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Does It Take a Tyrant to Carry Out a Good Reform?

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In this model a reform is a switch from one norm of behavior (equilibrium) to another and agents have to endure private costs of transition in case of a reform. An authority, which coordinates the transition, can enforce transfers across the agents and is capable of imposing punishments upon them. A transfer is limited, however, by an agent's payo , and a punishment can not exceed an upper bound. Carrying out a good, Pareto improving, reform can be hindered by asymmetric information about the costs of transition, which are privately known to the agents and can not be verified by the authority. In this case execution of some good reforms is impossible without a credible threat of a punishment, even if Bayesian mechanisms can be used. Allowing for harsher punishments in that framework reduces to 'softening' individual rationality constraints, thus widening the range of feasible reforms. The flip-side of increasing the admissible punishment is making 'bad' reforms possible as well as lowering well-being of selected individuals. We, thus, formulate a trade-o between successful implementation of good reforms and severity of acceptable punishments.

Why are some potentially good reforms never implemented? What can explain fruitfulness of recent economic reforms in China, overwhelming success of the newly industrialized countries in the 1970's-1980's along with a turbulent and murky path followed by India and Russia in the past decade, for example?[1] Our goal is not to provide an ultimate answer, but, rather, to illuminate some possible connections between political and economic changes. We envision the role of a reformer – be it a single "dictator" or a democratic government – as a one-time intervention, with the sole purpose of changing the "norm of behavior" in a country.[2] For example, a norm could describe production-consumption choices under a given market structure, degree of openness to the international trade and a monetary regime.[3] Even if two di erent norms can be ranked Pareto, a (decentralized) switch to a dominant one might not occur due to the reluctance of some individuals to cover the transition costs, which range from the e ort of re-structuring one's investment portfolio to

is. This creates a chance that the investors abandon local currency, even if the fundamentals are good, i.e., it creates a possibility of the switch to a Pareto dominated equilibrium. This can be remedied by a costly action of the “policy maker," as shown in Angeletos, Hellwig, and Pavan (2003). Inability of individuals to synchronize their actions can also lead to the failure of a (de-centralized) switch to the e cient equilibrium, as in Morris (1995). While strategic manipulation of individual beliefs can be interesting to explore, we leave it for future investigation, resorting, instead, to a common knowledge environment. This choice is dictated, in part, by our desire to relieve the pressure on necessary punishments by adhering to a less restrictive solution concept (Bayesian Nash).

The rest of the paper is organized as follows.

After setting up the model in section , we proceed with the full information model, in which individual costs of transition are known to the reformer (local authority). In section we show that the authority does not need to use punishments to implement good (Pareto improving) reforms, moreover an eccentric authority may be incapable of forcing undesirable reforms (i.e., a switch to a Pareto dominated equilibrium) without resorting to a punishment. Under asymmetric information, introduced in section , the authority may need to credibly threat individuals with punishments. The punishment might be higher for more divided countries and in case of bad reforms, as illustrated in section . for the discrete distribution case. We generalize the main results for the case of continuous costs distribution thereafter. Extensions and conclusions follow. The proofs are in the appendix.

A country consists of N individuals (agents). Their everyday interactions are reduced to a simultaneous move coordination game G with two actions A, B

s^B B, B, .., B − Nash equilibria.[5] These equilibria are 'Pareto' ranked as follows:

$$u \ s^A \quad a > b \quad u \ s^B \ \geq \ , \tag{4}$$

and assume both dominate a mixed strategy payo .

fi A reform is a switch from one equilibrium (norm) to another.

Agent i has a cost, c_i $\underline{c}, c$ R_+, associated with switching her action. In this model a switch from $^B s$ to s^A is a Pareto improving (good) reform, provided the average cost is below the gain, $a - b$. Otherwise a switch is a bad, or an undesirable one.

An authority, however, may have distinct interests from the rest of the society. It has the ability of coordinating a switch, or announcing the reform, besides, it has an access to two tools: (1) transfers to the agents, t_i $_i$ R^N (2) punishments, m_i $_i$ R^N_+. There are no outside sources of financing the reform so that

$$\Sigma_i t_i \leq \tag{BB}$$

Both the transfer and the punishment schemes, we assume, are anonymous, they are independent on the "names" of individuals, but rather, on the observed actions and on verifiable individual characteristics. More precisely, the transfers and the punishment vary only with the action, s^1_i, taken by individual i, actions taken by the rest of the players, s^1_{-i} and the cost of transition, c_i, if observed:

$$t_i \quad t \ s^1_i, s^1_{-i}, c_i, c_{-i}, I \ c \qquad m_i \quad m \ s^1_i, s^1_{-i}, c_i, c_{-i}, I \ c \ . \tag{5}$$

In particular, costs of transition might influence the decision with respect to the reform, indicated by I c , which is unity in case the reform is announced and zero otherwise, c $\underline{c}, c^{\ N}$.

[5] In addition, there could be "knife edge" assymetric equilibria of the form: proportion p (pN is an integer) of the agents are choosing A and the rest are choosing B

$$u \ \underbrace{A, .., A}_{pN}, \underbrace{B, ..B}_{(1Pp)N} \qquad w > u \ \underbrace{B, A, .., A}_{pNP1}, \underbrace{B, ..B}_{(1Pp)N} \tag{2}$$

$$w \ > \ u \ \underbrace{A, .., A,}_{pN+1} \ \underbrace{B, ..B}_{(1Pp)NP1} \ . \tag{3}$$

These are assumed away for simplicity.

While the authority announces its recommendation "switch to strategy A" or "continue with B, it also has to make sure that the agents are sure to follow. This implies that the prescribed action s_i should satisfy[6]

$$s \quad {}_{s_i^1 \ \{A,B\}} \; u \; s_i^1, s_{-i}^1 \; - c_i \iota \; s_i^0, s_i^1 \quad t_i - m_i, \; i \qquad \text{(IC)}$$

over the available (new) actions s_i^1 A, B , with ι s_i^0, s_i^1 is the switching index, it is unity, if i switched the action, so that pre- and post- reform actions are di erent, s_i^0 s_i^1 and zero otherwise.

There is no doubt that with the threat of a punishment harsh enough, any request of the authority will be "convincing enough," in other words, if the punishment m_i for disobeying the prescription is su ciently large, any prescription will be followed. One of our goals is to understand just how much punishment is needed to motivate the agents to follow the suggestions of the authority.

Another way of looking at it is to assume that during the transition "human rights" constraints should abided, as those are strictly enforced by an "international community,"[7]

$$m_i \leq m, \qquad \text{(IRH)}$$

where m R_+ denotes the upper bound on a credible punishment. Thus, we will be seeking to define the smallest such bound m that will allow for good reforms. This could be of interest to a benevolent international community, viewed as a "meta-mechanism designer" whose objective is to prevent bad reforms and not to inhibit good reforms with limited tools, those being just the bound on punishments, m. Indeed, it might be impossible for an outsider to judge whether the "reformer" is benevolent or not and to dictate precisely how to use the transfers and whether to undertake the reform, i.e., intervening in the internal a airs of a country.

Clearly, if there are no additional constraints, and if taxes (transfers) can be expropriated by the reformer or simply burnt, the (

a reform or not. Endowed with the common knowledge of the reformer's decision, the agents choose one of two actions A, B . They get transfers and are subject to punishment according to the mechanism thereafter.

A rule is implementable if every agent is choosing his best response given his cost and his beliefs about the costs of the others, the costs are truly revealed and everybody chose the action as instructed by the authority, i.e., according to $I \; \theta$.

In particular, the latter constraints imply,

$$E_{c_{P_i}} U \quad I \quad \theta_i, c_{-i} \quad - c_i I \quad \theta_i, c_{-i} \quad \tau \quad \theta_i, c_{-i} \quad \geq -mE_{c_{P_i}} I \quad \theta_i, c_{-i} \text{ for all } i, \tag{IIR}$$

where

$$\tau \quad \theta_i, c_{-i} \quad \equiv t \quad s^A, \theta_i, c_{-i}, \quad I \quad \theta_i, c_{-i} \quad t \quad s^B, \theta_i, c_{-i}, \quad - I \quad \theta_i, c_{-i} \quad . \tag{16}$$

Luckily, this is nothing but an interim individual rationality constraint from standard mechanism design literature, if m . Allowing for $m >$, thus, "softens" this constraint, undeniably "helping" the reformer.

As we demonstrate below, the minimal punishment might be above zero even for implementing a benevolent rule I_1 and it crucially depends on the shape of distribution F. However, an eccentric ruler has to be the most tyrannical, as she needs to resort to a punishment above the one pertinent to a benevolent rule. First, we calculate the latter "upper" bound, and then proceed by deriving the minimal threat to be granted to a benevolent reformer in order to be always successful.

The eccentric rule I_2 is implementable with punishment of at least , m_2 ,

$$m_2 \quad c - a, \tag{17}$$

where c is the upper support of the cost distribution.

It is worth noting that m_2 is not necessarily strictly positive, so that even in the asymmetric information case an eccentric ruler might not need to resort to strictly positive punishments. For example, if the improvement, $a - b$, is quite small relative to the costs, but the level of the new benefit a is su ciently high, $c < a$, no punishment will be necessary. A mechanism supporting such a reform is very simple. Impose no transfers if an agent complies with the request to switch his action. In case an agent obeys the authority, the new payo is then $a - c_i \geq a - c$

with truthtelling at the same time. In order to determine this bound, we will first analyze the case of a discrete distribution sections and then proceed to the continuous case in Section . .

Suppose that each agent's switching cost is either $\underline{c}$ (with probability ρ or c (with the complimentary probability) and is distributed independently and identically, so that the the costs are driven from distribution D

$$D \quad x \quad \begin{cases} \quad, \text{if } x < \underline{c} \\ \rho, \ \text{if } \underline{c} \leq x < c \\ \quad, \text{otherwise} \end{cases} . \tag{18}$$

If $a - \underline{c} \leq b$, then switching from s^B to s^A is never beneficial. If $a - c$

Note that if c is high and a or b are su ciently small, m_1 is positive. This is because it is expensive to make the high cost agents to switch, and the tax revenue that is available carry out a reform. That is why we compare boundary m_1 across di erent environments (countries). These comparisons are reproduced for the continuous case in section . .

We can compare two 'countries' that di er by the shape of their costs distribution. One is more 'divided' than the other, if the possible realizations of costs are further apart. This, for example, corresponds to the variation in attitudes towards the reform: if some people favor the transition (view its costs as rather small), while others perceive it as undesirable, or very costly. The bigger is this gap – we show – the harder it is to implement the reform. It happens as higher di erence in costs increases the "informational rents," which, in turn, call for a higher minimal punishment. As an illustration one could rely on economic success of (relatively) homogenous Far Eastern countries (Taiwan, Singapore) in the mid-1980's and challenges of economic reforms in the vastly diverse India.

As in the previous case, we want to keep the social decision with respect to reform, i.e., the smallest number of low cost announcements to execute the reform, n , constant. In order to do so, we can only consider cases in which low cost and high cost realizations are equally likely and the gain from reform is exactly between the costs, thus making the "majority rule" an optimal decision.

Assume the costs are distributed D independently, with $a - \underline{c} > b$ and $a - c < b$. Assume, in addition, that ρ / and $a - b$ N $\frac{\bar{c}+\underline{c}}{2}$. Then a mean preserving spread of the costs, i.e., if an individual cost either c δ or $\underline{c} - \delta$ with equal probabilities for any $\delta >$, leads to an increase in the required punishment, m_1, to implement the corresponding benevolent rule.

In this section we show that smaller reforms are easier to implement as opposed to big leaps. Relatively successful reforms in China and a painful transition in Russia can be seen as an illustration of this relation.

To make such a comparison we have to introduce "intermediate steps," or to extend the initial coordination game to generate additional equilibria. Let the initial action set in game G now include action X, and we assume, that every agent choosing action X constitutes a new (pure strategy) Nash equilibrium, s^X, in that game with the corresponding payo x b, a to each. Therefore, switching from s^B to s^X captures a proportion of the benefit of the big switch (s^B to s^A). Let α denote this proportion. That is, $x - b$ α $a - b$.

We think about a transition to X as a “scaled down" reform, so it is natural to think that the costs for this transition are also proportionally smaller. Let $\underline{c}\ x$ and $c\ x$ denote that switching cost respectively for a low cost agent and a high cost agent to s^X. Then

$$c_j\ x \quad \alpha c_j\ a \quad \alpha c_j,\ j \quad L, H\ . \tag{24}$$

In this set up the smallest number of the low cost agents needed for a reform to be worthwhile stays constant from switch to switch. Indeed, let $n\ \ x$ denote the minimum number of low-cost agents required for the switch to s^X to be beneficial. Then

$$N\ x - b \quad n\ \ x\ \underline{c}\ x \quad N - n\ \ x\ \ c\ x\ .$$

Since $x - b \quad \alpha\ a - b$, $\underline{c}\ x \quad \alpha\underline{c}$, and $c\ x \quad \alpha c$, we can conclude that $n\ \ x \quad n\ $.

Define the benevolent rule for small reforms, I_1^α, accordingly, with x replacing a and the new average cost being $\alpha\mu$.

Let $b >\ $. Assume the costs are distributed D independently, with $a - \underline{c} > b$ and $a - c < b$ and that an agent’s switching cost is proportional to the gain from a switch.

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Then I_1^α is implementable with allowable punishment of at least $\ , m_1^\alpha\ $,

$$m_1^\alpha \quad \frac{}{n_L \geq n} \ \alpha m_1 - \quad - \alpha\ \ b\ , \tag{25}$$

where m_1 is the punishment needed for a big (original) reform. Therefore for any

One may reasonably expect that breaking up a large reform into smaller ones would require lower total punishment. But showing this proves to be di cult. This is because earlier reforms reveal information regarding

Note that this bound, m_1, is the negative of two terms. The first is the expected 'virtual' payo in case of reform, and the second one is its counter-part in case no reform is undertaken. The first term is familiar from the mechanism design literature. Assume b ,
then $m_1 >$ only when the objective is not implementable in the standard framework, i.e., if the standard individual rationality constraint is incompatible with incentive compatibility and budget balance constraints.[13] Softening restrictions on the punishment, is identical (in this case) to relaxing the ex-post individual rationality constraint, thus, it extends the range of feasible reforms. Recall that without the individual rationality constraint, benevolent rule is implementable using d'Aspremont and Gérard-Varet (1979) mechanism.

The next proposition generalizes some of the comparative statics results for this case.

If costs distributions can be ordered according to the first order stochastically dominance criterion, then the dominating distribution corresponds to a more 'expensive' reform, in particular, with higher average cost of transition. In particular, it asserts that 'bad' reforms require harsh punishments. The second part of the proposition compares punishments under two distributions that are ordered by "more peaked" order. The following definition is adopted from Shaked and Shanthikumar (1994), p.77.

fi Consider two unimodal distributions, F and H, symmetric about μ. F is more peaked than H, if H x

To formulate a generalization of proposition , note that a 'small' step reform that generates a fraction α , of the original gain, $a - b$, and requires a fraction α of the original costs, $c_i^\alpha \equiv \alpha c_i$ for all agents i will require a punishment

$$m_1^\alpha \equiv \int_{\alpha \underline{c}}^{\alpha \bar{c}} \Big[F \quad \frac{}{\alpha} s_\alpha \qquad s_\alpha \frac{}{\alpha} f \quad \frac{}{\alpha} s_\alpha \qquad I \quad \frac{}{\alpha} s_\alpha \quad ds_\alpha - b - \alpha \;\; a - b \;\; Q \;\; \Delta \tag{27}$$

$$\alpha m_1 - \quad - \alpha \;\; b. \tag{28}$$

Clearly, with α small enough and $b >$, the small step reform will require no punishments, $m_1^\alpha \leq$, then identical argument to that in proposition establishes the rest of the result.

Here we demonstrate that it is easy to re-formulate this model to capture some cases of common uncertainty with respect to the outcome of a reform for the two types case.

Suppose that there are two di erent levels of payo $_L$

Consider another situation where the payo is the same for every agent in s^A but di erent agent receives di erent information about it. Suppose that all agents have the same switching cost. Let a be the common payo that every of them will receive in s^A, and agent i receives a signal a_i

this case, the necessary punishments, m_1 and m_2, (if positive) each decrease by $T / N I \;\; c$,
thus, making it easier to implement both a benevolent and an eccentric rule.[14] Provided the interim well-being of the highest cost individual is exactly equal to $-m_i$, this outside transfer T, may improve the (expected) utility of the least fortunate.[15] Clearly, this improvem2.0827Tc15.4(t4001-he)-3

evant individual characteristics might relieve the pressure on this boundary. Bundling, or linking independent decisions (public goods) can improve e ciency, see Jackson and Sonnenschein (2003), Fang and Norman (2003). However in the context of this model, provided the reform is interpreted as a single (global) public good the above results are not applicable.

So far we have assumed that a reform entails a coordinated response of all the agents in a society. No doubt, it might be a close description of some real-life transitions, for example, altering the alphabet, or exchanging the acceptable currency, a switch from driving on the left to driving on the right hand side and vice versa. However, some other reforms, say, privatization, rely on just a subset of individuals to substantially alter their actions for the reform to be "successful." It could be interesting to extend the framework by allowing some of the agents to retain their old action, for example, if their costs are high enough, i.e., to incorporate partial reforms.

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It is then natural to expect that the international community will come up with some mechanisms to protect individuals against bad reforms in their countries. With direct foreign intervention (determining which reforms to undertake, or dictating the identity of the ruler) being often impossible or undesirable, the outsiders can settle on enforcing human rights protection instead. As our results suggest, human rights, indeed, may be a sensible indicator to monitor. If the level of maximal i

Therefore the incentive constraint becomes

$$a - c_i \quad t\ s^A, c_i, c_{-i}, \quad \geq u\ \ B, s^A_{-i}\ \ - u\ \ B, s^A_{-i}\ \ - m \text{ for all } i, \tag{35}$$

which implies

$$a - c_i \quad t\ s^A, c_i, c_{-i}, \quad \geq -m \text{ for all } i, \tag{36}$$

Sum up over i and divide by N, and get

$$a - \mu \quad t \geq -m, \tag{37}$$

where t is the average tax and μ is the average switching cost. But in the view of BB , t , so if all the incentive constraints hold if

$$m \geq -a \quad \mu. \tag{38}$$

conversely, if ( ) holds, the reformer can pick taxes in such a way as to equalize the after tax switching cost across agents and thus, implement the reform. Note that this condition is independent on whether the reform is a good one $\mu < a - b$, or not. Therefore the boundary $m_1 \equiv \mu - a$ is also the smallest punishment to introduce any reform (bad ones included).

If $\mu > a - b$, a benevolent reformer, implemeatS2o1Tf2.792304c0TD0070Tj/TT241Tf8.03551484/TT488.144 discou7.8(-371355(f7.7(v)ro376.28[taxus,)ge)-32)2.3.2()35.8g[b)2(rsely1(t)tax)-33h.4(w7(u.1(s)t)4.3b)2(orm)--4md5(

It implies, that

$$a - c_i \quad t \quad s^A, \theta, \quad \geq -m \text{ for all } i. \tag{46}$$

Therefore, the minimum of m is

$$m_2 \quad c - a.$$

Note that t for all c_i $c, \underline{c}$ is individually feasible, satisfying RC . It also satisfies the rest of the constraints for $m \geq m_2$. ■

First, denote

$$c_1 \quad \underline{c} \quad n_L \geq n \; - \qquad c_1 \quad c \quad n_L \geq n \tag{53}$$

as the ex-ante probability that s^A should be enforced and

$$c_1 \quad \underline{c} \quad n_L < n \; - \qquad c_1 \quad c \quad n_L < n$$

as the probability that s^B should be enforced ex-ante. Note that can also be expressed as

$$n_L \geq n \qquad c_1 \quad \underline{c} \quad n_L \quad n \; - \quad .$$

This is because

$$n_L \geq n \; - \qquad n_L \geq n \qquad n_L \quad n \; - \quad .$$

Suppose that agent 1 has switching cost c_1. Let $E_A \tau \; c_1$ denote the expected transfer agent 1 receives conditional on that s^A should be implemented. Similarly, let $E_B \tau \; c_1$ denote the expected transfer agent 1 receives conditional on that s^B should be implemented. Thus,

$$E$$

$E_A \tau \; c$ is the transfer in this case. (As we can easily see below, having a constant transfer of $E_A \tau \; c$ helps to satisfy the incentive compatibility constraint.) If he refuses to switch, all of his income will be taxed away plus he is punished to the most extend. Therefore, he receives $-m$ in this case. That is, for $c_1 \quad c$ and $n_L \geq n$,

$$a - c \quad E_A \tau \; c \;\; \geq -m. \tag{54}$$

For $c_1 \quad c$ and $n_L < n$, no switch is required, and

$$b \quad E_B \tau \; c \;\; \geq -m. \tag{55}$$

Similarly, for $c_1 \quad \underline{c}$ and $n_L \geq n \;\; -$, switching to A is required, and

$$a - \underline{c} \quad E_A \tau \; \underline{c} \;\; \geq -m. \tag{56}$$

For $c_1 \quad \underline{c}$ and $n_L < n \;\; -$, no switch is required, and

$$b \quad E_B \tau \; \underline{c} \;\; \geq -m. \tag{57}$$

Now consider the information revelation in the first stage. Suppose that agent 1's switching cost is $\underline{c}$. Then the incentive compatibility constraint for him27.8(.3(agen)2-321Tf277.3(r9.4c)ee6(for)-332(1Tf

The two incentive compatibility constraints for truthful reporting (58) and (59) can then be simplified as

τ

which gives us

$$\tau\ \underline{c}\quad - a - \underline{c} - b\quad n_L\quad n\ -$$
$$c - a - m\quad n_L \geq n\quad -b - m\quad n_L < n$$
$$-m\quad n_L \geq n\quad -a\quad n_L \geq n\ -\quad -b\quad n_L < n\ -$$
$$c\quad n_L \geq n\quad \underline{c}\quad n_L\quad n\ - \tag{62}$$

Therefore, the minimum expected transfer is

$$E\ \tau\quad c_1\quad \underline{c}\ \tau\ \underline{c}\quad c_1\quad c\ \tau\ c$$
$$c_1\quad \underline{c}\ \ -m\quad n_L \geq n\quad -a\quad n_L \geq n\ -$$
$$-b\quad n_L <\quad n\ -\quad c\quad n_L \geq n\quad \underline{c}\quad n_L\quad n\ - \tag{63}$$
$$c_1\quad c\ \ c - a - m\quad n_L \geq n\quad -b\quad n_L < n$$
$$-m\quad n_L \geq n\quad -a\quad -b\quad c\quad n_L \geq n$$
$$\underline{c}\quad c_1\quad \underline{c}\quad n_L\quad n\ -$$

The ex ante budget balance $E\ \tau\ c\ \leq$ implies

$$m \geq -a$$

Note that $E_B\tau\ \underline{c}\quad -b$ and substitute m_1 for m. We can easily show that $E_A\tau\ \underline{c}\ > -a$. Therefore, the tax constraint for the low cost agent is satisfied as well. So the characterization we obtained indeed satisfies all of the conditions. ■

By the assumptions $n \quad \frac{1}{2}N$ under any such spread. By definition of m_1, (20), it is enough to show that $\quad n_L \geq n \quad > \quad c_1 \quad \underline{c} \quad n_L \quad n - \quad$. Indeed,

$$n_L \quad \geq \quad n \quad > \frac{N - n}{n} \quad \begin{matrix} N - \\ n - \end{matrix} \quad \rho^{n^t} \quad - \rho^{\,N-n^t-1} \quad \Big[\text{if } n \quad -N \tag{64}$$

$$\begin{matrix} N - \\ n - \end{matrix} \quad \rho^{n^t} \quad - \rho^{\,N-n^t-1} > \quad \begin{matrix} N - \\ n - \end{matrix}$$

$n_L \geq n \quad m_1 \qquad -a \qquad -b \qquad N \; a - b$

By setting τ a_L at its minimum level γ, we obtain the minimum (ex-ante) expected transfer, E τ , as follows:

$$E \quad \tau \qquad a_1 \quad a_H \;\; \tau\; a_H \qquad a_1 \quad a_L \;\; \tau\; a_L$$
$$a_1 \quad a_H \quad - \; a_H - c - b \qquad n_H \qquad n \quad -$$
$$c - a_L - m \qquad n_H \geq n \quad - b \qquad n_H < n$$
$$a_1$$

be expected payment of i, probability of reform, and expected “equilibrium" payo (in coordination game next period), conditional on i reporting θ_i, and all the rest are telling the truth. Note that

$$v(\theta_i) \quad l(\theta_i)a \quad -l(\theta_i)\, b. \tag{74}$$

Let

$$V(c_i) \equiv v(c_i) - c_i l(c_i) \quad \tau(c_i). \tag{75}$$

By a standard argument, Bayesian Incentive compatibility implies that $l(c_i)$ is non-increasing (weakly decreasing). Moreover,

$$V^{0}(c_i) \quad -l(c_i), \tag{76}$$

which implies

$$V(c_i) \quad V(\underline{c}) - \int_{\underline{c}}^{c_i} l(s)\, ds. \tag{77}$$

Let us incorporate additional constraints.

Recall that by , ,

$$a - c_i \quad \tau_i(c_i, c_{-i}) \geq -m, \text{ if } \sum_{j=1}^{N} c_j \leq \Delta \quad N(a-b) \tag{78}$$

$$b \quad \tau_i(c_i, c_{-i}) \geq \quad , \text{ if } \sum_{j=1}^{N} c_j > \Delta \quad N(a-b) \tag{79}$$

This implies that the (soft) interim individual rationality constraint should be satisfied:

$$V(c_i) \quad l(c_i)(a - c_i \quad \tau_A(c_i)) \quad -l(c_i)(b \quad E_B\tau(c_i)) \geq -ml(c_i), \tag{80}$$

where, as in the discrete case

$$E_A\tau(c_i) \equiv E_{c_{P_i}}\left(\tau_i(c_i, c_{-i}) \quad \sum_{j=1}^{N} c_j \leq \Delta\right) \tag{81}$$

$$E_B\tau(c_i) \equiv E_{c_{P_i}}\left(\tau_i(c_i, c_{-i}) \quad \sum_{j=1}^{N} c_j > \Delta\right). \tag{82}$$

Combining with , we get for all i

$$V(\underline{c}) - \int_{\underline{c}}^{c_i} l(s)\, ds \geq -ml(c_i), \tag{83}$$

$$\int_{\underline{c}}^{c_i} l(s)\, ds - ml(c_i) \leq V(\underline{c}). \tag{84}$$

When is this constraint binding?

As the left hand side in increasing in c_i, it is enough to verify that the constraint holds for the highest possible realization of cost, c_i c

$$\int_{\underline{c}}^{\bar{c}} I(s)\,ds - mI(c) \leq V(\underline{c}). \tag{85}$$

Inequality provides a lower bound on m

$$\frac{\int_{\underline{c}}^{\bar{c}} I(s)\,ds - V(\underline{c})}{I(c)} \quad m_1 \tag{86}$$

By definition

$$V(\underline{c}) \quad I(\underline{c}) \quad a - b - \underline{c} \quad b \quad \tau(\underline{c}). \tag{87}$$

It implies that

$$I(c)\, m_1 \quad \int_{\underline{c}}^{\bar{c}} I(s)\,ds - V(\underline{c}) \tag{88}$$

$$\int_{\underline{c}}^{\bar{c}} I(s)\,ds - I(\underline{c}) \quad a - b - \underline{c} \quad - b - \tau(\underline{c}) \tag{89}$$

¤

and

$$E_i \int_{\underline{c}}^{c_i} \frac{\partial I \quad s}{\partial s} sds \qquad \int_{\underline{c}}^{\bar{c}} \left[\int_{\underline{c}}^{c_i} \frac{\partial I \quad s}{\partial s} sds \quad f \quad c_i \quad d \quad c_i \right. \tag{96}$$

$\bar{c}$ Th04(o)eref,j-0.002Tc[((91781))]TJ/TT151Tf1.9290T10Tc003c[(we)/T 3676T6 0.6066 0 TD sds /TT15460 TD 0 Tc <0003>Tj /TT15891Tf 0.99 (97)

$$\int_{\underline{c}} \frac{\partial I \quad s}{\partial s}$$

Combining, the three observations above with , we get

$$E_i \tau \quad c_i \qquad \tau \quad \underline{c} \qquad a - b \qquad I \quad \underline{c} \quad - Q \quad \Delta$$

It is left to check that feasibility constraints RC are satisfied. Recall that

$$\tau_i \; c_i \qquad \tau_{il} \; [illegible] \; c_i \; [illegible] \; \underline{c} \; [illegible] \; c_i \; c_{il} \; [illegible]$$

Indeed, if it is not the case, then, provided this type gets the highest interim utility (which also implies in this case highest interim utility c

$F\ t \geq H\ t$, implying the first inequality below,

$$m_H \quad \bar{c} \quad \underline{c} \quad H\ t\ g_{H\ j} - \& \ U\ \Delta Q2\bar{e}1$$

where g_{Z_F}

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