DISCUSSION PAPERS IN ECONOMICS

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

Anna Rubinchik-Pessach
Department of Economics, University of Colorado at Boulder
Boulder, Colorado

Ruqu Wang
Department of Economics, Queen's University
Kingston, Ontario, Canada

December 5, 2005

Center for Economic Analysis
Department of Economics

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

Anna Rubinchik-Pessach, Ruqu Wang[†]

December 5, 2005

Abstract

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 payoff, 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

1 Motivation

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 different 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 effort 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 **2**, we proceed with the full information model, in which individual costs of transition are known to the reformer (local authority). In section **3** 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 **4**, 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 **4.2** 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.

2   The Setup

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:

$$u^i\left(s^A\right) = a > b = u^i\left(s^B\right) \geq 0, \tag{4}$$

and assume both dominate a mixed strategy payoff.

Definition 1 A reform is a switch from one equilibrium (norm) to another.

Agent i has a cost, $c_i \in [\underline{c}, \bar{c}] \subset \mathbf{R}_+$, associated with switching her action. In this model a switch from s^B 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, $(t_i)_i \in \mathbf{R}^N$; (2) punishments, $(m_i)_i \in \mathbf{R}^N_+$. There are no outside sources of financing the reform so that

$$\sum_i t_i \leq 0 \tag{BB}$$

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_i^1, taken by individual i, actions taken by the rest of the players, s_{-i}^1 and the cost of transition, c_i, if observed:

$$t_i = t(s_i^1, s_{-i}^1, c_i, c_{-i}, I(c)); \qquad m_i = m(s_i^1, s_{-i}^1, c_i, c_{-i}, I(c)). \tag{5}$$

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, $c \in [\underline{c}, \bar{c}]^N$.

---

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

$$\begin{pmatrix} \tilde{A} \\ pN \quad (1-p)N \end{pmatrix} = \begin{pmatrix} \tilde{A} \\ pN-1 \quad (1-p)N \end{pmatrix}; \tag{2}$$

$$\begin{pmatrix} \tilde{A} \\ pN+1 \quad (1-p)N-1 \end{pmatrix} \tag{3}$$

These are assumed away for simplicity.

5

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

Proposition 3

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 $I(\ )$.

In particular, the latter constraints imply,

$$E_{c_{D_i}} [U(I(\theta_i, c_{-i})) - c_i I(\theta_i, c_{-i}) + \tau(\theta_i, c_{-i})] \geq -\bar{m} E_{c_{D_i}} I(\theta_i, c_{-i}) \text{ for all } i, \qquad \text{(IIR)}$$

where

$$\tau(\theta_i, c_{-i}) \equiv t^i s^A, \theta_i, c_{-i}, 1^{\phi} I(\theta_i, c_{-i}) + t^i s^B, \theta_i, c_{-i}, 1^{\phi} (1 - I(\theta_i, c_{-i})). \qquad (16)$$

Luckily, this is nothing but an interim individual rationality constraint from standard mechanism design literature, if $\bar{m} = 0$. Allowing for $\bar{m} > 0$, 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.

Proposition 6 The eccentric rule I_2 is implementable with punishment of at least $\mathbf{max}\{0, \bar{m}_2\}$,

$$\bar{m}_2 = \bar{c} - a, \qquad (17)$$

where $\bar{c}$ is the upper support of the cost distribution.

It is worth noting that $\bar{m}_2$ 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 sufficiently high, $\bar{c} < a$, 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 payoff is then $a - c_i \geq a - \bar{c}$

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 (4.3).

4.1.1 The Two Types Case

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

$$D(x) = \begin{cases} 0, \text{ if } x < \underline{c} \\ \quad, \text{ if } \underline{c} \quad x < \bar{c} \\ 1, \text{ otherwise} \end{cases}. \tag{18}$$

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

Note that if $\bar{c}$ is high and a or b are sufficiently small, $\bar{m}_1$ 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 $\bar{m}_1$ across different environments (countries). These comparisons are reproduced for the continuous case in section (4.3).

4.2.1 Reforms in Divided Countries are Harder to Implement

We can compare two 'countries' that differ 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 difference 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.

Lemma 8 Assume the costs are distributed D independently, with $a - \underline{c} > b$ and $a - \bar{c} < b$. Assume, in addition, that $= 1/2$ and $a - b = N^{-1} \frac{\bar{c}+\underline{c}}{2}$. Then a mean preserving spread of the costs, i.e., if an individual cost either $\bar{c} +$ or $\underline{c} -$ with equal probabilities for any > 0, leads to an increase in the required punishment, $\bar{m}_1$, to implement the corresponding benevolent rule.

4.2.2 Smaller Reforms are Easier to Implement

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 payoff x (b, a) to each. Therefore, switching from $s^B >$

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 $\bar{c}(x)$ denote that switching cost respectively for a low cost agent and a high cost agent to s^X

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

Note that this bound, $\bar{m}_1$, is the negative of two terms. The first is the expected 'virtual' payoff 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 $b = 0$, then $\bar{m}_1 > 0$ 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.

Definition 11 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 **(9)**, note that a 'small' step reform that generates a fraction $\theta \in (0, 1)$ of the original gain, $(a - b)$, and requires a fraction θ of the original costs, $c_i \to \theta c_i$ for all agents i will require a punishment

$$\bar{m}_1 \geq \int_{\underline{c}}^{\bar{c}} \left[F\left(\mu - \frac{1}{\theta}s\right) + s f\left(\mu - \frac{1}{\theta}s\right), \bar{l}\left(\mu - \frac{1}{\theta}s\right) \right] ds - b - (a - b) Q(\theta) \quad (27)$$

$$= \bar{m}_1 - (1 - \theta) b. \quad (28)$$

Clearly, with θ small enough and $b > 0$, the small step reform will require no punishments, $m_1 \leq 0$, then identical argument to that in proposition **(9)** establishes the rest of the result.

5   Extensions

5.1   Outcome Uncertainty

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 different levels of payoff L

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

this case, the necessary punishments, $\bar{m}_1$ and $\bar{m}_2$, (if positive) each decrease by $T/(N \mid (\bar{c}))$, 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 $-\bar{m}_i$, this outside transfer T, may improve the (expected) utility of the least fortunate.[15] Clearly, this improvem2.0827Tc‡5.4(t4001-he)-3

evant individual characteristics might relieve the pressure on this boundary. Bundling, or linking independent decisions (public goods) can improve eﬃciency, 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.

tnntedendcoftbveincontribution by Ledyard and é3raT69.6(g33.4(t)4.28c1-302.i,)-358..h6i6.4(a)t5.22T-vide

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

$$a - c_i + t^i \left(s^A, c_i, c_{-i}, 1 \right)^{\not c} \quad u^i \left(B, s^A_{-i} \right)^{\not c} - u^i \left(B, s^A_{-i} \right)^{\not c} - \bar{m} \quad \text{for all } i, \tag{35}$$

which implies

$$a - c_i + t^i \left(s^A, c_i, c_{-i}, 1 \right)^{\not c} \quad - \bar{m} \quad \text{for all } i, \tag{36}$$

Sum up over i and divide by N, and get

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

where $\bar{t}$ is the average tax and μ is the average switching cost. But in the view of (BB), $\bar{t} = 0$, so if all the incentive constraints hold if

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

conversely, if (38

It implies, that

$$a - c_i + t^i s^A,\ ,\ 1^{\not c}\ \ - \bar{m} \text{ for all } i. \tag{46}$$

Therefore, the minimum of $\bar{m}$ is

$$\bar{m}_2 = \bar{c} - a.$$

Note that $\hat{t} = 0$ for all $c_i \in [\bar{c}, \underline{c}]$ is individually feasible, satisfying (RC). It also satisfies the rest of the constraints for $\bar{m} \geq \bar{m}_2$. ∎

Proof of proposition 7. First, denote

$$\Pr\{A\} = \Pr\{c_1 = \underline{c}\}\Pr\{n_L \geq n - 1\} + \Pr\{c_1 = \bar{c}\}\Pr\{n_L \geq n\} \tag{53}$$

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

$$\Pr\{B\} = \Pr\{c_1 = \underline{c}\}\Pr\{n_L < n - 1\} + \Pr\{c_1 = \bar{c}\}\Pr\{n_L < n\}$$

as the probability that s^B should be enforced ex-ante. Note that $\Pr\{A\}$ can also be expressed as

$$\Pr\{A\} = \Pr\{n_L \geq n\} + \Pr\{c_1 = \underline{c}\}\Pr\{n_L = n - 1\}.$$

This is because

$$\Pr\{n_L \geq n - 1\} = \Pr\{n_L \geq n\} + \Pr\{n_L = n - 1\}.$$

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

$$E$$

E_A ($\bar{c}$) is the transfer in this case. (As we can easily see below, having a constant transfer of E_A ($\bar{c}$) 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 $-\bar{m}$ in this case. That is, for $c_1 = \bar{c}$ and $n_L \geq n$,

$$a - \bar{c} + E_A (\bar{c}) \geq -\bar{m}. \tag{54}$$

For $c_1 = \bar{c}$ and $n_L < n$, no switch is required, and

$$b + E_B (\bar{c}) \geq -\bar{m}. \tag{55}$$

Similarly, for $c_1 = \underline{c}$ and $n_L \geq n - 1$, switching to A is required, and

$$a - \underline{c} + E_A (\underline{c}) \geq -\bar{m}. \tag{56}$$

For $c_1 = \underline{c}$ and $n_L < n - 1$, no switch is required, and

$$b + E_B (\underline{c}) \geq -\bar{m}. \tag{57}$$

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

which gives us

$$\bar{\tau}(\underline{c}) = -(a - \underline{c} - b)\,Pr\{n_L = n - 1\}$$
$$+ (\bar{c} - a - \bar{m})\,Pr\{n_L \geq n\} + (-b - \bar{m})\,Pr\{n_L < n\}$$
$$= -\bar{m}\,Pr\{n_L \geq n\} - a\,Pr\{n_L \geq n - 1\} - b\,Pr\{n_L < n - 1\}$$
$$+ \bar{c}\,Pr\{n_L \geq n\} + \underline{c}\,Pr\{n_L = n - 1\} \tag{62}$$

Therefore, the minimum expected transfer is

$$E\left(\bar{\tau}(\cdot)\right) = Pr\{c_1 = \underline{c}\}\,\bar{\tau}(\underline{c}) + Pr\{c_1 = \bar{c}\}\,\bar{\tau}(\bar{c})$$
$$= Pr\{c_1 = \underline{c}\}[-\bar{m}\,Pr\{n_L \geq n\} - a\,Pr\{n_L \geq n - 1\}$$
$$- b\,Pr\{n_L < n - 1\} + \bar{c}\,Pr\{n_L \geq n\} + \underline{c}\,Pr\{n_L = n - 1\}] \tag{63}$$
$$+ Pr\{c_1 = \bar{c}\}[(\bar{c} - a - \bar{m})\,Pr\{n_L \geq n\} - b\,Pr\{n_L < n\}] \qquad]$$
$$= -\bar{m}\,Pr\{n_L \geq n\} - a\,Pr\{A\} - b\,Pr\{B\} + \bar{c}\,Pr\{n_L \geq n\}$$
$$+ \underline{c}\,Pr\{c_1 = \underline{c}\}\,Pr\{n_L = n - 1\}$$

The ex ante budget balance $E\left(\bar{\tau}(c)\right) \geq 0$ implies

$$\bar{m} \leq -a\,\frac{Pr\{A\}}{\tilde{\beta}}$$

Note that $E_B(\underline{c}) = -b$ and substitute $\bar{m}_1$ for $\bar{m}$. We can easily show that $E_A(\underline{c}) > -a$. Therefore, the tax constraint for the low cost agent is satisfied as well. So the characterization we obtained indeed satisfies all of the conditions. ∎

Proof of lemma 8. By the assumptions $n = \frac{1}{2}N$ under any such spread. By definition of $\bar{m}_1$, (20), it is enough to show that $\Pr\{n_L \quad n\} > \Pr\{c_1 = \underline{c}\} \Pr\{n_L = n - 1\}$. Indeed,

$$\Pr\{n_L \quad n\} > \frac{(N-n)}{n}\left(\begin{array}{c}N-1\\n-1\end{array}\right)^h(1-\quad)^{N-n^h-1} = \left[\text{if } n = \frac{1}{2}N\right. \qquad (64)$$

$$= \left(\begin{array}{c}N-1\\n+1\end{array}\right)^h(1-\quad)^{N-n^h-1} > \left(\begin{array}{c}N-1\\n-\end{array}\right)$$

Proof.

$$\Pr\{n_L \quad n\}\bar{m}_1 \;=\; -a\,\Pr\{A\} - b\Pr\{B\} + \; N(a-b$$

By setting $\bar{\ }(a_L)$ at its minimum level , we obtain the minimum (ex-ante) expected transfer, $E\ (\bar{\ }(\cdot))$, as follows:

$$
\begin{aligned}
E\ (\bar{\ }(\cdot)) \ &=\ \ Pr\{a_1 = a_H\}\bar{\ }(a_H) + Pr\{a_1 = a_L\}\bar{\ }(a_L) \\
&=\ \ Pr\{a_1 = a_H\}[-(a_H - c - b)\,Pr\{\tilde{n}_H = \tilde{n}\ - 1\} \\
&\quad +(c - a_L - \bar{m})\,Pr\{\tilde{n}_H\quad \tilde{n}\ \} - b\,Pr\{n_H < \tilde{n}\ \}] \\
&\quad +\ Pr\{a_1
\end{aligned}
$$

be expected payment of i, probability of reform, and expected "equilibrium" payoff (in coordination game next period), conditional on i reporting $\hat{c}_i$, and all the rest are telling the truth. Note that

$$\bar{v}(\hat{c}_i) = \bar{l}(\hat{c}_i) a + \left[1 - \bar{l}(\hat{c}_i)\right] b. \tag{74}$$

Let

$$V(c_i) \equiv \bar{v}(c_i) - c_i \bar{l}(c_i) + \bar{\pi}(c_i). \tag{75}$$

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

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

which implies

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

Let us incorporate additional constraints.

Recall that by (46, 47),

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

$$b + \pi_i(c_i, c_{-i}) \geq 0, \quad \text{if} \quad \sum_{j=1}^{N} c_j > N(a - b) \tag{79}$$

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

$$V(c_i) = \bar{l}(c_i)(a - c_i + \pi_A(c_i)) + \left[1 - \bar{l}(c_i)\right](b + E_{\pi_B}(c_i)) \geq -\bar{m}\bar{l}(c_i), \tag{80}$$

where, as in the discrete case

$$E_{\pi_A}(c_i) \equiv E_{c_{-i}}\left[\pi_i(c_i, c_{-i}) \middle| \sum_{j=1}^{N} c_j \right]$$

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, $c_i = \bar{c}$:

$$\int_{\underline{c}}^{\bar{c}} \bar{l}(s)\,ds - \bar{m}\bar{l}(\bar{c}) \geq V(\underline{c}). \tag{85}$$

Inequality **(85)** provides a lower bound on m:

$$\mu\left(\int_{\underline{c}}^{\bar{c}} \bar{l}(s)\,ds - V(\underline{c})\right) \frac{1}{\bar{l}(\bar{c})} = \bar{m}_1 \tag{86}$$

By definition

$$V(\underline{c}) = \bar{l}(\underline{c})(a - b - \underline{c}) + b + \underline{}(\underline{c}). \tag{87}$$

It implies that

$$\bar{l}(\bar{c})\bar{m}_1 = \int_{\underline{c}}^{\bar{c}} \bar{l}(s)\,ds - V(\underline{c}) \tag{88}$$

$$= \int_{\underline{c}}^{\bar{c}} \bar{l}(s)\,ds - \bar{l}(\underline{c})(a - b - \underline{c}) - b - \underline{}(\underline{c}) \tag{89}$$

w

and

$$E_i \int_{\underline{c}}^{c_i} \frac{\bar{l}(s)}{s} s ds = \int_{\underline{c}}^{\bar{c}} \left[\int_{\underline{c}}^{c_i} \frac{\bar{l}(s)}{s} s ds \right]' f(c_i) d(c_i) = \quad (96)$$

$$= \int_{\underline{c}}^{\bar{c}} \frac{\bar{l}(s)}{s} s ds$$

Combining, the three observations above with **(92)**, we get

$$E_i^-(c_i) = {}^-(\underline{c}) + (a - b)^i (\bar{l}(\underline{c}) - Q()^{\not c} + {}^Z$$

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

$$\bar{\ }_i(c_i) = \bar{\ }_{il} \ldots$$

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

$F(t) \le H(t)$, implying the first inequality below,

$$m_H = \int_{\underline{c}}^{\overline{c}} H(t) \, g_H \left(\cdots \right)$$

where g_{z_F}

Lang, C. and S. Weber (2000). Ten Years of Economic Reforms in Russia: Windows in a Wall. In R. M. Lastra (Ed.), The Reform of the International Financial Architecture, pp. 413 – 430. London: Kluwer Law International.

Ledyard, J. O. and T. R. Palfrey (2003, November). A General Characterization of Interim E cient Mechanisms for Independent Linear Environments. Caltech Working Paper 1186.

Mailath, G. J. and A. Postlewaite (1990). Asymmetric information bargaining problems with many agents. Review of Economic Studies 57, 351–367.

McAfee, R. P. and P. J. Reny (1992). Correlated Information and Mechanism Design. Econometrica 60