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Aid Effectiveness Revisited, Part 1: Optimal Discipline in Donor-Recipient Relationships

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Abstract

This paper constitutes the first stage of an analysis of the problem of aid allocation when the donor is sensitive to both needs and governance considerations and is moreover able to influence local governance through its own disciplining effort. In this first stage, we write a principal-agent model of the relationship between a donor and a single recipient country. One key and original feature is the assumed comparability between domestic and donor-imposed disciplines: the two types can be summed up to obtain an aggregate discipline. We show that, paradoxically, an (exogenous) improvement of domestic discipline may be over-compensated by the donor so that total discipline actually decreases and elite capture increases. The relationship between domestic and total disciplines may thus be non-monotonous so that no simple general testable prediction can be inferred from economic theory regarding the impact of aid even controlling for domestic governance.

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1 Introduction

Increased attention to the issue of aid effectiveness has sparked a flurry of empirical studies attempting to measure the macro-level impact of aid flows on the performances of developing countries. Following the seminal paper by Burnside and Dollar (2000), a standard approach consists of looking at the effect of aid on long-run growth rates controlling for quality of governance or the policy environment in recipient countries, itself interacted with aid. Their main result, that "in the presence of poor policies, aid has no positive effect on growth" (p. 847), has been thoroughly challenged for its lack of robustness, and the available literature is replete with ambiguous conclusions and contradictory evidence, leaving a strong impression of disarray. Especially noticeable is the work of Rajan and Subramanian (2007, 2008) who found that the impact of foreign aid on growth is non-existent whatever is the estimation approach used, the type of aid or the time period considered. They attribute this disappointing result to the detrimental effect of aid on governance quality, in a way reminiscent of Easterly (2007). In contrast, Arndt, Jones and Tarp (2010) have argued that, by applying a different econometric methodology to the data, a different conclusion can be reached, namely that aid has a positive and significant causal effect on growth over the long run. Other studies actually add fuel to this unsettled controversy (see, e.g., Dalgaard et al., 2004; Roodman, 2007; Djankov et al., 2008; Doucouliagos. and Paldam, 2009; Juselius et al., 2013), or show that uncertainty of aid impact also obtains when performance is measured by poverty reduction or inequality rather than economic growth (Masud and Yontcheva, 2005; Chong et al., 2009).

A central problem with this voluminous literature is that the main hypothesis put to the test is grounded in the intuitive straightforward assumption that domestic governance is exogenous and not influenced by the donors. Since the idea of endogenous governance makes sense in the light of past and recent experiences in development aid strategies, solid theorizing is thus necessary to design valid and interpretable empirical tests, and this is what we purport to do in this paper.

Our analytical endeavor starts from the premise that donors resort to monitoring and sanctioning mechanisms in order to improve preference alignment, particularly

with respect to poverty reduction. It is true that, in the scant theoretical literature devoted to the problem of aid effectiveness, several attempts feature a donor able to impose punishment on non-compliant recipient governments, typically through a conditionality mechanism (Azam and Laffont, 2003; Svensson, 2000, 2003; Gaspart and Platteau, 2012; Chauvet et al., 2012). The originality of our endeavor lies in the fact that the discipline brought to bear by the donor is made analytically comparable to the domestic discipline to which the target population subjects its own elite or government.[1] In other words, governance is conceived as the outcome of two types of discipline, internal and external, which can be somehow aggregated. This allows us to explore a new set of issues, such as whether internal and external disciplines are substitutes or complements, and whether an increase in internal discipline has the effect of also raising the level of total discipline and, therefore, the overall quality of governance.

Rather unexpectedly, there is no easy answer to the second question. Even though external and internal disciplines are substitutes, the donor *may* be induced to over-compensate a change in internal discipline in the recipient country. In particular, an increase in internal discipline may lead, paradoxically, to a fall in total discipline with the effect that the quality of governance actually decreases. Whether this happens or not depends not only on the initial level of internal governance, but also on the shapes of the cost functions. Namely, if the internal governance is of low quality and the cost function moderately convex, total discipline tends to fall when internal discipline improves. This result also critically depends on whether

[1]Thus, in Svensson (2000), the recipient country is disciplined because the aid contract specifies the amount of aid disbursed as a function of observed performances that counfound the effects of a shock and of internal reform effort. As for Azam and Laffont (2003), they define the optimal aid contract thus: the recipient government will receive an aid amount (which is endogenous) linearly dependent on the level of consumption of the poor. In both cases, because external discipline is modeled as a mechanism of conditional aid release, it is not possible to measure it by an index or variable that captures its level of intensity. The same holds true of Chauvet et al. (2012), and of Gaspart and Platteau (2014), where the donor also uses a conditionality mechanism to discipline the recipient. In Azam and Laffont (2003), the level of internal discipline is represened by an altruism parameter in the utility function of the recipient government whereas in Chauvet et al. (2012) it is conceived as the extent of congruence of interests between the donor and the recipient, and in Gaspart and Platteau (2014), it is determined by the exit options of a bargaining game between this elite and the grassroots. In the latter two contributions, the recipient chooses the level of effort, or aid appropriation, which influences the probability of detection of inappropriate behaviour by the donor.

the participation constraint of the local elite or the government to the aid program is binding or not, which, ceteris pariblus, requires the joint cost of monitoring and punishment to be above some threshold.

The implication of our analysis for empirical testing is therefore rather counter-intuitive : when aid effectiveness is measured by the proportion of aid that effectively reaches the targeted beneficiaries (or the inverse of local elite capture), countries with better initial levels of governance quality may well be less aid-effective than other recipient countries because the donor may choose to respond to better domestic governance by relaxing his own external discipline in a disproportionate way. If the required conditions, which by no means seem abnormally demanding, are satisfied, we should not expect to find in the data the sort of positive relationship between aid, governance and performance that is typically presumed in the vast empirical literature devoted to the subject.

When, in a subsequent paper, we will probe into the issue of aid allocation between countries with varying governance quality, a central question will be the following: if a country has succeeded in improving its internal governance, will it be entitled to receive a higher share of aggregate aid? The question needs to be especially elucidated in the above case where total discipline falls as a result of the donor's disciplining action. Given the complexity of the problem of aid effectiveness when the donor is able to influence governance, it did not prove possible to deal with it in a single paper. Hence our choice to analyze the one-recipient case in a first paper and the issue of inter-country allocation of aid within a two-country framework in a second paper. This second paper is organically related to the first one since it will be built upon the analytics of the relationship between a donor and a single recipient country.

The present paper, corresponding to the first stage of our analysis, proceeds as follows. In Section 2, we provide a snapshot of the history of successive approaches to development aid in the world donor community. This is with a view to showing the renewed importance of the aid effectiveness debate as well as the salience of the idea of external discipline. In Section 3, we describe the main assumptions behind our model. In Section 4, its building blocks are then presented. In Section 5, we analyze the general case that obtains when the participation constraint of the leader

is not binding, leaving to Section 6 the more simple case where this constraint is binding. Section 7 concludes by stressing the implications of the basic mechanisms uncovered in this paper, in particular for the empirical analysis of the effectiveness of aid.

2 Renewed interest for external discipline

Following disillusionment with past approaches that relied on conditionality programs and project aid, new principles have been formulated in the Paris Declaration (March 2005) and the Accra Agenda for Action (September 2008), itself followed by the Busan Partnership for Effective Development Cooperation (December 2011). The underlying idea is that aid effectiveness can be significantly raised through new aid modalities that emphasize ownership (giving more policy space to recipient governments) and 'policy dialogue', as well as transparency and accountability, reduce the role of conditionalities, and avoid reform overload (Edwards, 2014). Following up on these principles, priority has been increasingly given to so-called General Budget Support (GBS) deemed to more effectively reduce poverty through non-earmarking of aid funds and enhanced recipient country ownership.

After a few years of active implementation of the new strategy, however, donor agencies came to realize that excessive hopes had been placed in it, especially when there is wide divergence between their objectives and those of recipient countries. In practice, donors started budget support even when entry conditions were not met and recipient governments just committed to or stated their intentions of improving policies, governance or public financial management. In other words, donors used GBS to bring about the desired changes in policies and governance instead of supporting deserving governements (Dijkstra, 2013). A major conflict thus emerged between the objective of reducing transaction costs and engaging recipient governments by providing freely spendable money that can be used in line with their own priorities, on the one hand, and the objective of influencing their policies and governance in a way considered appropriate by the donor agencies, on the other hand. The latter typically included such concerns as organizing free and fair elections, establishing the rule of the law and an independent judiciary, fighting against corruption, enacting sound macroeconomic policies, and committing to poverty reduction.

The reaction of many donor agencies consisted of reintroducing substantial ex post conditionalities, often via the threat of witholding further tranches of aid money in case of the recipient's non-compliance with the donor's conditions. This implied that GBS can be suspended or reduced, such as happened with Nicaragua, for example, when the European Union and bilateral donors concluded that the government of prime minister Ortega did not want to fulfill his commitment to ensure free and fair elections in the country (Dijkstra, 2013). The World Bank, to give another example, decided to halt its budget support to the government of Honduras and to replace it with project funding after the International Monetary Fund did not renew a standby agreement (2013). More significantly, several aid agencies known for their rigorous approach to aid cooperation (such as SIDA in Sweden, or DFID in the United Kingdom) have begun to retreat from GBS programmes altogether, owing to serious misuses of aid resources (see the evaluation reports by SADEV, 2010, and DFID, 2011). Thus, in a review the OCDE notes that "weak systems to align with and a high risk of corruption have influenced Swedish readiness to provide general budget support" (OECD DAC, 2009, p. 47). In this context, it is not surprising that in the corridors of aid agencies a "Paris Agenda fatigue" is increasingly mentioned (Oden and Wohlgemuth, 2011). Also in line with the above diagnosis, the European Union has re-introduced the concept of result-based disbursements into its budget support programmes (part of the aid is variable, being released in successive tranches conditioned on the performances of the country),[2] and the World Bank has launched a new results-based lending instrument, the so-called Program-for-Results.

Among different aid modalities, budget support is obviously most difficult to fit into a donor-imposed disciplining mechanism, especially because it is linked to the fulfillment of fundamental principles that are politically sensitive, arguable, and difficult to implement in a rather short time (on the latter point, see Pritchett et al., 2013). Hence the poor enforcement of external discipline on countries (such as Rwanda and Uganda) characterized by blatant violations of political conditionalities yet by good performances on the front of poverty reduction. At the other extreme,

[2]Through the so-called split response mechanism, the donors link disbursements of a portion of aid money to a general assessment of the principles agreed upon with the recipient government, and the other part to the degree of performance of specific indicators specified in the Performance Assessment Matrix (Dijkstra, 2013: 116).

project aid is probably the easiest to bring into the purview of external discipline (although the resulting transaction costs are likely to be larger), and programme aid occupies the middle ground (Bigsten, 2013).

A detailed empirical study based on a review of 1426 World Bank projects completed between 1981 and 1991 highlights the potential contribution of monitoring to effectiveness of project aid (Kilby, 1995).[3] This study concludes that (i) past supervision has a positive and perceptible impact on project performance; (ii) early supervision is much more effective than later supervision; and (iii) the impact of supervision is relatively homogenous across regions, sectors and macroeconomic conditions. Moreover, the benefits of supervision greatly exceed the costs: a substantial and sustained increase in the average level of supervision may generate a noticeable improvement in the average economic rate of return. Using the same dataset, Chauvet et al. (2012) argue that not only a more precise supervision of projects increases the likelihood of project success, but the effect of higher monitoring precision is significantly more effective when interests between donor and recipient (as perceived by the donor) are more diverging.

3 The setup of the model

In writing the model, we stick to a well-established tradition whereby the incentive aspects of alignment between the interests of donors and recipient governments are analyzed within the principal-agent framework. We restrict our attention to the one-donor-one-recipient case because we deliberately focus on the interaction between internal and external disciplines, which requires an elaborate treatment. The next step naturally consists of looking into the way aid should be allocated between several recipient countries in the presence of an explicit tradeoff between considerations of needs and governance (the more needy countries are also more badly governed). It is undertaken in another, companion paper (Bourguignon and Platteau, 2014).

Given the perspective that we adopt, a central question is how to represent gov-

[3]Endogeneity (supervision influences performance which in turn influences subsequent supervision allocation decisions) is overcome by relating lagged annual supervision to annual changes in interim performance.

ernance. We use an outcome variable, namely the inverse of elite capture or the share of aid flows that reaches the ordinary citizens or the poor. When this share is larger, governance is considered to have improved. On the other hand, a disciplining mechanism is at work when not only the elite's utility from fraud decreases as discipline gets tighter, but also the marginal loss of utility caused by such a tightening increases when fraud or embezzlement is larger. The elite is disciplined internally when the local civil society or citizenry exerts its own control, or externally when the discipline is imposed by the donor. The punishment meted out by the civil society can be conceptualized as a 'tax' imposed on the share unduly appropriated by its elite. Alternatively, such a 'tax' can be regarded as being self-imposed in the sense that the elite may feel some uneasiness or guilt vis-à-vis its own people when appropriating part of the aid flow. It may also consist of patronage gifts made by the elite to buy people's compliance. In our model, internal discipline is exogenous, but external discipline is optimally chosen by the donor.

Unlike the local civil society which is assumed to perfectly observe the fraud, the donor agency may get unequivocal evidence of it only with a positive probability. We adopt this simplified framework only for the sake of capturing the fact that citizens are better informed than outside agencies. As for punishment, since it may prove practically difficult to enforce it for an external organization, it helps to think of sanctioning as the withdrawal of future benefits such as happens when the elite's foreign bank accounts are frozen or foreign visas are denied.

4 The building blocks

Our model is deliberately parsimonious because the issue that we tackle is complex, and we need to achieve interpretable results that can be relevant for donor agencies and policy-makers. In this section, we successively describe the objective function of the leader or the elite, the probability function for fraud detection, the leader's optimal behavior given the aid delivery parameters chosen by the donor, and the latter's maximization problem yielding the optimal values of these parameters.

4.1 Objective of the leader

For each unit of aid, the leader's problem is written:

$$\underset{y}{Max}\, V(y) = y - \gamma\pi(by) - \beta y^2 - g \tag{1}$$

Bearing in mind that y is the share of aid appropriated by the leader or the elite of the recipient country (that is, the extent of 'fraud'), so that $y \in [0,1]$, the first two terms show the expected gain by the leader, assuming he/she will have to pay the penalty, γ, inflicted by the donor when the fraud is detected. This penalty can simply be the moral cost of being exposed as embezzlers by an external agency, or the economic cost of being cut further subsidies. The probability function, $\pi(y)$, is the probability that the fraud is detected at the monitoring precision, $b = 1$. By increasing the monitoring precision, b, the donor may raise the probability $\pi(by)$ for any given y. The third term in the above expression is the domestic cost of the fraud for the leader, with β representing the internal governance parameter of the recipient country ($\beta > 0$). As pointed out earlier, the cost of fraud may be conceived as the cost imposed by the national community or as a self-inflicted cost, such as when the leader makes voluntary gifts to clients to buy their compliance. We shall refer to it as the strength of *internal discipline* or governance in what follows. In keeping with our understanding of the disciplining mechanism, the relationship between this cost and the extent of the fraud, y, is assumed to be increasing and convex. In this way, we ensure that not only the leader's utility, V, decreases as β is raised, but also that the marginal loss of utility caused by an increase in β is greater when the fraud is more important, that is $V_{y\beta} = \frac{\delta^2 V}{\delta\beta.\delta y} \leq 0$. As will soon become clear, the same property applies to externally imposed discipline.

The last component of the leader's utility function, g, is the cost of handling one unit of aid, which is assumed to be constant (it is, therefore, independent of the amount of the fraud). Such a cost includes all the expenses or effort that the leader must incur in order to get hold of the aid amount by applying to the donor agency, organizing meetings with the intended beneficiaries, receiving foreign experts, submitting follow-up reports, and the like.

The leader's utility function (1) is unconventional not only because it allows for

punishment but also because the quality of domestic governance, instead of being captured by a positive term representing altruism, appears as a negative coefficient representing a tax (self-) imposed on the leader. Foster and Rosenzweig (2002), for example, interpret the leader's (government's) altruism as reflecting a "traditional aristocratic governance structure" in which the leader is compelled to attach a certain weight to the welfare of the community. The reason why we depart from this practice is that, in the altruistic case, it is not certain that the indirect utility of the leader depends negatively on the altruistic/governance parameter. This leads to the paradox that a donor may be more severe with a more altruistic leader or a leader in a better governed country, a case that can reasonably be dismissed for lack of realism (see Bourguignon et al., 2014, for a detailed discussion).

4.2 Specifying the probabillity of fraud detection, $\pi(y)$

It will be assumed that the probability of fraud detection is an increasing and convex function of the share of aid being embezzled. There are several justifications underlying the convexity assumption. First, as embezzlement increases, the donor observes that the output of the aid project is increasingly below expectation. Second, it is obviously more difficult to conceal malpractices when they are important and their consequences are therefore more visible than when they correspond to minor thefts. In particular, the number of sources of evidence about the fraud increases with its amount. The donor is thus told of elite people increasing luxury spending, of contractors being bribed, of aid-supported infrastructure being incomplete or of dismal quality, etc.. Increased disclosure of information arises not only from the greater difficulty of concealing large thefts but also from greater willingness of non-elite people to speak out when embezzlement exceeds acceptable levels. Third, the case the donor can make against the leader in front of the public domestic and international opinion becomes increasingly easier when the fraud bears on large amounts than in the opposite case.

To make the analytics of the model tractable, we shall assume that the probability of detection is a quadratic function of the fraud:

$$\pi(by) = b^2y^2/a^2$$

where a may be interpreted as the natural variance of the outcome of the aid program. Of course, this is for y being in the interval $[0, a/b]$.Actually, a more rigorous specification accounting for the fact that $\pi()$ is a probability function would be:

$$\pi(by) = Inf\left(b^2y^2/a^2, 1\right)$$

Yet, only the 'interior' specification $y < a/b$, where non-degenerate solutions are found, will be considered in what follows .[4]

4.3 The leader's behaviour

The interior solution of the leader's program, (1), is given by $dV/dy = V_y = 1 - 2\beta y - b\gamma\pi'(by) = 0$. When $\pi = (by)^2/a^2$, this yields the optimal level of embezzlement, $\widetilde{y}(b,\gamma)$:

$$\widetilde{y}(b,\gamma) = \frac{1}{2(\beta + b^2\gamma/a^2)} \tag{2}$$

It will be analytically convenient in what follows to refer to $b^2\gamma/a^2$ as a measure, φ, of the aggregate *external discipline* imposed by the donor :

$$\varphi = \frac{b^2\gamma}{a^2} \tag{3}$$

and to formally ignore the distinction between monitoring and punishment when this is not needed. The optimal fraud can then be written simply as:

$$\widetilde{y}(\varphi) = \frac{1}{2(\beta + \varphi)}, \tag{4}$$

where $(\beta + \varphi)$ is the aggregate discipline corresponding simply to the sum of internal and external disciplines. At this optimum, the fraud is a decreasing function of both internal and external disciplines.

In order to avoid the unrealistic corner solution $y = 1$, it is necessary to assume

[4] It is shown in the online earlier version of this paper that the counter-intuitive corner solution $\pi(by) = 1$ can easily be dismissed.

that $\beta + \varphi > 1/2$. Of course, it will never be in the interest of the donor to allow for such a possibility. On the other hand, the leader will never choose to refrain from cheating altogether because V_y is necessarily positive when $y = 0$. Therefore, the probability of fraud detection is positive at equilibrium.

4.4 Optimal punishment/monitoring by the donor

The donor draws satisfaction from increasing the consumption of the grassroot population in the recipient country and, for a given amount of aid, from preventing the leader from appropriating too large a portion of aid. The satisfaction of the donor thus appears as a function of the external discipline imposed to the leader in the recipient country. Assuming a logarithmic specification to simplify the analysis, this satisfaction, or utility, writes:

$$U(\varphi) = Ln\left[w + T(1 - \widetilde{y}(\varphi)\right] \tag{5}$$

where w is the per capita income of the community without aid and T the total amount of aid per capita, which is taken as exogenous. Such an objective function fits well the decision process of bilateral or multilateral development agencies, which are essentially given exogenous aid funds they have to manage with their own resources. A more general specification would make not only φ but also T endogenous. However, such an approach would significantly increase the complexity of the analysis without affecting the most important results achieved in this paper.[5]

Exerting external discipline has a cost for the donor, whether it consists of monitoring projects - the b parameter above - or of imposing sanctions when the leader is found to cheat- i.e. γ above. As far as the latter is concerned, the cost may involve starting a complex lawsuit but also the moral cost of appearing as too harsh to the local population or to the global aid community. Because the cost of the sanction will be incurred only if the fraud is detected, it is logical that the cost of the external discipline per unit of aid depends on both its intensity, φ, and the probability of detection that depends itself on the size of the fraud. A simple Cobb-Douglas like

[5] A discussion of the case where T is allowed to be endogenous is offered in the online earlier version of this paper.

functional form that represents such a unit cost function is:

$$\Gamma(\varphi) = B.\varphi^k.(\beta + \varphi)^{-2p} \tag{6}$$

where B, k and p are constant positive parameters. Recall that, in the above expression, $(\beta + \varphi)^{-2}$ stands for the probability, π, that the fraud will be detected. It is shown in Appendix A1 that this expression results logically from minimizing the total cost of monitoring aid projects (b) and of the expected value of the sanction ($\gamma\pi$) when the cost of monitoring and the cost of the sanction are power functions. With this specification, it is reasonable to assume that the total (unit) cost is convex with respect to the strength of the external discipline, φ ($k > 1$), and concave with respect to the probability of detection, π ($p < 1$). The latter is justified by the fact that an increase in that probability raises the expected cost of the sanction but not that of the monitoring. The elasticity of the total cost of the external discipline with respect to the probability of detection must therefore be less than unity, hence $p < 1$. Finally, it must be logically assumed that the overall cost of the external discipline is non-decreasing with its strength, φ.[6] Altogether, these assumptions imply the following constraints on the parameters of the cost function, $\Gamma(\varphi)$:

$$p < 1 < k;\ k \geq 2p \tag{7}$$

Putting satisfaction and costs together, the objective of the donor is to find the strength of the external discipline that maximizes:

$$Max_{\varphi}\ U(\varphi) - T.\Gamma(\varphi)$$

or, using (5) and (6):

$$Max_{\varphi}\ Ln[w + T(1 - \widetilde{y}(\varphi))] - TB\varphi^k(\beta + \varphi)^{-2p} \tag{8}$$

[6] If this were not the case, it can be seen on (6) that the cost of the external discipline would tend towards zero when φ becomes increasingly large. An infinite punishment would thus be the optimal strategy for the donor, a rather unrealistic case. The idea of a punishment being commensurate to the crime being punished is analyzed in the optimal law enforcement literature, see Garoupa (1997).

This maximization must take place under the participation constraint of the leader. Using (1) and (3), this constraint writes:

$$\widetilde{y}(\varphi) - \beta\widetilde{y}^2(\varphi) - \varphi\widetilde{y}^2(\varphi) - g \geq V^0 \tag{9}$$

where V^0 is the reservation utility of the leader per unit of aid. Assuming without loss of generality that $V^0 = 0$, the donor must make sure that the leader can at least cover the cost of handling aid. Using (4), this constraint writes simply:

$$1/4(\beta + \varphi) - g \geq 0 \tag{10}$$

As far as the participation constraint of the donor is concerned, we assume that the parameters of the model are such that, at the optimum :

$$Ln\left[w + T(1 - \widetilde{y}(\varphi))\right] - T.\Gamma(\varphi) > Ln(w)$$

In other words, we assume that the income per head in the recipient country is sufficiently low and/or the parameters of the cost functions are sufficiently small to make the donor's participation constraint automatically satisfied. Because of this assumption, it is unnecessary to take into account the condition $\beta + \varphi > 1/2$ seen above, which guarantees that the leader does not embezzle the totality of aid. The donor would prefer not to give aid to such a policy.

Now, the Lagrangian of the donor's maximization problem can be written :

$$Ln\left\{w + T\left[1 - 1/2(\beta + \varphi)\right]\right\} - TB\varphi^k(\beta + \varphi)^{-2p} + \mu\left\{1/4(\beta + \varphi) - g\right\} \tag{11}$$

where μ is the multiplier associated with the leader's participation constraint. Two situations can then arise depending upon whether this constraint is binding at equilibrium or not. The case where it is binding reflects conditions under which the monitoring and punishment technology is cheap enough to allow the donor to prevent the leader from obtaining any surplus. Conversely, when the cost of this technology is too high, the donor will not find it profitable to put the leader at his reservation utility. We start by examining the latter, more general case, which also turns out to be

the more analytically complex and the more interesting.

5 The general case: the leader's participation constraint is not binding

As the leader's participation constraint is not binding at equilibrium, the Lagrangean coefficient μ is nil in (11).The original maximization problem thus writes simply:

$$Max_{\varphi}\, U(\varphi) - T\Gamma(\varphi) = Log\left[w + T(1 - \frac{1}{2(\beta+\varphi)})\right] - TB\varphi^{k}(\beta+\varphi)^{-2p} \quad (12)$$

An interior solution, if it exists, is then obtained by equalizing the corresponding marginal utility of the external discipline, $U'(\varphi)$, and the marginal cost, $T\Gamma'(\varphi)$. The former is given by :

$$U'(\varphi) = \frac{(\beta+\varphi)^{-2}}{w + T(1 - \frac{1}{2(\beta+\varphi)})} \quad (13)$$

which is monotonically decreasing with respect to φ and, as could be expected, tends towards zero when φ tends towards infinity - see Figure 1. The marginal cost per unit of aid is given by:

$$\Gamma'(\varphi) = B.\varphi^{k-1}(\beta+\varphi)^{-2p-1}\left[k(\beta+\varphi) - 2p\varphi\right] \quad (14)$$

For further use, this may also be expressed as:

$$\Gamma'(\varphi) = \frac{\eta}{\varphi}\Gamma(\varphi);\ with\ \eta = k - \frac{2p\varphi}{\beta+\varphi} \quad (15)$$

where η is the elasticity of the cost of the external discipline.

It turns out that analyzing the standard first-order optimality condition:

$$U'(\varphi) = T\Gamma'(\varphi) \quad (16)$$

is rather intricate. Knowing the shape of the marginal utility function, a simpler way to proceed consists of considering the relative value $R(\varphi) = T\Gamma'(\varphi)/U'(\varphi)$ of the marginal cost with respect to the marginal utility rather than both of them separately. An interior solution is then given by equalizing this ratio to unity.

It comes after some manipulation that:

$$R(\varphi) = B\left[(k-2p)\varphi + k\beta\right]\left[\frac{\varphi^{k-1}}{(\beta+\varphi)^{2p-1}}\right]\left[w + T(1 - \frac{1}{2(\beta+\varphi)})\right] \qquad (17)$$

Given that $k > Max(1, 2p)$ as assumed in (7), it can be seen that the three terms in square brackets are increasing functions of φ, so that $R(\varphi)$ increases monotonically from zero to infinity when φ goes from zero to infinity. It follows that $R(\varphi)$ necessarily goes once and only once through unity and this occurs for a strictly positive value, φ^*. Thus, there is a single intersection point between the marginal cost and the marginal utility curve, and therefore, a single (interior) solution to the optimality condition (16). Moreover, the marginal cost curve crosses the marginal utility curve from below so that the second order condition for optimality is satisfied, whatever the actual shape of the marginal cost curve (14), when its parameters meet constraints (7) - see Figure 1.

We now look at the comparative statics of this interior solution with respect to the internal discipline β, which is the main objective of the paper. Several interesting results emerge. Combined with the existence result, the first one may be stated as follows :

Theorem 1. *(Substitutability) The optimal external discipline is a substitute for the internal discipline: an increase in internal discipline, β, causes the optimal external discipline, φ, to decrease.*

At first sight, this property seems very intuitive. With a better internal discipline, the leader allocates a larger share of aid to the grassroot population in the recipient country, and this reduces the marginal utility of the external discipline for the donor. Without change in the marginal cost, the external discipline should thus diminish. What is less evident, however, is the way the marginal cost is modified. As can be

seen from (15), an increase in β has two opposite effects on the marginal cost. On the one hand, it increases the elasticity, η, of the cost with respect to the level of external discipline but, on the other hand, it reduces the cost $\Gamma(\varphi)$. The substitutability between internal and external disciplines is reinforced if the maginal cost increases, that is, if the former effect is stronger than the latter. In the opposite case where the marginal cost decreases with β, it is shown in Appendix A2 that it decreases less than the marginal utility - i.e. the $R(\varphi)$ curve keeps shifting upward - so that the substitutability between internal and external disciplines holds in that case too.

The question then arises of the extent of the substitution of internal by external discipline. Is it partial, complete, or could it even overshoot the initial change in internal discipline? The substitution is partial (under-substitution), and possibly complete, if the total discipline $\beta + \varphi$ does not decrease when β increases, or:

$$-1 \leq \frac{d\varphi}{d\beta} \leq 0 \tag{18}$$

Alternatively, over-substitution occurs when :

$$\frac{d\varphi}{d\beta} < -1 \tag{19}$$

In this second case, therefore, the overall discipline falls despite the fact that its internal component, β, has increased.

A rather simple condition determines whether over- or under-substitution occurs:

Theorem 2. *(under- and over-compensation) An increase in internal discipline, β, is always compensated by a drop in external discipline, φ. There is under-compensation or complete substitution, i.e. total discipline, $\beta + \varphi$, increases or remains constant, iff:*

$$\eta \geq 1 \tag{20}$$

There is over-compensation, i.e. total discipline, $\beta + \varphi$, decreases, otherwise. In this second eventuality, the optimal level of fraud increases despite the higher level of internal discipline.

A formal proof of the above theorem is given in Appendix A3. An intuitive proof is as follows. Consider the equilibrium condition (16) and a small simultaneous change in internal and external discipline leaving the total discipline unchanged: $\Delta\beta + \Delta\varphi = 0$ or $\Delta\varphi = -\Delta\beta$. Clearly, the marginal utility is unchanged. This is not true of the marginal cost, though . Since η is the elasticity of the total cost, the marginal cost Γ' is approximatley proportional to $\eta\varphi^{\eta-1}$, and the change in the marginal cost $\Delta\Gamma'$ to $-\eta(\eta-1)\varphi^{\eta-2}\Delta\beta$. If $\eta = 1$, equilibrium has not been disrupted and there is no need for a further change in φ. There is perfect substitution between internal and external discipline. If $\eta > 1$, the marginal cost has moved down and it is thus necessary to increase φ (that is, φ should fall to a smaller extent than what is needed to keep $\beta + \varphi$ constant) in order to get back to equilibrium. There is under-compensation: total discipline therefore goes up together with internal discipline, yet it increases to a smaller extent. Finally, the marginal cost moves up if $\eta < 1$, which requires a drop in φ beyond what allows to keep $\beta + \varphi$ constant if equilibrium is to be re-established. There is overcompensation and total discipline falls despite the fact that the internal discipline has improved.

The intuition of this apparently paradoxical result is simple. When internal discipline increases, the fraud committed by the leader decreases, and the grassroots receive more aid so that the marginal utility of the donor falls. To re-establish equilibrium, the donor must reduce its marginal cost, which he does by lowering φ. By how much depends on the elasticity of the marginal cost, which depends itself on the convexity of the cost function, and therefore on its elasticity. If it is large, the change in φ needed to reequilibrate the optimality condition is small and the change in the overall discipline remains positive. If the elasticity of the cost function is small, however, re-establishing optimality requires a large change in φ, which may lead to a decline in the overall discipline.

Actually, things are slightly more complicated than the preceding argument suggests. This is because the elasticity of the cost function, η, depends itself on both the internal and external disciplines. Thus, condition (20) actually is a condition on the whole set of parameters of the model. As there is no analytical solution to the optimality condition $R(\varphi) = 1$, it is not possible to precisely identify the condition under which η is above or below unity. Yet, an interesting and important particular case

is when the strength of the internal discipline is very small. In the limit case where $\beta = 0$, it can be seen from (15) that the $\eta \geq 1$ condition for under-compensation is satisfied only if $k \geq 2p+1$. If this is not the case, then over-compensation necessarily occurs. Hence the following interesting result:

Theorem 3. *(limit case of over-compensation) When the internal discipline is sufficiently weak, i.e. β sufficiently small, and $k < 2p+1$, any improvement in the internal discipline is accompanied by a fall in the external and total discipline so that the fraud actually increases.*

In actual fact, this result can be extended to consider the whole interval of variation of the internal discipline.

Theorem 4. *(non-monotonicity) The relationship between internal discipline (β) and total discipline ($\beta+\varphi$) or the level of the fraud $(1/2)(\beta+\varphi)^{-1}$ is not monotonous. If $k < 2p+1$, the optimized fraud is an increasing function of β for low enough values of β. However, this property reverts at some stage as β increases.*

The proof directly follows from Theorems 1-3 and from the definition of η as given by (15). Notice first that the elasticity η is a decreasing function of $\varphi/\beta+\varphi$. Second, it is evident that $(\varphi/\beta+\varphi)$ is a decreasing function of β since $d\varphi/d\beta < 0$ on the basis of Theorem 1. It follows that $d\eta/d\beta > 0$ for all values of β. Theorem 3 states that $\eta < 1$for low enough values of β. As β increases, η thus increases from below to above unity so that under-compensation follows over-compensation when internal discipline in the recipient country improves. The turning point is given by:

$$\eta = 1 \; or \; \frac{\varphi}{\beta+\varphi} = \frac{k-1}{2p}$$

The condition $k < 2p+1$ for the optimized fraud to possibly increase with the autonomous quality of the governance in the recipient country may be looked at from the point of view of the parameter k or the parameter p. In the former case,

the condition is that the cost of the external discipline must not increase too quickly with the strength of the discipline, or the cost curve not to be too convex for a given probability of fraud detection. In the latter case, the condition is that the cost of the external discipline must not increase too slowly with the probability of detection. Coming back to the intitial instruments of aid delivery, i.e. the monitoring and the sanction, this is equivalent to assuming that the cost of punishment is not too small relative to that of monitoring. In the opposite limit case where this cost woud be nil, clearly the paradoxical result of the optimized fraud increasing with the internal governance would vanish.

To see that the condition $k < 2p+1$ is not unduly restrictive, it is worth going back to the parameters of the original cost functions for the monitoring of aid and for punishment, and to take into account the original constraints (7) on k and p. With q (>1) being the elasticity of the cost of monitoring, b, and with m (>1) being the elasticity of the cost of punishment, γ, the following equivalence may be derived from the definitions of k and p, as given in Appendix A1.

Theorem 5. *The condition* $Sup(1,2p) < k < 2p+1$ *is equivalent to the following conditions on the elasticities of the cost of monitoring (q) and of punishment (m):*

$$q > 2 \; and \; 2 < m < \frac{3-2/q}{1-2/q} \tag{21}$$

The proof is given in the Appendix A4.

The condition $m > 2$ is equivalent to the condition that the total cost (6) is increasing with the external discipline and simply guarantees that the optimal external discipline - i.e. the punishment - is not infinitely large, a rather unrealistic case. As for the condition $q > 2$, it guarantees the optimal external discipline is not zero, which seeems of little interest in the present context. Within this range, $[2,\infty] * [2,\infty]$ for q and m, the paradoxical result of an over-substitution of internal by external discipline simply requires the cost of punishment not to be too convex. The range of variation for m remains nevertheless substantial. It has practically no limit (above

2) when q is slightly above 2 . Its upper limit decreases slowly when q increases but always remains above 3.

Based on these examples, it has to be admitted that the over-substitution of internal by external discipline is a real possibility as soon as the internal discipline in the aid recipient country is weak enough, provided of course that the donor finds it optimal to engage with it.

Considering now the comparative statics with respect to the other parameters of the model, the following results are easily obtained:

Theorem 6. *(other comparative statics) The external discipline is a decreasing function of the cost parameters, B, and of the income of the recipient country. The external discipline is also decreasing with the size of the transfer.*

The proof is immediate from differencing the optimality condition $R(\varphi) = 1$ with respect to B, w and T. That higher values of the cost parameters reduce the extent of the external discipline is rather obvious. What is perhaps less evident is that the initial income of the population in the recipient country has the same effect. This is easily understood, though. Other things being equal, it can be seen from (13) that an increase in the income of the population, w, causes the marginal utility of the donor to fall. Equilibrium is re-established by reducing the discipline so as to lower the marginal cost. Put in the converse manner, the optimal external discipline is more severe for poorest countries with the same level of intrinsic governance, the size of the transfer being the same.

Regarding the effect of a change in the amount of aid transferred, the proof is again straightforward. It is obvious from (14) that the marginal cost of external discipline, $T\Gamma'$, increases with T. As for the the marginal utility, (13) implies that it unambiguously decreases as T rises. Clearly, optimality is re-established by reducing external discipline.

Distinguishing between the two components of external discipline, the following additional results can be established:

Corollary 1. *The optimal levels of monitoring and punishment both decrease monotonically with the level of internal discipline.*

The proof is given in the Appendix A5.

Corollary 2. *Both monitoring and punishment are decreasing functions of their own cost. However, whether they are gross complements or substitutes is ambiguous.*

The proof is given in Appendix A6.

6 The particular case: the leader's participation constraint is binding

The donor maximization problem now includes the leader's participation constraint given by (10):

$$V(\tilde{y}) = \frac{1}{4(\beta+\varphi)} - g \geq 0 \;\; or \;\; \varphi \leq \frac{1}{4g} - \beta$$

By assumption, this constraint is not binding under the solution of the general case. Since that solution does not depend on the cost of managing aid, g, it is sufficient to assume that this cost is sufficiently high for the leader's participation constraint to be binding. The donor has then no choice anymore, since the leader will only agree to manage the aid amount if external discipline does not exceed the threshold $\varphi = 1/4g - \beta$.

The comparative-static analysis is rather straightforward and yields the following results. First, when the level of internal discipline, β, increases, the external discipline, φ, is adjusted so as to maintain total discipline, $\beta + \varphi$, constant (at the level $1/4g$). We have perfect substitutability between the two types of discipline, instead of under- or over-substituability as before.

Second, the external discipline is not affected anymore by the size of aid or the poverty of the recipient country. The only parameter other than β that affects φ is the unit cost of handling aid for the leader, g. When g rises, the donor is forced to reduce external discipline in order to keep the leader at his reservation utility.

We are now in a position to summarize the results obtained under the assumption of a binding participation constraint of the leader, allowing for a comparison with

the case of a non-binding constraint.

Theorem 7. *When the donor is able to put the leader of the recipient country at his reservation utility, changes in external discipline exactly compensate changes in internal discipline, and this is true regardless of the initial level of internal governance. The size of the aid transfer and the income of the population in the recipient country do not influence external discipline, but the unit cost of handling aid for the leader does. When this cost increases, external discipline is reduced.*

It remains to specify when the participation constraint is binding. This will be the case if the marginal utility of external discipline is above its marginal cost, or, in other words, when the external discipline is at the level that makes the leader indifferent between participating or not. Namely (13) and (15) imply:

$$\frac{T(\beta+\varphi)^{-2}/2}{w+T(1-\frac{1}{2(\beta+\varphi)})} \geq \frac{T\eta}{\varphi} B\varphi^k(\beta+\varphi)^{-2p} \; with \; \beta+\varphi = 1/4g$$

After, a few transformation, this condition writes:

$$\frac{1}{2\left[w+T(1-2g)\right]} \geq B\left[k-2p(1-4\beta g)\right](1-4\beta g)^{k-1}(4g)^{2p-1-k}$$

Practically, the participation constraint is more likely to be binding as the management cost of aid, g, is high and the cost parameters of the cost function of the external discipline, the income of the population in the recipient country, and the size of aid are small. Not surprisingly, these last three conditions are the same as those that would lead to a high level of external discipline in the unconstrained model . More importantly, however, it is easily shown that the right hand side of the preceding inequality is a decreasing function of the internal governance when the condition $k < 2p+1$ holds[7], precisely the same condition that causes total discipline to be a decreasing function of internal discipline when the latter is small enough. If that condition is satisfied, the participation constraint of the leader is binding for high

[7]To see this, define $X = (1-4\beta g)$ so that the RHS of the preceding inequality is proportional to $kX^{k-1} - 2nX^k$. As $X < 1$, this expression is an increasing function of X and therefore a decreasing function of β if $k < 2p+1$.

levels, rather than low levels of internal governance. Therefore, when the internal governance goes down from an initially high level, participation is first binding so that total discipline is constant (at 1/4g). At some stage, however, the participation constraint does not bind anymore and total discipline increases when the internal governance keeps falling. The opposite outcome is obtained when $k \geq 2p+1$. When the internal governance goes up from an initially low level, participation is first binding, so that total discipline is constant (at 1/4g). At some stage, however, the participation constraint does not bind anymore, and total discipline increases when the internal governance keeps on improving.

7 Conclusion

This paper has attempted to elucidate the impact of the quality of domestic governance in recipient countries on the effectiveness of the targetting of aid when the donor is able and willing to use instruments (monitoring and punishmnet) to constrain the local elite's behavior. The attempt is novel and has led to several important results some of which are quite unexpected. To begin with, and this result is entirely according to intuition, external discipline acts as a substitute for internal discipline: when domestic discipline is increased in the recipient country, the donor responds by reducing the level of external discipline (along both the monitoring and the punishment dimensions). Yet, the outcome of governance, measured as the proportion of aid effectively reaching the poor (or the inverse of local elite capture), depends on total discipline consisting of the sum of internal and external disciplines. The central question is thus whether the improvement in internal discipline also results in an increase in total discipline so that the poor can obtain a higher share of aid money. This is where unexpected results emerge from our formal analysis.

When the elite's participation constraint is binding, internal and external disciplines exactly balance out with the consequence that total discipline and the share of the poor in the aid transfer remain constant. In other words, any change in internal discipline is fully neutralized by a change in exernal disicpline. When the elite is able to retain a surplus from the aid tranfer, our surprise actually increases. It now

becomes possible that an improvement in domestic discipline is over-compensated by the donor so that total discipline is paradoxically reduced and elite capture increases. Whether this happens or not depends on the initial level of internal discipline and on the shapes of the cost functions, that is, on the technolologies of monitoring and punishment available to the donor. Namely, the paradoxical role does occur when the internal discipline is low and the cost functions not too convex.[8] Moreover, the relationship between internal discipline and total discipline or the level of elite capture is not necessarily monotonous: if initially there is over-substitution of internal by external discipline and elite capture is an increasing function of internal discipline, both properties are likely to revert at some stage as internal discipline improves. The policy implication is important: if one wishes to avoid the paradoxical effect according to which the population of the recipient country is 'punished' by the donor for achieving a better domestic discipline, innovations must ensure that monitoring and punishment technologies are convex enough in their costs.

On the other hand, the model that we propose has the original feature of allowing the study of the effects of aid availability in addition to those of the initial income level. This is done in a framework where the utility of the donor is concave in the average income accruing to the recipient population, itself the sum of its stand-alone income and the amount of aid money per capita. With respect to the latter, the most interesting result is the following: when the elite's participation constraint is not binding, the optimal external discipline chosen by the donor decreases with the size of the aid transfer. When this constraint is binding, however, external discipline is unaffected by the amount of aid money. In other words, a greater aid supply induces the donor to relax his discipline but only when he is unable to put the local elite at its reservation utility. The effect of the initial level of income in the recipient country is analogous to that of the transfer amount: a higher income induces the donor to relax his discipline but only when the elite's participation constraint is not binding.

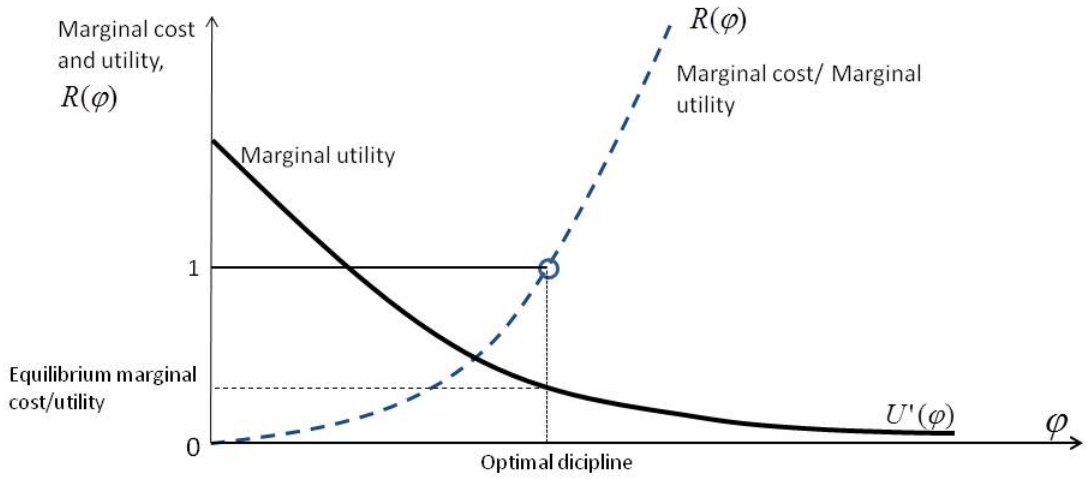
The major implication of the whole endeavor is, therefore, that when governance

[8]The latter condition requires the elasticities of the cost function of the aid delivery instruments (monitroing and punishment) not to be too much higher than 2. It must be stressed that this critical value of 2 is the consequence of the assumption of a quadratic internal cost of fraud and a quadratic probability of detection. If the elasticity of these two functions had been $e(>1)$ rathen than 2, the critical value of the elasticities of the delivery cost functions for the paradoxical result to hold would have been e, too.

is considered to be partly endogenous to the donor's effort, no general prediction can be made about the effect of variations in domestic governance on the effectiveness of aid targetting. We need to know more about initial levels of domestic governance, the aggregate amount of aid available, and the characteristics of the disciplining technology to be able to infer more precise testable propositions. Absent such information, empirical results are likely to be misleading or hard to interpret.

Even though the analysis in this paper is essentially static, its implications for the literature on the growth effectiveness of aid needs to be stressed. If aid effectiveness is defined by the amount of aid actually reaching the grassroot population of the recipient country, as it is in our analytical framework, then it is the case that aid effectiveness depends in an *ambiguous way* on the level of internal governance. This is true although it depends *positively*, but also trivially, on the overall governance measured by the inverse of the aid leakage or embezzlement by the leader. This may explain the inconclusiveness of the empirical aid effectiveness literature. It also sheds light on the difficulty of measuring governance. In the present framework, the question arises of which governance should be considered: the intrinsic one or the one that results from the pressure of donors? The difficulty essentially arises from the two-way relationship pointed by Edwards (2014): "aid agencies influence policies, and the reality in the recipient country affects the actions of aid agencies" (p.41).

Figure 1: Equilibrium of marginal utility and marginal cost of external discipline when $q > 2$ and $m > 2$



Appendix

A1. Derivation of the cost function

Let C(b) and D(γ) be, respectively, the cost per unit of aid of monitoring and punishmment. Both functions are assumed to be increasing and convex. Bearing in mind that punishment is only meted out when fraud is detected, which occurs with probability $\pi = \left(b^2/a^2\right) y^2$, the cost function of the external discipline per unit of aid defined in (3) is obtained from :

$$\Gamma(\varphi) = Min_{b,\gamma} C(b) + D(\gamma) \left[\frac{1}{4} \frac{b^2}{a^2} \frac{1}{(\beta+\varphi)^2} \right] \;\; s.t \; \varphi = \frac{b^2 \gamma}{a^2} \tag{22}$$

To simplify the analysis, we specify the two cost functions as convex power functions:

$$C(b) = \frac{cb^q}{q},\; D(\gamma) = \frac{d\gamma^m}{m},\; with\; q \geq 1,\; m \geq 1$$

Then, using the definition of φ above to express γ as a function of b and φ, the donor's problem becomes:

$$\Gamma(\varphi) = Min_b \, c\frac{b^q}{q} + \frac{d}{4m} \frac{b^2 a^{2m}}{(\beta+\varphi)^2} \frac{\varphi^m}{b^{2m}} \tag{23}$$

the solution of which is given by:

$$b^*(\varphi) = \left[\frac{d}{c} \frac{m-1}{2m} \frac{a^{2m-1}\varphi^m}{(\beta+\varphi)^2} \right]^{\frac{1}{q+2(m-1)}} \tag{24}$$

After plugging this expression back into (23), we obtain expression (6) for the cost of the external discipline per unit of aid:

$$\Gamma(\varphi) = B\varphi^k (\beta+\varphi)^{-2p} \tag{25}$$

where:

$$p = \frac{q}{q+2(m-1)}\,;\; k = mp\,;\; B = \frac{c^{1-p} d^p 2^{-(1+p)} a^{2(m-1)p}}{q(m-1)^{1-p} m^p} [(m-1)2+q] \tag{26}$$

It can be seen on this expression that p can logically be assumed to be less than one as in the main text, whereas the assumption made there that $k > 1$ - which actually requires $q > 2$ in the preceding specification - is for practical convenience. The complementary case $1 < q < 2$ is analyzed in detail in the online earlier version of this paper.

A2. Proof of Theorem 1

Consider $R(\varphi)$ as given by (17) . It is clearly increasing in β if $p < 1/2$. To see that this is aso true if $p \in [1/2, 1]$ take the logarithmic differential:

$$\frac{1}{R}\frac{\partial R}{\partial \beta} = \frac{k}{k(\beta+\varphi)-2p\varphi} - \frac{2p-1}{(\beta+\varphi)} + \frac{(\beta+\varphi)^{-2}/2}{w+T(1-\frac{1}{2(\beta+\varphi)})}$$

The third term on the RHS is clearly positive. Evaluate then the sum S of the first two terms. It comes after rearrangements that:

$$S = \frac{2(1-p)\left[k(\beta+\varphi)-2p\varphi\right]+2p\varphi}{\left[k(\beta+\varphi)-2p\varphi\right](\beta+\varphi)}$$

This sum is positive since $k(\beta+\varphi)-2p\varphi = (k-2p)\varphi + k\beta$ is positive under conditions (7). As R'(φ) is positive, the substitutability between β and φ follows. QED

A3. Proof of Theorem 2.

Differentiate logarithmically the optimality condition:

$$R(\varphi) = B\left[(k-2p)\varphi + k\beta\right]\left[\frac{\varphi^{k-1}}{(\beta+\varphi)^{2p-1}}\right]\left[w+T(1-\frac{1}{2(\beta+\varphi)})\right] = 1$$

with respect to φ, while keeping $(\beta+\varphi)$ constant, and denote Δ_φ the corresponding operator. It comes:

$$\frac{\Delta_\varphi(R)}{R} = \frac{-2p}{k(\beta+\varphi)-2p\varphi} + \frac{k-1}{\varphi} = \frac{k-1-\frac{2\varphi p}{\beta+\varphi}}{\varphi\left[k(\beta+\varphi)-2p\varphi\right]}$$

It is thus the case that:

$$sign(\frac{\Delta_\varphi(R)}{R}) = sign(\eta - 1)$$

As R is an increasing function of φ, it follows that φ must fall by less than β to reestablish equilibrium if the cost elasticity, η, is more than unity and by more than

β if η is less than unity. The total discipline, $\beta+\varphi$, increases in the former case and decreases in the latter. QED.

A4. Proof of Theorem 5

From conditions (26), it comes immediately that $k \geq 2p$ is equivalent to $m \geq 2$, $k > 1$ to $m > 1/p$ and $k < 2p$+1 to $m < 2+1/p$. Substituting the expression of p in (26), $k > 1$ thus implies $q > 2$ whereas $k < 2p$+1 requires:

$$m < 2 + \frac{q+2(m-1)}{q}$$

or:

$$m(1-2/q) < 3-2/q$$

which is (21) when $q > 2$.

A5. Proof of Corollary 1

It can be seen from (24) that b^* is an increasing function of φ and a decreasing function of β. As φ reacts negatively to an increase in β (Theorem 1), b^* decreases when β increases. Things are less easy for $\partial\gamma^*/\partial\beta$. First, the optimal punishment is defined by:

$$\gamma^* = \varphi/b^{*2}$$

Replacing b^* by (24), it comes that :

$$\gamma^* = \varphi\left[\frac{d}{c}\frac{m-1}{2m}\frac{\varphi^m}{(\beta+\varphi)^2}\right]^{\frac{-2}{q+2(m-1)}}$$

Differentiating logarithmically with respect to β leads to:

$$sign(\frac{\partial\gamma^*}{\partial\beta}) = sign\left[\frac{\partial\varphi}{\partial\beta} - \frac{\varphi/(\beta+\varphi)}{\varphi/(\beta+\varphi)+(q-2)/4}\right] \tag{27}$$

Differentiating the equilibrium condition $R(\varphi)=1$ with respect to φ and β yields after some manipulation:

$$\frac{\partial\varphi}{\partial\beta} = -\frac{\varphi/(\beta+\varphi)}{\varphi/(\beta+\varphi)+N/M}$$

where:

$$M = \frac{1}{(\beta+\varphi)-1} + \frac{4(m-1)\left[m(\beta+\varphi)-\varphi\right]+2q\varphi}{\left[q+2(m-1)\right]\left[m(\beta+\varphi)-2\varphi\right]};$$

$$N = \frac{m(m-1)(q-2)(\beta+\varphi)-2qm\varphi}{\left[q+2(m-1)\right]\left[m(\beta+\varphi)-2\varphi\right]}$$

It is then easily proven that $N/M \leq (q-2)/4$, so that the sign in (27) is negative. QED

A6. Proof of Corollary 2

Consider optimal monitoring as given by (24). An increase in c clearly reduces the extent of monitoring for given external discipline, φ. As external discipline falls with the two cost parameters, c and d, and as $\varphi^m/(\beta+\varphi)^2$ varies in the same direction as φ (provided that $m \geq 2$, which must be fulfilled in the case of an interior solution), the overall effect of a change in c on b^* is negative. The corresponding two effects when the cost of punishment increases are opposite to each other. Hence the ambiguity.

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