partial derivatives*):

$$f_i > 0, \quad f_{ij} > 0 \quad \text{and} \quad f_{ii} < 0 \quad (\text{for } i \neq j, i,\ j = Y, h, g^h, A). \tag{2}$$

The assumption $f_{ij} > 0$ is the standard assumption of gross complementarity, which, since there are more than two inputs, does not impose any restriction on the sign of the Hicksian elasticities of substitution. Further, the assumption of homotheticity in production is convenient but not essential to our results. In the proofs of the ensuing propositions we outline the consequences of eschewing this assumption, where relevant.

We assume that inputs h and g^h are imperfect substitutes, because often public subsidies take the form of semi-fixed inputs such as services and infrastructure that may be distinctly different from the inputs that

[3]The 'policy for sale' literature has been employed to study protectionism [19], pollution control [17], land use [26] and other topics.

[4]In an Appendix available from the authors we show that the main results also hold when subsidies take the form of tax exemptions.

farmers themselves buy on markets. It is reasonable, however, to assume that h and g^h are closer substitutes than g^h and A (land). This implies Condition H.

Condition H. *The Hicksian elasticity of substitution between h and g^h is greater than that between g^h and A. That is*: $\sigma^{g^h h} > \sigma^{g^h A}$, *where* $\sigma^{g^h j} = (f_{g^h}/f_j)/(g^h/j)(d(g^h/j)/d(f_{g^h}/f_j))$.

The three stages of the lobbying game are solved recursively, starting with stage 3.

3.1. Stage 3: choosing optimal levels of the privately supplied variable input

The producer: The farmer chooses y to maximize profits, taking as given all variables chosen in preceding stages:

$$V(w, P; h, g^{h,}, A) \equiv \operatorname*{Max}_{y}\{Pf(Y, h, g^h, A) - wy\}, \tag{3}$$

where w, r and v are the costs of inputs y, A and h, respectively, and P is the given price of output (which we assumed exogenous to the farmer). The function V is the dual variable profit function.[5] Differentiating with respect to y:

$$Pf_Y(Y, h, g^h, A) - w = 0. \tag{4}$$

Solving (4) the optimal solution may be expressed as

$$y^* + \phi(g^y) = B(w, P, h, g^h, A) \;\; \Rightarrow \;\; y^* = B(w, P, h, g^h, A) - \phi(g^y). \tag{5}$$

For future reference note that by total differentiation of (4) the following comparative static properties hold:

$$\frac{dy^*}{dh} > 0, \quad \frac{dy^*}{dg^h} > 0, \quad \frac{dy^*}{dA} > 0, \quad \frac{dy^*}{dg^y} < 0. \tag{6}$$

Thus greater investment in semi-fixed inputs, increases farm capacity and induces greater expenditure on variable factor, y. On the other hand, since y and g^y are perfect substitutes, government supplies of the variable input lowers the need for private purchases.

3.2. Stage 2: the political equilibrium

Following GH [19] we assume that producers seek to influence government supplies of each input by offering political contributions or bribes. The political contributions or bribes denoted S^i ($i = h, y$), are chosen to maximize:

$$\tilde{\Pi} = V(w, P, h, g^h, A) + w\phi(g^y) - rA - vh - S^h - S^y. \tag{7}$$

The first order conditions (FOCs) are:

$$\frac{\partial \tilde{\Pi}}{\partial S^h} = V_{g^h}\frac{\partial g^h}{\partial S^h} - 1 = 0. \tag{8a}$$

Since $V_{g^h} > 0$, an interior solution to (8a) only exists if $\partial g^h/\partial S^h > 0$. Thus by the inverse function rule (8a) can be rearranged to yield:

$$V_{g^h} = \frac{\partial S^h}{\partial g^h}. \tag{8b}$$

Eq. (8b) reveals that bribes are truthful in the sense that producers pay a bribe to the government up to the point where the marginal cost of the bribe, $\partial S^h/\partial g^h$, equals the marginal benefit in the form of higher profits,

[5] V is increasing in P, h, A and declining in w. It is homogenous of degree one in output price, P and input price, w. Moreover, it preserves all the properties of the production function and is therefore increasing and concave in h, g^h and A ($V_i > 0$, $V_{ii} < 0$, $V_{ij} > 0$ ($i \neq j$, i, $j = h$, g^h, A)).

V_{g^h}. This is the local truthfulness condition of the common agency model by Bernheim and Whinston [8] and GH [19].

Analogously, the FOC for S^y is given by

$$w\frac{\partial\phi(g^y)}{\partial g^y} = \frac{\partial S^y}{\partial g^y}. \tag{8c}$$

In what follows we focus on interior solutions. Let S^{h^*} and S^{y^*} be the solutions to (8b) and (8c). For future interpretation we determine how bribes vary with investments in A and h in stage 1 of the game:

Lemma 1a. *Assume that Conditions* B1 *and* B3 *are satisfied. Then* $dS^{h^*}/dA > 0$, $dS^{h^*}/dh > 0$.

Proof. See Appendix.

Thus, an increase in A, translates into an increase in the optimal bribe. Intuitively, an increase in land area raises the marginal productivity of the semi-fixed input g^h supplied by the government. Thus, by truthfulness the equilibrium bribe increases. Similarly, since g^h and h are gross complements by B3, an increase in h raises the marginal product of the government-supplied substitute (g^h) and, by the truthfulness property of the equilibrium, the optimal bribe increases. Furthermore:

Lemma 1b. *Assume that Conditions* B1 *and* B3 *are satisfied. Then* $dS^{y^*}/dA = 0$, $dS^{y^*}/dh = 0$.

Proof. See Appendix.

Lemma 1b states that variations in h and A have no impact on the optimal bribe for input g^y. The reason is obvious from (5), and follows from the fact that Y is a variable input. The farmer eventually chooses the optimal amount of the private input by equating marginal benefits and costs of the variable input, taking into account supplies of the variable input by the government. However, as government and private inputs are perfect substitutes, public supplies "crowd out" private supplies on a one-to-one basis: $dy/d\phi = -1$. The value of additional public supplies is entirely determined by the savings on private supplies. While A and h will determine the total supply of the variable input Y, they do not affect the value of this input at the margin, which is simply the cost of the variable input w (independent of both h and A).

The government: The government's objective function is a combination of social welfare and transfers from the farmers. Social welfare, W, is defined by profits, less the costs of government supply of inputs. That is: $W = V(w, P, h, g^h, A) + w\phi(g^y) - rA - vh - c^y g^y - c^h g^h$, where c^i ($i = h,y$) is the cost of government supplied inputs, which is assumed to incorporate any social distortions arising from the need to raise funds—whether by taxation or debt financing. Thus, the government's utility function is

$$U = S^{h^*} + S^{y^*} + \alpha W, \tag{9}$$

where α is the weight given to social welfare in the objective function. The value of α is inversely related to the degree of corruption of the government. Using (8b) and (8c), the FOCs for the choice of g^i ($i = h$, y) are:

$$(1+\alpha)V_{g^h} - \alpha c^h = 0 \tag{10a}$$

and

$$(1+\alpha)w\frac{\partial\phi(g^y)}{\partial g^y} - \alpha c^y = 0. \tag{10b}$$

The interpretation of (10a) and (10b) is that the government supplies an input (fiscal benefits) to farmers until the marginal cost of the input (summing the provision cost and social distortions) are equal to the marginal benefits (or the sum of the increase in producer surplus, and the marginal benefit to the government from the bribe).

3.3. Stage 1: choosing semi-fixed inputs

The farmer: Finally, in stage 1 optimum levels of A and h are chosen simultaneously to maximize:

$$\operatorname{Max} \hat{\Pi} = V(w, P, h, g^h, A) + w\phi(g^y) - rA - vh - S^{y^*} - S^{h^*}. \tag{11}$$

The FOC for the choice of A is

$$V_A(P, w, h, g^h, A) - r + V_{g^h}\frac{dg^h}{dA} - \frac{\partial S^{h^*}}{\partial g^h}\frac{dg^h}{dA} = 0. \tag{12a}$$

Using (8b) to eliminate $\partial S^{h^*}/\partial g^h$, (12a), simplifies to

$$V_A(P, w, h, g^h, A) = r. \tag{12b}$$

Similarly the FOC for h simplifies to

$$V_h(P, w, h, g^h, A) = v. \tag{12c}$$

How do government policies vary with farmers' investment decisions and how does corruption influence private investment decisions? These issues are taken up in the following section.

4. Model results

We begin by assessing the effects of private investment decisions on the provision of inputs supplied by the government.

Proposition 1. *Assume that Conditions* B1 *and* B3 *are satisfied. Given the landowner's choice of A in the game's first stage, a higher level of investment in land induces higher levels of government expenditure on the semi-fixed inputs g^h, but has no impact on the supply of variable input g^y (i.e. $dg^h/dA > 0$, $dg^y/dA = 0$).*

Proof. See Appendix.

The intuition for this result is the following. *Ceteris paribus*, an increase in land holdings (A), raises the marginal productivity of semi-fixed inputs. Since the optimal bribe is increasing in the profitability of production (see (8b)), the bribes paid to the government increase and as a consequence the supply of government input g^h rises. On the other hand, variations in land holdings have no impact on the bribes paid for the variable input (Lemma 1b); hence their supplies are unaffected. Using similar techniques (see Appendix) we can show that $dg^h/dh > 0$, $dg^y/dh = 0$ holds. Since g^h and h are gross complements, greater investment in h raises the scope for further increasing the marginal profitability of production through the provision of additional government inputs. Hence the supply of government inputs rises. However, whether land use becomes more or less intensive as a consequence of bribery depends critically upon the aggregate investments levels in all variable and semi-fixed inputs relative to land—an issue that we address in the following propositions. Turning to variable inputs, it still holds that the value of additional public supplies to the rancher is determined by how much can be saved on private supplies (or: $w\phi$). Increasing the level of semi-fixed inputs affects the supply of variable inputs, but not the incentive to pay bribes (Lemma 1b). Supply of public inputs is unaffected.

We now assess the affects of corruption on private investment decisions. Specifically, we consider the effect of lobbying on the intensity of land use, and we compare levels of land use (deforestation) under lobbying to those under welfare maximizing behavior.

Proposition 2a. *Assume that Conditions* B *and* H *are satisfied. Then as the level of corruption increases, the ratio of private investment in semi-fixed inputs (h) relative to land (A), declines (i.e. $d(h/A)/d\alpha > 0$).*

Proof. See Appendix.

Recall that a *decline* in α represents a *greater* preference for bribes, or a higher level of corruption. Proposition 2a reveals that as corruption levels rise (α declines), there is less investment in semi-fixed inputs (h) relative to land (A). Farmers voluntarily under-invest in semi-fixed inputs, even though further investment remains sufficiently profitable. The reason is that by choosing low levels of inputs for their semi-fixed factors, farmers commit to an extensive farming style and leverage greater support from the government. An extensive mode of production thus 'tilts' the political equilibrium in the favor of farmers. Because of the truthfulness of the equilibrium, valuable public services translate into higher bribes, and a government that is receptive to interest groups will be induced to increase the level of assistance to farmers.

The implications of this finding on development are complex. The country as a whole unambiguously loses because of lobbying. In addition to the potentially distorting effects of taxation to finance the flow of transfers to the frontier, lobbying causes an inefficient agricultural production choice and wasteful conversion of tropical forests. This is evident when we consider the effect of lobbying on resource depletion: let A^{w} be the optimal investment in land in the absence of lobbying, and let A^{L} be investment in land with lobbying as defined in (12b):

Proposition 2b. *Assume that Conditions* B1 *and* B3 *are satisfied. Then corruption induces over-investment in land relative to that which occurs in the absence of lobbying* ($A^{\mathrm{L}} > A^{\mathrm{w}}$).

Proof. See Appendix.

The intuition for this result is similar to the one above—by 'developing' large tracts of land farmers increase the value of government transfers at the margin, and thus signal their willingness to pay for such policies. Corrupt governments are sensitive to this signal. The implication is that farmers exploit too much land and, from a social perspective, excessive deforestation occurs.[6]

Next, we turn to the issue of land use intensity. The main result is summarized in Proposition 3.

Proposition 3. *Define I^* as agricultural intensity measured as the total shadow value of inputs* (*i.e., valuing each input at its respective true shadow price*) *per hectare of land in production and I as agricultural intensity defined as the total input value per hectare measured at market prices. Assume that Condition* B *is satisfied. A small increase in corruption* (*starting from no corruption*) *will lower I^* if and only if the elasticity of substitution between land, A, and government-provided inputs, g_h, is less than one. Increasing corruption lowers I starting from any initial level of corruption* (*not necessarily zero*) *if the same condition holds.*

Proof. See Appendix.

Though, as shown in Proposition 2a, government corruption reduces the total level of private inputs per unit of land, this does not mean that the overall level of agricultural intensity falls. The reason is that corruption also causes a greater supply of government-provided inputs. Whether or not 'total agricultural intensity,' defined as an aggregate measure that encompasses private inputs such as stocking rates and pasture management and public inputs like farm infrastructure per unit of land, falls or rises depends on whether or not corruption increases government inputs by less than the induced reduction of private inputs. Proposition 3 derives the necessary and sufficient condition for overall agricultural intensity to fall. The degree of substitutability between land and government-provided inputs is the crucial parameter. It shows that under homothetic production, greater corruption induces a fall in the non-land input to land ratio if the elasticity of substitution between land and government-supplied inputs (not to be confused with the elasticity of substitution between public and private variable inputs) is less than one—which we consider a plausible assumption.

The intuition behind this result is as follows: greater corruption reduces the "price" (paid as bribes) of government-supplied inputs, and consequently increases the use of such inputs by farmers. This causes an output expansion effect and an input substitution effect. Consider first the substitution effect only (keeping output constant). If the implicit price of g^h (η, see Appendix) falls, so does the total cost of production, given

[6]Note that a similar result might be obtained assuming the government is a traditional welfare-maximizing planner, and that this result then even holds in the absence of bribes. Then ranchers choose to commit to an extensive farming style *ex ante*, knowing that the planner will correct any misallocation of inputs *ex post*. However, the available evidence on corruption in Latin America indicates that our assumption of a less than perfectly altruistic and benevolent planner is more realistic. For instance, in the corruption rankings provided by Transparency International, the most honest governments receive a score 10. The average score for the 14 member countries of the EU is 7.5, the score for the USA is 7.7, while that of Brazil is only 4. This clearly suggests that corruption plays an important part in shaping policies.

the initial output level. The level of land falls if land and the government input are substitutes or, alternatively, it increases if they are complements. If they are complements ($\sigma^{g^hA}<0$), then the share of land in the total cost must increase, which means the ratio of the value of all other inputs over the land value (or per hectare of land as the land price is fixed) is reduced (i.e., I falls). If, however, A and h^g are substitutes ($\sigma^{g^hA}>0$) then A will be reduced as η falls (corruption increases). If the proportional reduction of A is less (greater) than the proportional decrease of the total cost of production then the share of the non-land costs must fall (rise). Input intensity, I, will be reduced (increased). If A decreases at the same rate as the total cost falls then the share of all non-land inputs remains constant and I also must remain unchanged. The elasticity of substitution between A and g^h is equal to the ratio of the demand elasticity of A with respect to η divided by the cost share of g^h [13]. A fall of η causes the total cost to be reduced at the margin by the share of g^h, and the proportional change in the level of land used in response to a change in η is given by the demand elasticity of A with respect to η. Thus, an elasticity of substitution less (greater) than one causes I to fall (increase) in response to a lower level of η. If the elasticity of substitution is equal to one I is not affected by η.

The above analysis reflects the substitution effect *keeping the total output level constant*. But a fall of η also brings about an increase in output which, in turn, causes land and other inputs to increase thus, in principle, further affecting I.[7] If the production function is homothetic, however, the output effect causes each input to change by the same proportion. Therefore, under homothetic production the scale effect plays no role on factor intensity.

5. Empirical evidence

We have developed a novel theory to explain inefficient land use in Latin America. There are alternative theories, such as the one based on weak property rights advanced by Alston et al. [3]. A ''horse race'' of these competing theories—evaluating which theory explains the data best—is beyond the scope of this paper. Instead, we argue that these theories might be complementary, and we simply focus on determining whether our theory is supported by the data. Our model suggests the following testable hypotheses, which we empirically evaluate below.

5.1. Subsidies lower agricultural productivity and tend to be higher when agricultural productivity is low

The data: Evidence of the impact of rural subsidies is studied from a new data set of public expenditures recently released. The data disaggregate public expenditures in rural areas into several categories that permit separation between expenditures on public goods and on private goods. The annual data covers the period 1985–2001 for nine countries in Latin America.[8] The Food and Agricultural Organization (FAO) prepared the data with support of the World Bank. An advantage of this data set is that it is highly disaggregated while at the same time it has been measured using a reasonably consistent methodology across countries and over time. In addition, the public expenditure data as provided is comprehensive, covering the vast majority of the items in which the public sector spends money in the rural areas. The level of detail of the data allows us to obtain a fairly accurate measure of the evolution of the level and composition of government expenditures in rural areas over the period.

The data for public expenditures in the rural sector covers all rural expenditures, including expenditures for agriculture as well as rural infrastructure, animal and plant sanitary protection, environmental expenditures, and social services to rural areas. The latter group covers expenditures in rural education, health, and other social sectors. All in all, rural public expenditures are disaggregated into 13 categories. The expenditure groups are the following (in parentheses the average share in total public expenditure for the year 1995): production promotion (18.1%); domestic and foreign marketing promotion (8.1%); irrigation (12.5%); technological generation and transfers (7.9%); soil conservation (1.3%); forest, aquaculture and fishery promotion (4.5%);

[7] In fact, as Proposition 2b shows, the scale effect is more powerful than the substitution effect, so that the level of land use, A, necessarily increase as corruption increases.

[8] The countries included in the sample are Costa Rica, Dominican Republic, Honduras, Panama, Paraguay, Peru, Uruguay, Ecuador and Venezuela.

plant and animal sanitation (4.7%); communications and information (0.3%); "focalized" expenditures directed to particular commodities (9.4%); integral rural development (4.1%); rural public infrastructure (7.7%); land acquisition programs (2.8%); and social services (18.5%).

Private vs public government expenditures: To allocate the above expenditures into private vs public goods we follow the conceptual taxonomy proposed by López [27]. Among the items that according to such taxonomy clearly qualify as public goods are technology generation and transfers; soil conservation; rural public infrastructure of unrestricted use; plant and animal sanitary protection; communications and information services; and social services. The above expenditures were classified as public goods because they increase the supply of services that generate important positive externalities and in part palliate the effects of market failure. Alternatively these expenditures roughly satisfy at least one of the criteria for pure public goods (non-excludability and non-rivalry).

Items that were considered private goods are commodity-specific or focalized expenditures; so-called domestic and foreign marketing promotion; production promotion; and irrigation expenditures. An important portion of "market promotion" and production promotion includes direct subsidies and credit subsidies to mostly well-off producers, which are not likely to suffer the effects of failures in credit markets. Most irrigation services target a limited number of farmers, excluding everyone else. Also irrigation services do not satisfy the indivisibility criterion for a public good.

The third group (the gray group) includes the categories of forestry, aquaculture and fishery promotion; integral rural development programs; and land acquisition programs. A high proportion of the forest, aquaculture and fishery promotion expenditures were allocated to private goods since the main recipients of the subsidies are private producers and in most cases it was considered that these subsidies were not directed to palliate market failures. In fact, in many cases they tend to exacerbate rather than ameliorate environmental and natural resource externalities. Integral rural development expenditures and land acquisition program expenditures are subsidies to promote particular patterns of agricultural expansion that the planners desire but also have components that include public goods such as technological extension and local infrastructure. We use a 50–50 distributional allocation between private and public goods for these categories.[9]

Table 1 provides a summary of the data, including an overview of the total public expenditures in rural areas and its public good/private good distribution for the nine countries studied using average annual values for the 1985–2001 period (Panel B). On average, 51% of the total government expenditures in rural areas were spent in private goods, while 49% was spent in public goods.

Total rural expenditures showed some real changes in several countries over time, especially in the period 1995–1999, a period in which they decreased an average of almost 27% per country. But there is a dramatic variability across countries in this respect. The structure of government expenditures changed quite significantly over the period. The average per country share of subsidies in total expenditures substantially declined, particularly over the last five years of the period. The average share of subsidies steadily fell from 54% in 1985–1989 to 46% in 1995–1999. Moreover, in practically all countries the proportion of subsidies in total government expenditures decreased or remained stable, the exceptions being Peru and Paraguay. The structure of public expenditures, not surprisingly, varies a lot across countries.[10] López and Galinato [28] provide further details about the data and conceptual justifications used to perform this analysis. The rest of the data including agricultural and non-agricultural GDP, rural population, agricultural land area and others are obtained from the World Bank data bank.

We thus relate agricultural productivity to the level of total government expenditures in rural areas (normalized per hectare) and to the share of subsidies in total rural government expenditures. We also control

[9]Given the inevitable divergent views about the classification of some items into one or the other category, we did perform some limited sensitivity analysis to check for the robustness of the results to the classification criteria. The main results are robust with respect to varying the classification criteria.

[10]Moreover, it also exhibits a meaningful and large variability within countries over time. These large and seemingly meaningful variances are extremely important features, which allow us to appropriately use panel data econometrics, including fixed effects methods [32].

Table 1
Summary statistics of selected data

Variables	Mean	Std. dev.	Minimum	Maximum
(a) Summary statistics				
Share of non-social subsidies in public expenditures in the rural sector	0.503	0.247	0.023	0.952
Index of trade openness	−14.221	22.452	−62.500	53.800
Agricultural GDP per capita in 000s dollars (1995 = base)	955.187	950.933	207.222	4894.981
Total per capita public expenditures in the rural sector in 000s dollars (1995 = base)	142.399	230.582	5.880	1269.551
Non-social subsidies per capita in 0000s dollars (1995 = base)	61.509	68.843	0.207	303.675
Public goods expenditure per capita in 000s dollars (1995 = base)	80.891	189.531	2.564	1012.771
Land area in agriculture per capita in 000s of hectares	8.856	13.983	0.406	56.517
Non-agricultural GDP per capita in 000s of dollars (1995 = base)	3721.179	1891.042	478.183	9399.091
Crop price index	0.928	0.109	0.636	1.178
Income per capita of 40% poorest in the rural sector	134.28	74.840	35.230	291.250

(b) Country statistics

	Costa Rica	Ecuador	Honduras	Panama	Paraguay	Peru	Dom. Rep.	Uruquay	Venezuela
Subsidies (% of total)	127.04	100.17	4.29	50.18	20.09	200.69	157.36	51.03	174.45
	(48.44)	(68.87)	(8.61)	(51.35)	(31.89)	(63.52)	(79.55)	(18.52)	(53.77)
Public goods (% of total)	135.23	45.27	45.56	47.55	42.90	115.27	40.45	224.46	150.00
	(51.56)	(31.13)	(91.39)	(48.65)	(68.11)	(36.48)	(20.45)	(81.48)	(46.23)

Source: FAO (Regional Office for Latin America and the Caribbean and Main Office) and World Bank. Country statistics: annual country averages 1985–2001, in millions of 1995 US$.

for various other factors that could play a role in affecting agricultural productivity, such as the economy's openness to international trade, exchange rate overvaluation and others.[11]

Econometric methods: The estimated coefficients associated with the public expenditures and expenditure composition variables on agricultural output per hectare can be affected by two types of biases: (1) Omitted variable biases due to the fact that there may be unobserved country characteristics which are correlated with our government expenditure variables, potentially leading to spurious correlation; (2) Reverse causality biases. That is, a positive correlation between public expenditures and agricultural productivity may emerge when, for example, a more productive agriculture induces the government to spend more in the sector, and perhaps to spend more on public goods as a proportion of total expenditures. Reverse causality may also be caused by governments offering greater subsidies to areas that have low productivity and, hence, a relatively poor population.

The econometric estimates of agricultural productivity presented below deal with these biases in two ways: (1) The use of two-way fixed effect (FE) estimators allows us to control at least for unobserved country characteristics that are fixed over time (soil quality, plant diseases, climatic features not so easily accounted for by the usual measures of temperature and precipitation, etc.), as well as for time shocks that are common to all countries. Also, for comparison purposes we provide random effect (RE) estimators, which consider cross-country heterogeneity as random rather than fixed. (2) The use of a dynamic generalized method of moments (GMM) estimation allows us to reduce the risks of simultaneous equation biases due to the fact that the GMM as originally proposed by Arellano and Bover [5] uses as instruments a complete set of predetermined variables. Moreover, standard statistical tests (i.e., the Sargan test) permit one to verify the validity of the instruments (a test of the hypothesis that the instrumental variables are uncorrelated with the residuals).

[11]The indicator of trade openness is intended to measure the degree of openness of trade *policy* rather than trade volumes. A common measure of trade openness is the total value of trade over gross domestic product (GDP), i.e. $(exports + imports)/GDP$. However, this measure overestimates the policy openness of small countries that trade more even with a lot of trade protectionism and understates trade openness of large countries that trade less even if they have a liberal trade regime. For this reason, we normalize trade flows as in López and Galinato [28].

Table 2
Determinants of agricultural productivity: regressions using five year averages (dependent variable: log agricultural GDP per Ha)

Explanatory variables	Random effects	Fixed effects
Share of subsidies in total government expenditures in rural areas	−0.121**	−0.128**
	(0.059)	(0.062)
Total rural government expenditures per ha (log)	0.197**	0.210**
	(0.055)	(0.057)
Index of trade openness	0.006**	0.005*
	(0.003)	(0.003)
Constant	5.561**	5.533**
	(0.245)	(0.063)
Time dummies	Yes	Yes
Adj R^2	0.465	0.913

Number of observations: 27; number of countries: 9.
**Significant at the 5% level.
*Significant at the 10% level.

Finally, using the lagged dependent variable as an additional regressor allows us to deal with the potential autoregressivity of the dependent variable and to capture the implicit lagged effects of the other explanatory variables on agricultural productivity.

Since the effects of public expenditures and its composition on agricultural productivity are likely to be subject to lagged effects, we first "smooth" the data by using five-year annual averages. The problem with using five-year averages is that it considerably reduces the number of observations and thus the degrees of freedom, which makes it difficult to deal with the possible simultaneous equation biases. Therefore we also use the annual data series, which gives us the possibility of dealing with both the omitted variable and the reverse causality biases (Table 3). Since it is difficult to elucidate the actual time lagged effects of the variables, we use ad hoc lag structures for the explanatory variables in the FE and RE regressions. The GMM estimator allows for an implicit lag structure where the lag effect is entirely embodied in the autoregressive nature of the dependent variable.

The results: Table 2 presents the results of FE and RE regressions using five-year averages. The dependent variable is the log of agricultural GDP per hectare, which is used as a proxy for agricultural productivity. The data are averaged over five-year periods (1985–1989, 1990–1994, and 1995–2000). In both the RE and FE models government rural subsidies have a significant negative impact on agricultural productivity—larger subsidies and depressed productivity hang together, and this provides at least partial evidence of a distorted pattern of input usage. The other controls used in the regression, the rural government expenditures in public goods and an index of trade openness, both have a positive impact on agricultural productivity. Government expenditures on rural public goods mainly represent complements to private inputs in creating agricultural GDP—think of the provision and maintenance of infrastructure or upholding the rule of law. Therefore the positive sign is expected and consistent with the theory [28].

We implemented several other econometric approaches as a way of checking for the robustness of the estimates presented in Table 2. For example, we implemented dynamic estimates that allow for sluggish adjustment of the dependent variable, and implemented a systematic control of possible biases by using the lagged explanatory variables as instruments. The main results are robust with respect to these specifications. Table 4 shows the GMM estimates using annual data. For comparison Table 3 also includes the FE and RE estimators. The GMM estimates pass satisfactorily the test for autocovariance of order 2 in the residuals. In addition the Sargan test for the validity of the instruments is also passed by the estimates with a Chi square value that is not significant at any reasonable level.

The GMM estimates reveal that while the effect of government rural expenditures on agricultural productivity is positive and significant, the effect of the share of private subsidies is negative and significant. These results are robust to the method of estimation as shown by the fact that they are also valid for the FE

Table 3
Estimating agricultural GDP normalized by land area, 1985–2000, using annual data

Variables	Generalized method of moments	Panel regression	
		Fixed effects	Random effects
Lag of agricultural GDP per hectare	0.522**		
	(0.099)		
Log of total public expenditures in rural areas normalized by land area	0.047**	0.031**	0.032**
	(0.014)	(0.009)	(0.009)
Share of private subsidies in total expenditures	−0.120**	−0.119**	−0.123**
	(0.059)	(0.048)	(0.049)
Index of trade openness	0.001	0.002**	0.002**
	(0.001)	(0.001)	(0.001)
Log of per capita non-agriculture GDP	0.085	0.140**	0.162**
	(0.056)	(0.044)	(0.043)
Constant	0.004	4.662**	4.515**
	(0.004)	(0.346)	(0.383)
Time dummies	Yes	Yes	Yes
Arellano–Bond test auto-covariance in residuals of order 2	0.99		

Note: Number of observations: 133; number of countries: 9.
**5% level of significance.
*10% level of significance.

and RE estimates in Table 3. They are also robust to changes in the specification and data as shown by a series of experiments not reported here. That is, the estimates strongly confirm an important prediction from our theoretical model: government subsidies induce lower agricultural land productivity.

Comparing the GMM results with those obtained using FE and RE estimators which do not account for possible reverse causality biases shows that while the GMM estimates for the coefficient of total rural expenditures are significantly higher, the coefficient of the share of private subsidies is practically identical to the FE and RE estimators. That is, the estimates suggest that a higher agricultural productivity may induce governments to spend *less* on agriculture (thus downwardly biasing the FE and RE estimators which do not control for the simultaneity problem) but the composition of public expenditures is not affected by agricultural productivity. This result is also consistent with our theoretical predictions: a less intensive agriculture induces the government to spend more on agriculture. Moreover, since the share of subsidies in total expenditures does not appear to be affected by agricultural productivity, it follows that, as predicted by the theory, the absolute volume of subsidies increases as agriculture becomes less intensive.

The coefficient of the lagged dependent variable is about 0.5 suggesting that it takes approximately two years for the system to adjust to an exogenous change. This means that the long run elasticity of total public expenditures on agricultural productivity is about 0.1. Also, the long-run effect of the share of private subsidies is about −0.24, meaning that a one percentage point increase of such share leads to a reduction of agricultural productivity of 0.24%.

The qualitative results (that is, the sign and significance of the coefficients) presented above are consistent with recent studies in the literature which have used different estimation techniques, different data samples and different controls than we do. This suggests a high degree of robustness of the econometric estimates presented above. López and Galinato [28] using an expanded data set for rural Latin America covering 16 countries yields the same qualitative results as in Tables 2 and 3. Also, the results are highly consistent with the findings by Allcott et al. [1], also using data for rural Latin America, which use a very different set of control variables and instruments and quite different estimation methods from what we used. They also find that subsidies are closely associated with low agricultural productivity. The results are also consistent with the finding by Tanzi and Davoodi [37] that corruption leads to allocations of public expenditure in favor of less productive investment projects.

Table 4
Determinants of land use per capita, 1985–2000

Variable	Panel regression			
	Fixed effects	Random effects	Fixed effects	Random effects
Log of lagged agricultural GDP per capita	0.307***	0.339***	0.312***	0.349***
	(0.061)	(0.046)	(0.061)	(0.046)
Log of average annual public expenditures per capita in the rural sector	−0.020***	−0.019***	−0.018***	−0.016***
	(0.006)	(0.006)	(0.007)	(0.006)
Share of non-social subsides in public expenditures in the rural sector	0.119***	0.113***	0.110***	0.101***
	(0.033)	(0.030)	(0.034)	(0.031)
Log of (predicted) non-agricultural GDP per capita	0.028	0.035	0.029	0.036
	(0.026)	(0.026)	(0.025)	(0.026)
Index of trade openness	−0.002***	−0.002***	−0.002***	−0.002***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Transparency and governance			0.002	0.002*
			(0.001)	(0.001)
Time dummies (86–2000)	Yes	Yes	Yes	Yes
Constant		−6.012***		−6.016***
		(0.190)		(0.177)
Number of countries	9	9	9	9
Adj R^2	0.979	0.696	0.979	0.696
Hausman test Chi square		6.013		2.704

Dependent variable: log of agricultural land surface per capita (annual data for nine countries).
Note: All standard errors are heteroskedastic consistent. The coefficients of time dummies are omitted.
***5% level of significance.
**10% level of significance.
*15% level of significance.

5.2. More land is taken in production as policy-makers are more corrupt (Proposition 2b)

In Table 4 we econometrically estimate the (log of) per capita agricultural land on several explanatory variables for the same countries and period. As in the previous regression, we used a two-way FE and RE models to control for unobserved country characteristics and common time effects.[12] The main results of interest are twofold: (i) landholdings are increasing in the share of private subsidies in public expenditures in the rural sector, and (ii) the transparency and governance variable (say the inverse of corruption) is at best marginally significant (at the 15% level). Since the share of subsidies is positively affected by corruption, we have identified an indirect channel through which corruption affects land use decisions: land clearing and corruption interact through subsidies. Controlling for this indirect channel, the direct effect of governance proxies almost disappears. The finding nicely complements earlier work on corruption and deforestation (especially in relation to trade) by Barbier et al. [6].

5.3. Agricultural subsidies are larger when governments are more corrupt

We analyze the provision of public goods as a percentage of total government expenditures using an annual panel data set for the period 1972–2000 for 130 countries. Public goods include expenditures in education, health, roads, housing, social security and welfare. That is, goods that either the private sector cannot supply

[12]Total country land area as well as other characteristics (e.g., natural resources) is likely to affect the size of the agricultural land area. The use of country effects control for such cross-country heterogeneity. Agricultural commodity prices may also affect the demand for agricultural land. The use of time dummies may help to mitigate the potential bias arising from the lack of data of domestic commodity prices. Most of the countries are open to trade and use mainly *ad valorem* import tariffs as the key instruments of protection. The use of time dummies in combination with the data on tariffs implicit in the trade openness variable may thus proxy for domestic commodity prices.

Table 5
Determinants of the provision of public goods by the government 1970–2002 (dependent variable: government expenditures on health, education, housing, social security and welfare expenditure as a percentage of total government expenditures)

Explanatory variables	Linear models		Log–log models	
	Random effects	Fixed effects	Random effects	Fixed effects
GDP per capita	0.001**	0.001**	0.293**	0.354**
	(0.0003)	(0.0004)	(0.105)	(0.135)
Lagged GDP pc	−0.0003	−0.0003	−0.054	−0.052
	(0.0003)	(0.0004)	(0.104)	(0.126)
Transparency and Governance	0.502**	0.466**	0.007**	0.007**
	(0.037)	(0.044)	(0.001)	(0.002)
Constant	33.615**		1.681**	
	(1.048)		(0.129)	
Adj R^2	0.408	0.863		0.830

**Significant at the 5% level.
*Significant at the 10% level.
Number of observations, 2250; number of countries, 130.

or that are affected by significant externalities. We econometrically estimated the share of expenditures in public goods using measures of governance and per capita GDP as explanatory variables.[13] RE and FE methods were used. We find that governments with higher governance scores in the previous period (i.e., less corrupt governments) spend a significantly larger share of their money on public goods (Table 5). This implies that the share of expenditures allocated to subsidies must be lower for more corrupt governments (these shares must sum to one). The findings are robust to changes in the specification and controlling variables used. Moreover, the finding that more corrupt governments spend less on public goods (and consequently more on private goods or subsidies) is consistent with results obtained earlier. Deacon [15], for example, using a different sample of countries and periods, found similar results.

6. Conclusion

Economists have been intrigued by the predominantly extensive nature of the production techniques used by large farmers, and by the large areas of land that such farmers choose to retain. Such farmers often receive the lion's share of government subsidies, and the conventional wisdom is that the subsidies trigger excessive use of land and extensive production methods. In this paper we argue that it might be the other way around. By choosing large land areas and low private inputs, farmers can manipulate policy makers to induce them to provide more subsidies. We derive three testable predictions: (i) more corrupt governments channel larger sums to the agricultural sector, (ii) subsidies tend to depress agricultural productivity, while (iii) promoting excessive deforestation.

Our empirical results are consistent with the above predictions. We find that agricultural productivity *falls* as governments spend more on subsidizing farmers. This finding is robust to many different specifications and controlling for potential omitted variables or reverse causality does not attenuate it either. Another new empirical result establishes that the link between agriculture land expansion (which often involves deforestation) and corruption is mainly indirect. Consistent with Barbier et al. [6] we find a positive association between corruption and expansion of agricultural land, but corruption (nearly) ceases to be significant when we control for the share of private subsidies in public expenditures on the rural sector. Given that we also show a positive association between this share and the level of corruption, an effect of corruption is likely to operate through the fiscal channel.

[13]The democracy and governance index developed by Marshall and Jaggers [29] captures certain important components of the quality of governance and of institutional conditions that tend to reduce corruption. The indicators are derived from a point system based on the competitiveness and transparency of political recruitment, ability of political heads to exert power, and competitiveness and regulation of political participation.

Observers have noted an increase in private investments in land productivity in the Amazon over the past few years. We argue that such developments are not independent of the reduction of public subsidies in the 1990s which was mainly due to exogenous changes in fiscal policy. The decreased predisposition of government to provide subsidies has undermined the farmer's incentive to commit to extensive production patterns. This brings us to a somewhat ironic conclusion. Fiscal support to Amazon agriculture triggered overly extensive production patterns that were detrimental for the country as a whole and, possibly, for the rural regions affected. After decades of support, governments have curtailed these policies in the 1990s causing the Amazon cattle sector to start utilizing technology that increases productivity. Our analysis suggests that this is no coincidence.

Finally, while this paper has focused specifically on the case of land use in Latin America, it is clear that the central mechanisms identified apply more generally. By credibly committing or "locking-in" to a subsidy dependent mode of production, a sector can make subsidy removal harder for the government to achieve. For instance, in Australia water reform has been impeded in regions where irrigators have (credibly) "locked-in" to inefficient (open drain and flood) irrigation systems. These (typically large) irrigators continue to receive water at a fraction of the price paid by other more efficient farmers (Commonwealth of Australia 2001). The continued support for "infant industries" many decades beyond the anticipated period of protection may be another example, and so is support for inefficient agricultural production in 'backward' regions in the European Union.

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Appendix A. Proofs of lemmas and propositions

Proof of Lemma 1. To ensure interior solutions it is assumed that $\tilde{\Pi}$ is jointly concave in S^h and S^y, and that the Inada conditions hold (i.e. $\partial\tilde{\Pi}/\partial S^i > 0$, $\partial^2\tilde{\Pi}/\partial S^{i2} < 0$, and for $S^j > 0$, then $\partial\tilde{\Pi}/\partial S^i \to \infty$ as $S^i \to 0$, $i, j = h, y$, $i \neq j$). By differentiation of (8b) and (8c) the partial derivatives are given by: (a) $\tilde{\Pi}_{S^hA} = V_{g^hA}\partial g^h/\partial S^h > 0$; (b) $\tilde{\Pi}_{S^yA} = \tilde{\Pi}_{S^yh} = 0$; (c) $\tilde{\Pi}_{S^hh} = V_{g^hh}\partial g^h/\partial S^h > 0$, (d) $\tilde{\Pi}_{S^hS^y} = \tilde{\Pi}_{S^yS^h} = 0$. Given the definition of $V(\cdot)$ in Eq. (3) and using the first order condition (4) it follows that Condition B3 on $f(\cdot)$ assures that $V_{g^hA} > 0$, and $V_{g^hh} > 0$. This yields (a) and (c). Result (d) also follows from the definition of the dual profit function using the envelope theorem: $V_{g^h} = P(f_Y B_{g^h} + f_{g^h}) - wB_{g^h}$. Using (4) $V_{g^h} = Pf_{g^h}$, so that (8a) can be rewritten as

$$\frac{\partial\tilde{\Pi}}{\partial S^h} = Pf_{g^h}\frac{\partial g^h}{\partial S^h} - 1 = 0. \tag{8a$'$}$$

Hence

$$\frac{\partial^2\tilde{\Pi}}{\partial S^h \partial S^y} = Pf_{g^hY}\frac{\partial g^h}{\partial S^h}\frac{\partial Y}{\partial S^y} > (<)0.$$

Note that

$$\frac{\partial Y}{\partial S^y} = \frac{\partial\phi}{\partial g^y}\frac{\partial g^y}{\partial S^y} + \frac{\partial y^*}{\partial g^y}\frac{\partial g^y}{\partial S^y}.$$

Using (5) we have that $\partial y^*/\partial g^y = -\partial\phi/\partial g^y$, hence $\partial Y/\partial S^y = 0$ and $\tilde{\Pi}_{S^hS^y} = 0$. In addition $\tilde{\Pi}_{S^iS^i} < 0$ ($i = h, y$), by the second order conditions. Thus we conclude

$$\frac{dS^h}{dA} = \frac{-\tilde{\Pi}_{S^hA}}{\tilde{\Pi}_{S^hS^h}} > 0, \quad \frac{dS^y}{dA} = 0, \quad \frac{dS^h}{dh} = \frac{-\tilde{\Pi}_{S^hh}}{\tilde{\Pi}_{S^hS^h}} > 0 \quad \text{and} \quad \frac{dS^y}{dh} = 0. \qquad \square$$

Proof of Proposition 1. Assume U is concave in g^h and g^y. Differentiate (10a) and (10b) to obtain: $U_{g^hg^h}<0$, $U_{g^yg^y}<0$ (by concavity of U in g^y and g^I), $U_{g^hg^y}=0$, $U_{g^yA}=0$, $U_{g^yh}=0$, $U_{g^hA}=(1+\alpha)V_{g^hA}>0$, and $U_{g^hh}=(1+\alpha)V_{g^hh}>0$.

Therefore the following holds:

$$\frac{dg^h}{dA}=\frac{-U_{g^hA}}{U_{g^hg^h}}>0,\quad \frac{dg^y}{dA}=0,\quad \frac{dg^h}{dh}=\frac{-U_{g^hh}}{U_{g^hg^h}}>0 \quad\text{and}\quad \frac{dg^y}{dh}=0. \qquad \square$$

Proof of Proposition 2a. Rearranging Eq. (10a), the implicit price of g^h is defined by η: $V_{g^h}=\alpha c^h/(1+\alpha)\equiv\eta$. Observe that $\partial\eta/\partial\alpha>0$. Let Q^* be the equilibrium output level from the optimization decisions of the farmers and define $C(r, v, \eta, w; Q^*)$ as the corresponding dual cost function from the optimization problems. By Shephards Lemma, $C_r=A$ and $C_v=h$, where subscripts denote partial derivatives. Hence, $h/A=C_v/C_r$. Differentiating this expression with respect to η:

$$\frac{d(h/A)}{d\eta}=\frac{h}{A}\left(\frac{C_{v\eta}}{C_v}-\frac{C_{r\eta}}{C_r}\right)+\frac{h}{A}\left(\frac{dh}{dQ^*}\frac{1}{h}-\frac{dA}{dQ^*}\frac{1}{A}\right)\frac{dQ}{d\eta}, \tag{A.1}$$

Rearranging (A.1), yields after manipulation:

$$\frac{d(h/A)}{d\eta}=\frac{hC_\eta}{A}(\sigma^{g^hh}-\sigma^{g^hA})+\frac{E_{Q^*\eta}}{m_\eta}(E_{hQ^*}-E_{AQ^*}), \tag{A.2}$$

where $\sigma^{g^hh}=C_{v\eta}C/C_vC_\eta$, $\sigma^{g^hA}=C_{r\eta}C/C_rC_\eta$ are the elasticities of substitution between g^h and h and g^h and A, respectively. $E_{Q\eta}=(dQ^*/d\eta)(\eta/Q^*)$ is the elasticity of output with respect to η. $m_\eta=g^h\eta/C$ is the cost share of g^h in total costs, and $E_{hQ}=(dh/dQ)(Q/h)$, $E_{AQ}=(dA/dQ)(Q/A)$ are elasticities of demand with respect to output. Condition B2 (homotheticity of f) implies that $E_{hQ^*}=E_{AQ^*}$.[14] Moreover, Condition H implies that $\sigma^{g^hh}>\sigma^{g^hA}$. Thus

$$\frac{d(h/A)}{d\alpha}=\frac{d(h/A)}{d\eta}\frac{\partial\eta}{\partial\alpha}=\frac{\partial\eta}{\partial\alpha}\left(\frac{hC_\eta}{A}(\sigma^{g^hh}-\sigma^{g^hA})\right)>0. \tag{A.3}$$

Note that when the production function is not homothetic then a sufficient condition for this result to hold is that $E_{hQ}\geqslant E_{AQ}$ which implies that h is at least as responsive to output increases as is A. $\square$

Proof of Proposition 2b. Let g^{hL} be government provision of the semi-fixed input with lobbying and let g^{w} = government provision when there is *no* lobbying. *Result*: $g^{hL}>g^{w}$.

Proof. By (8a) political contributions satisfy

$$\frac{\partial\tilde{\Pi}}{\partial S^h}=V_{g^h}\frac{\partial g^h}{\partial S^h}-1=0.$$

Since $V_{g^h}>0$ then an interior solution only exists if $\partial g^h/\partial S^h>0$. Moreover, since $S^h>0$ with lobbying and $S^h=0$ with no lobbying, it follows from the SOC that $g^{hL}>g^{w}$.

Next, totally differentiating the system in (12b) and (12c):

$$\begin{bmatrix} V_{AA} & V_{Ah} \\ V_{hA} & V_{hh} \end{bmatrix}\begin{bmatrix} dA \\ dh \end{bmatrix}=\begin{bmatrix} -V_{Ag^h} \\ -V_{hg^h} \end{bmatrix}dg^h, \tag{A.4}$$

where by the SOCs: $D=V_{AA}V_{hh}-V_{Ah}V_{Ah}>0$. Solving by Cramer's rule:

$$\frac{dA}{dg^h}=\frac{-V_{Ag^h}V_{hh}+V_{hg^h}V_{Ah}}{D},$$

Since $V_{Ag^h}>0$, $V_{hg^h}>0$ and $V_{Ah}>0$ and $V_{hh}<0$ (by concavity), we always find $dA/dg^h>0$. $\square$

Proof of Proposition 3. We define agricultural intensity measured at market prices as $I=(\eta g^h+vh+wl)/A$. Also, the shadow value expression is $I^*=(qg^h+vh+wl)/A$, where $q=(1+\alpha)\eta/\alpha$ is the social shadow price

[14] See, e.g. Takayama [36, Chapter 3].

of the government-provided good. The only difference between I^* and I is that the former is evaluated at the shadow price of the government input while the latter is valued at the "market" price, i.e. the price that the government charges through bribes. Diewert [14] has shown that the dual cost function is homogenous of degree one in input prices for any production technology (not only a homogenous one). Moreover, the assumption of homotheticity of the production function (Condition B2) means that the structure of the cost function is separable in prices and output. That is, we can write $C = \phi(Q)c(r, v, \eta, w)$, where $\phi(Q)$ is non-decreasing in Q and $c(\cdot)$ is monotonically increasing, concave and homogenous of degree one in input prices [14]. Using the homogeneity condition of $c(\cdot)$ and the separability condition associated with homotheticity we can rewrite I as

$$I = \frac{vh + wl + \eta g^h}{A} = \frac{v\phi(Q)c_v + w\phi(Q)c_w + \eta\phi(Q)c_\eta}{\phi(Q)c_r} = \frac{c - rc_r}{c_r}.$$

Note that homotheticity implies that I is independent of Q; it only depends on input prices. Next, differentiate I with respect to η to obtain: $dI/d\eta = (g^h/A)(1 - \sigma^{Ag^h}) > 0$ if σ^{Ag^h} (the Hicksian elasticity of substitution between land and the government-provided input) is smaller than unity: increasing corruption causes I to fall. The effect of η on I^* is identical except that the use of the homogeneity condition is valid only if initially $\alpha/(1+\alpha) \to 1$ (if initially corruption is absent). □

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