

UNDERINVESTMENT TRAPS AND POTENTIAL COOPERATION

by

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INTRODUCTION

A. The Possibility of Collective Good Underinvestment Traps under a Cournotian Investment Interaction

It is well-known that Cournot-Nash solution sets may contain points that are worse for everyone than other points in these solution sets (Nash, J. Friedman). Historically important economic examples of such inferior noncooperative equilibria may exist. In particular, some cases of economic underdevelopment during the early stages of our industrial revolution can apparently be understood as situations in which different potential producers of complementary, collective-good inputs ("social overhead factors"), although able to internalize all of the incremental benefits flowing from their separate inputs, each find it unprofitable to produce their particular input only because none of the other potential suppliers produce theirs; each of the producers would provide his input only if the others did the same (Makowski, Scitovski, Thompson (1968)). To illustrate, suppose a particular region requires a port in a particular location, some mines in a second location, and a road connecting the port with the mines before any one of these three kinds of inputs generates positive net private and social benefits; once any pair of these input types are present, independently supplying the third is highly profitable, both privately and socially. One possible Cournot solution to the corresponding producer interaction problem has a zero supply of each of these inputs: Each potential input supplier rationally provides none of his input because the others provide none of theirs. Of course, another, possible, highly Pareto superior, Cournot solution point has each potential supplier

providing his input and earning a positive profit.¹ As a result, some regions would be highly developed, those with institutions designed to push investors out of such traps, while others would remain in their initial, underdeveloped,

¹Since we are discussing a market economy — not just some abstract quantity game — the payoffs in the Nash-Cournot production game must be consistent with those generated from prices formed in a separate game of exchange. In particular, when there are many independent buyers, the payoffs must be consistent with Bertrand-Marshall, market-run, price-taking behavior on the part of buyers. This eliminates payoffs that would induce inefficient underinvestment traps for simple, private-good complements (such as the "traps" described by Hart and Salop). We are in no danger of underinvestment traps in the likes of turkey and cranberry sauce. For even if both of their initial outputs were zero, the low prices necessary to induce zero outputs would also induce excess demands and price increases for both goods by the globally rational final users. But for collective good complements, like our road and port, where no final user is a large part of the separate exchange market for rights to use a given seller's output, the low input prices that induce mutual underinvestment do not induce excess market demands and price increases for the inputs. For the users cannot rationally assume that they influence the quantities produced of either good and must therefore assume, at a zero investment point, that one good is unavailable when they bid for the other (Thompson, 1968). This, of course, rules out price offers contingent on the supplies of other producers. Such cooperative behavior will be considered in the text below. (These underinvestment-inducing complementarities also, as asserted and argued through examples in my '68 and '82 papers, imply a nonconvex technology. A general proof of this proposition will be sent on request.)

An additional, important, consequence of including the exchange game is that it informs the investors — who cannot observe one another's outputs under the Cournot-Nash assumption — which of the multiple equilibria the several other investors have adopted. So repeated plays will, under stationary and rational price expectations, yield the same solution point. If the investors directly observed the past investments of each of the others rather than just prices (or total outputs), a Stackelberg-Von Neumann-Morgenstern production interaction (which we shall consider later in the argument) rather than a Cournot-Nash interaction would apply. And if investors observed neither past outputs nor prices, then our multiplicity of the Nash solutions would make the Nash solution a wholly inappropriate solution concept because the players would have no basis whatever for assuming any one of the alternative solution points and would therefore simply form a prior probability distribution over the other players' adopting these — and many other — strategies. The resulting solution — which is not a mixed-strategy Nash solution because the players are not subjecting their strategies to a predictable mixing device — admits almost any behavior and is apparently too general to be of much use. To say that each person behaves rationally given his prior probability distribution over all possible behaviors — while always admitting a solution — is to say almost nothing of any empirical power. It's akin to describing a single position in a dynamic model.

condition. However, since most countries by the end of the 19th century had adopted the institutions of the successful countries and still most of them remained underdeveloped, the persistence of huge income differences between countries cannot be explained simply by a multiplicity of Cournotian, collective-goods equilibria.

Similar malinvestment traps are encountered when Pigouvian taxes are applied in attempting to correct external diseconomies. Since any of several possible allocations satisfying all of the marginal conditions for a local Pareto optimum qualifies as an equilibrium under a Cournot interaction with Pigouvian taxes while one of these allocations may be globally Pareto superior to others, Pigouvian taxes are generally insufficient to achieve globally Pareto optimal allocations (Baumol, Thompson-Batchelder). A simple empirical example is provided by a pollution externality, occurring in Slippery Rock Creek, Pennsylvania, in which both acid-creating coal mines and alkaline-creating limestone mines both dump their waste into a stream and thereby neutralize each other's effluent, creating no significant externality when operating together, even though any one mine, appearing alone, pollutes the water and kills millions of fish (see Harder). One Cournot equilibrium has no mining on the stream and understandably heavy Pigouvian taxes while another, Pareto superior, Cournot equilibrium has both types of mines present and zero Pigouvian taxes. However, looking beyond Slippery Rock, we have as yet found no historically important empirical examples of such multiple equilibrium inefficiencies. Correspondingly, in searching for an economic explanation for the puzzling governmental reliance on quantity controls and direct governmental investment rather than Pigouvian tax-subsidy policies toward sizeable externality creators, we should not be at all empirically satisfied with the argument that direct controls are employed because they enable the

government to avoid the possibility of local Pigouvian equilibria that are not globally efficient.

B. The Similar Explanatory Weakness of Sequential, But Still Noncooperative, Investment Interactions

When related investments are sufficiently lumpy that potential investors can observe the prior investments of others, Cournotian solution concepts are no longer appropriate. Rather, ruling out strategic communication, or "cooperative" interaction, wherein the investors can commit themselves to and communicate reaction functions so as to affect the behavior of others, the appropriate solution concept becomes the von Stackelberg-von Neumann-Morgenstern (VNM) "perfect information" solution concept. Here, each investment is made subject to observed, past investments and in view of accurately forecasted, rational, uncommitted, future investment responses. Section I of this paper shows that adopting this perfect information form of noncooperative interaction eliminates the possibility of Pareto superior multiple equilibria. No point in a perfect information solution set can be strictly Pareto superior to another.

Thus, in our Pigouvian taxation example, if the investment decisions were sequential, any one of the investors would be willing to enter first, as he knows that his investment would inspire the other to enter, the latter's entry being induced by the absence of positive Pigouvian taxes on him once the former has entered. The possibility of a malinvestment trap would be gone, and with it the theoretical possibility -- now understandably ahistorical -- of a multiple-equilibrium explanation for the widespread use of direct quantity controls rather than Pigouvian taxes or subsidies for sizeable externality creators.

In our more important, underdevelopment example, any one of the collective-input suppliers, say the port-producer, is now willing to enter first because he knows that the second collective-input supplier, the road-producer, will then enter because the latter knows that once a port and road are supplied, the miners will enter. Again, the coordination afforded by a perfect information interaction serves to exclude situations in which some outcomes in a noncooperative solution set are uniformly inferior to others. Nevertheless, competitive pricing of collective-good inputs will still produce a substantial free-market undervaluation of collective-good complements in that buying one will raise the demand price -- and thus the actual price paid -- for other, subsequently purchased, complements (Thompson, 1982). A substantial underinvestment in collective good complements would therefore remain despite the perfect information interaction between the investors. However, this underinvestment problem, like the Cournotian one, can still be eliminated with sufficient subsidization of early innovations, something like 16th century England's granting of broad, private-good monopolies and early protection of various technical innovations. Therefore, given the easy international availability of the resulting, numerous, highly advanced technologies, together with the relatively generous governmental support of public overhead investment projects around the world during the 19th and 20th centuries, we are still left with no explanation of the persistence of widespread underdevelopment.

C. The Need for a Model Admitting Moderately Expensive Cooperation

Since noncooperative investment interactions (or at least the polar cases of perfect information a la Stackelberg-VNM or zero information a la Cournot) cannot explain either the persistence of underdevelopment or the widespread

use of direct governmental quantity controls and investment, we must introduce somewhat "cooperative" forms of investment interaction, where individuals can communicate committed "strategies" (or reaction functions) to others before certain investments are undertaken, if we are to explain these phenomena. This may appear a bit paradoxical. We've become accustomed to thinking that the ability to communicate and cooperative can only enhance social efficiency. Indeed, if there were initial strategic communication (i.e., if communication and commitment costs were sufficiently low that investors -- prior to any productive investment -- each sequentially selected a reaction function among all technically feasible functions), then not only would underinvestment traps and externalities be impossible, but a jointly optimal investment pattern would be assured (Thompson-Faith). With initial strategic communication among the investors in our underdevelopment example, the first committer would say: "I will invest and supply my input if all of the others do, and I will take all of the net profits except those just sufficient to induce each of the others invest; otherwise I will not invest." The others will rationally invest and supply their inputs, and the solution set of outputs would maximize the joint profits of the various investors. So, at least if we are to explain modern underdevelopment, the following, seemingly paradoxical, result must hold: While initial cooperation between investors, based on sufficiently low cooperation costs, would unambiguously increase the investor-efficiency of the investment outcomes over those arising under prohibitively high cooperation costs, future-but-not-initial investor cooperation, based on moderately expensive cooperation costs, must dramatically decrease joint investor-efficiency way below that arising under prohibitively high cooperation costs!

The main purpose of this paper is to show that this is, in fact, the case.

D. Underinvestment Traps under "Moderately" Expensive Cooperation

Section II of this paper shows that underinvestment equilibria are theoretically inevitable whenever the overhead costs of strategic communication are neither so low that initial cooperation occurs nor so high that subsequent cooperation is precluded when prior investors adopt certain, desirable, investment levels. In particular, Section II shows that a given, noncooperative investment sequence will not occur whenever the fixed, overhead cost of cooperation is: (1) Initially above the maximum initial return to cooperation, the sum of the potential net profits to all the investors, but, (2) subsequently, after some investments in the given, noncooperative sequence have been made, below the then-maximal return (an amount generally exceeding the sum of the potential net profits to all investors). Early investments in an ordinary, noncooperative sequence would necessarily induce costly cooperation and a net loss to at least one of the earlier investors. If, say, any two of our three types of investors in the mines-port-road example independently made their investments (say the seaside investor built his port and the mineral reserve owners built their mines), the third (the road owner) would then be willing to devote the requisite resources to commit not to supply its input unless appropriately paid by the other investors. The induced commitment would, in this example, gain the committer the coveted capital values of the previous investors in what would otherwise be an

approximately efficient, noncooperative solution.² Anticipating such a commitment, the first two types of suppliers would see net losses on their original investments and therefore not provide their inputs. Inevitable underinvestment characterizes any equilibrium constrained by potential cooperation.

Alternatively, while the pre-investment potential economic surplus from an efficient investment sequence does not justify the substantial resource cost of making and communicating reaction commitments to the other investors, some post-investment surplus might. With cooperation costs in a given, "moderate," range, an initial sub-sequence of investments in an efficient sequence would generate -- not a continuation to an optimum as occurs approximately in the wholly noncooperative, perfect-information model -- but a sufficiently large return to establishing later reaction commitments that the commitments would be made. This in turn would make at least one of the early investments in the efficient sequence necessarily unprofitable. Therefore, a rationally adopted, jointly efficient sequence of investments is impossible under "moderate" cooperation costs. Again, the force of "potential cooperation" works to preclude highly economic investment sequences. Thus, the general results of Section II will provide us with a non-Cournovian,

²While the "hold up" problem in this example has long been recognized by men of affairs, it has received little attention from economic theorists. The first discussion we are aware of by an academic economist appears in Rothenberg. Some recent applications appear in Batchelder, Goldberg, Klein-Crawford-Alchian, and V. Thompson. Our theoretical contributions here will be to: (1) Generalize the problem and show that moderate cooperation costs imply inevitable underinvestment traps, even when no "hold up" is involved, and (2) describe optimal policy responses to the resulting underinvestment traps. Our corresponding empirical contributions will lie in (1) explaining various observed underinvestment traps and (2) providing economic rationalizations for various widespread forms of governmental intervention, policies that have been heretofore widely considered to be economically inefficient.

the general results of Section II will provide us with a non-Cournotian, potential-cooperation explanation of modern underdevelopment.

Regarding our Pigouvian taxation example, the Section I method of avoiding the problem of inefficient multiple Cournot-Nash equilibria — i.e., having the actors behave under a perfect information interaction — also loses its empirical power once we recognize that cooperative interaction, which is initially too costly, may easily become profitable after a certain number of individuals have made their investments. If so, returning once again to our Slippery Rock mining example, one miner, having seen the other enter, would rationally commit himself not to enter (even though it is profitable to do so) unless he is paid (for his "acid-neutralizing services") the value of his entry to the other miner. The first miner, realizing that such a payment would make his net profits negative, does not enter. The inefficient Pigouvian equilibrium is not only restored; it becomes a unique underinvestment equilibrium rather than merely a multiple-equilibrium curiosity whenever cooperation costs drop down into the moderate range.

E. Optimal Policy

An optimal policy response to the potential cooperation problem is not one that simply outlaws cooperation. This would crudely eliminate actual as well as potential cooperation and thereby obviously wipe out some highly efficient free-market behavior. Nor would it be appropriate to subsidize early investments until they are undertaken. For cooperation would then be induced, and cooperation costs, which would not be reduced by such a policy, generally exceed the net economic surplus from the investment sequence.

A policy that would, theoretically, remove the problem would have judges treat all interactions constrained by potential cooperation as if they were

initially cooperative. Confiscatory reaction functions would then be illegal because it would never have paid the early investors to join the hypothetical cooperative if they were going to lose while subsequent investors gained. While the resulting solution is theoretically a first-best optimum to the interested parties (Thompson-Faith, 1980), the judge would have to be able to determine compensation in any cooperative interaction according to what an ideal pre-investment contract between all of the various investors would have been. Of course, if the interaction remained noncooperative, there would be no basis for legal remedy and a Pigouvian fiscal system would be relied upon to induce an optimum. In either case, government officials would have to be bound not to impose rule changes designed to substitute for the confiscatory private reaction functions.

Given a sufficiently high cost of (1) determining the conditions of these hypothetical contracts and (2) committing government officials to nonconfiscatory responses, a superior, simpler approach would have central authorities directly controlling quantities, investing tax dollars in the underdevelopment case and directly regulating polluting activities in the externality case. However, for this direct approach to be feasible, prior knowledge of who should decide upon the investment would have to exist. With perfect knowledge of this sort, central authorities would simply hire these individuals, forcing upon them an incentive system that rewards late investment less, and punishes early noninvestment more, than the less centralized system described above. These theoretically efficient, bureaucratically determined, solutions -- by inducing a correct stream of investments -- could easily produce much more efficient solutions than the complex judicial and Pigouvian fiscal system described above.

However, when there is no prior knowledge of who should do the investing, the above, direct, authoritarian strategy is not available to the central authority. Then, with the judicial solution also prohibitively costly, achieving a constrained optimum could well require the fisc to tax the returns on later investments so as to reduce the returns to cooperation to where potential cooperation is no longer a binding constraint. This non-Pigouvian tax on the returns to these later, complementary investments, by removing the otherwise inevitable underinvestment trap, has the seemingly paradoxical effect of dramatically increasing total investment.

F. Empirical Applications

Section III of this paper outlines some empirical applications of our potential cooperation theory of underinvestment equilibrium. The Section rationalizes a wide range of legislated policy responses to the underinvestment equilibria created by potential cooperation, responses that economists have widely criticized apparently without understanding the underlying problem. Besides rationalizing direct quantity intervention in the underdevelopment and externality cases discussed above, Section III develops an application of the model to simple bilateral interactions in which certain types of transactions are precluded by potential cooperation regardless of their surplus values. Direct governmental intervention in the form of emergency service provision is feasible in many such cases; but its infeasibility in other such cases provides empirical examples in which the judicial solution outlined above is the only practical policy solution. The Section closes by discussing optimal policy in a simple model containing criminal activities. The resulting optimal policy rules rationalize certain, observed, allegedly inefficient, penal principles in terms of an otherwise

prohibitive cost of committing local officials to nonconfiscatory responses to certain private investments. These observed policies exemplify the case in which an infeasibility of both the direct intervention and the "as if" judicial solutions lead to a second-best optimum in which taxing the returns to the later investments in a given sequence eliminates the constraint of potential cooperation and thereby removes an otherwise inevitable underinvestment trap.

I. THE ABSENCE OF TRAPS UNDER VON STACKELBERG, OR
VON NEUMANN-MORGENSTERN, PERFECT INFORMATION INTERACTION

We assume that each of n individuals, $i = 1, 2, \dots, n$, has a real-valued utility function, $U_i(x_1, \dots, x_n)$ over the actions x_i of the various individuals, where each action is chosen from a finite set, X_i , of feasible actions for that individual. (This is more realistic than assuming an infinite set of feasible actions in that effective utility differences only exist between measurably different, and therefore discretely varying, actions. It also avoids a severe assignment problem, as noted below.)

To obtain a perfect information solution, we first have individual n maximize $U_n(x_1, \dots, x_{n-1}, x_n)$, setting up a dependence of x_n^* on x_1, \dots, x_{n-1} , expressed in the correspondence, $x_n^*(x_1, \dots, x_{n-1})$; then individual $n-1$, in attempting to choose an x_{n-1} that maximizes $U_{n-1}(x_1, \dots, x_{n-1}, x_n^*(x_1, \dots, x_{n-1}))$, may find that his maximizing solution is ambiguous in that it depends on the particular value of x_n^* chosen from the $x_n^*(x_1, \dots, x_{n-1})$ correspondence for any given x_{n-1} . To remove this "assignment," or "selection," ambiguity, we do not let $n-1$ decide among these x_n values. (Alternatively, we could fix up preferences so that individuals $n-1$ would pick an action near x_{n-1}^* , one generating close to the same payoffs for $n-1$ and a unique solution for individual n .) So $n-1$ may choose not only among the x_{n-1} in X_{n-1} , but also among several possible values of x_n satisfying n 's response correspondence, $x_n^*(x_1, \dots, x_{n-1})$. Individual $n-1$'s choice solution is therefore described as the set, (x_{n-1}^*, x_n^{**}) , that maximizes, with respect to x_{n-1} and x_n^* , $U_{n-1}(x_1, \dots, x_{n-2}, x_{n-1}, (x_1, \dots, x_{n-1}))$, where x_n^{**} is a subset of $x_n^*(x_1, \dots, x_{n-1})$. Note that $n-1$'s solution set, besides presenting some

possible ambiguities in his own actions for earlier movers, may fail to resolve ambiguities in n 's moves in that $n-1$ may also be indifferent between several x_n^* belonging to $x_n^*(x_1, \dots, x_{n-1}^*)$. So $n-2$'s solution is the set $(x_{n-2}^*, x_{n-1}^{**}, x_n^{***})$ that maximizes, with respect to x_{n-2}, x_{n-1}^* , and x_n^{**} , $U_{n-2}(x_1, \dots, x_{n-3}, x_{n-2}, x_{n-1}^*(x_1, \dots, x_{n-2}), x_n^{**}(x_1, \dots, x_{n-2}, x_{n-1}^*)$ where x_{n-1}^* is a particular value of $x_{n-1}^*(x_1, \dots, x_{n-2})$ and x_n^{**} is a particular value of $x_n^{**}(x_1, \dots, x_{n-1}^*)$.

The non-emptiness of the solution set to this series of problems follows immediately from the real-valuedness of $U_i(\cdot)$ and the finiteness of every X_i . Had we allowed infinite X_i 's and continuous $U_i(\cdot)$'s, our method of resolving ambiguities would have precluded any general existence result (Peleg-Yaari), although Goldman has shown that a solution always exists for some, non-necessarily-rational method of resolving ambiguities.

Our main interest is in Pareto optimality and in particular in the fact that the perfect information solution set (in contrast to a Cournot-Nash solution set) cannot contain elements that are strictly Pareto inferior to other allocations that are also in the solution set. That is, the final solution set, x^* , contains no points that are strictly Pareto inferior to other points in the solution set.

The proof follows almost immediately from the definition of a solution. Consider a point $x' \in x^*$ and another point x'' with the property that $U_i(x'') < U_i(x')$ for all i . Since individual 1's particular choice uniquely determines the particular solution, and $U_1(x') > U_1(x'')$, individual 1 would only choose x_1'' over x_1' if $U_1(x_1'', x_2(x_1''), \dots) > U_1(x')$, in which case a choice of $x_1 = x_1''$ implies a particular solution unequal to x'' . And since a choice of $x_1 \neq x_1''$ also implies a particular

solution unequal to x'' , any rational choice by 1 rules out a particular solution equal to x'' . So x'' cannot be in the solution set.

II. GENERAL UNDERINVESTMENT UNDER POTENTIAL COOPERATION

We now introduce the possibility of strategic communication, or the communication of committed reaction functions. Strategic communication requires incurring the overhead costs of commitment and communication. If these cooperation costs were sufficiently low that strategic communication occurred prior to any investment in a sequence, then a jointly optimal investment sequence among the producers would be reached (Thompson-Faith, 1980). We assume, however, that these costs preclude initial strategic communication. Nevertheless, a simple noncooperative solution such as in Section I is not implied because the corresponding actions by early movers may make it profitable for some subsequent player or players to select and announce, rather than simple, noncooperative actions, committed reaction functions to then-subsequent actions.

A special form of strategic interaction arises when actions are available to the first and subsequent committers that can make all actors subsequent to the first committer worse off than if they had selected actions most preferred by the first committer subject only to the achievement of endowed, minimum utility levels of the subsequent actors.³ Under this "punishability" condition, the solution actions following the first commitment are simply those maximizing the utility of first committer given all actions prior to the establishment of the commitment and the given utility endowments of the subsequent actors (Thompson-Faith, 1981). Thus, a solution inducing

³These utility endowments replace the underlying private property constraint, described in footnote 1, a constraint applicable in a standard, competitive environment. The rationale and efficiency of utility endowments for non-competitive environments is developed in Thompson-Faith (1980, 1981).

cooperation — call it x^c — under this simplifying punishability condition would be obtained from the following maximization sequence:

$$U_1(x^c) = \max_{x_1} U_1(x_1, x_2^c(x_1), \dots, x_n^c(x_1))$$

$$U_{r-1}(x^c) = \max_{x_{r-1}} U_{r-1}(x_1^c, \dots, x_{r-2}^c, x_{r-1}, x_r^c(x_{r-1}), \dots, x_n^c(x_{n-1}))$$

$$U_r(x^c) = \max_{x_r, \dots, x_n} U_r(x_1^c, \dots, x_{r-1}^c, x_r, \dots, x_n).$$

subject to $U_{r+1}(x^c) > U_{r+1}^0, i=1, \dots, n-r,$

where r is the first to commit. (We are assuming away the indifference problem discussed in the previous section.) On the other hand, if choices are made so that it pays no individual to establish a reaction function; then we have a Section I solution, x^* , except that choices are also constrained to satisfy, for any r , $B_r(x^c) = U_r(x^c) - U_r(x^*) < C_r$, where C_r represents r 's, positive, utility-equivalent of the resource cost of establishing a punishment commitment. The first actor will pick either such a constrained x_1^* or an x_1^c , given that one of these actors gives him a higher utility than the other. With $x_1^* \neq x_1^c$, this sets the course: If he picks x_1^* , then the second actor will find it utility-maximizing to pick x_2^* , the third x_3^* , etc.; and if he picks x_1^c , number two will choose x_2^c , etc. If the solution is x^* with binding c_r - constraints for some individuals, then we say that the equilibrium is "constrained by potential cooperation."

Such an equilibrium is of little interest without a corresponding notion of an "investment" activity. To simplify the notation for this, we first partition our n actors into T equal subsets. The first $\frac{n}{T}$ actors are in

set n_1 , the second in set n_2 , etc. Think of the j^{th} , $(\frac{n}{T} + j)^{\text{th}}$, $(\frac{2n}{T} + j)^{\text{th}}$, and $(\frac{(T-1)n}{T} + j)^{\text{th}}$ actors as representing the same biological entity (or a sequence of his offspring). Correspondingly, to avoid commitment-inducing, Strotz-type "inconsistencies" between these actors, we must assume — from a generalization of the theorem of Blackorby, Nissen, Primont, and Russell (Thompson, 1982a) — that $U_j(x) = U_j(x_1, \dots, x_{n_1+j-1}, U_{j+n_1}(x))$. Now an "investment" by j relative to x_j^0 is an $x_j' \neq x_j^0$ such that $U_j(x(x_j')) > U_j(x(x_j^0)) + U_{j+n_1}(x(x_j')) > U_{j+n_1}(x(x_j^0))$, where $x(x_j)$ the solution resulting from j 's choice of x_j . Our results will be restricted to investments that are "coveted" in that they increase the gross return to subsequent expropriation (Thompson, 1974). More precisely, j 's investment is "coveted" when $U_r(x^c(x_j')) - U_r(x^*(x_j')) > U_r(x^c(x_j^0)) - U_r(x^*(x_j^0))$, or, more simply, $B_r(x^c(x_j')) > B_r(x^c(x_j^0))$, $r > j$.

Given this condition on the nature of investments, we wish to show that in any equilibrium constrained by potential cooperation, investments are unavailable to some individuals, regardless of their preferences. (This latter condition implies "general underinvestment.")

The proof is quite simple. Say individual j is constrained by potential cooperation in the solution, x^* . From the above analysis, any investment attempt from x_j^* will induce not an increase in utility of $j + \frac{n}{T}$ but rather a minimal utility level for this actor, $U_{j+\frac{n}{T}}^0$. The committer, r , would reap the returns from j 's sacrifice. Now notice that any alteration in j 's preferences (or the technology underlying them) — he may place greater and greater values on $U_{j+\frac{n}{T}}$ relative to x_j — will not change this fact. Any attempt to invest by an increasingly willing individual j will result in expropriation. So x^* is impervious to increases in j 's willingness to invest, which is all we have to prove.

The seriousness of the underinvestment pockets produced by the force of potential cooperation is more easily seen when we consider a sequence of complementary investments, each of which is necessary before any of them is profitable. In such a case, the returns to establishing a confiscatory reaction function uniformly increase superadditivity with each successive investment while the costs of punishability remain about the same because a prospective investor can always punish by merely withholding his investment. His rational reaction function, of course, is to withhold his investment unless he is paid amounts that expropriate the returns from the prior investments.

As indicated in the Introduction, the theorem can be generalized to environments without the punishability condition, in particular, to any environment in which groups do or do not cooperate according to whether the aggregate benefits to the cooperating members exceed or fall short of the aggregate, overhead costs of cooperation. (While this cooperation-determining condition is obviously implied by punishability, it just-as-obviously does not imply punishability.) The resulting generalized theorem states that simple noncooperative investment levels do not occur whenever aggregate cooperation costs are neither so low that initial cooperation is profitable nor so high that subsequent cooperation is always precluded given the prior investments occurring in the noncooperative solution. As complete confiscation does not generally occur without punishability; the proof does not rely on it. Rather, to prove the more general result, we rely on the assumption that cooperation costs are fixed overhead costs. In this case, the condition on cooperation costs defining the interaction as neither initially cooperative nor completely noncooperative becomes, for some r ,

$$\sum_{i=1}^{n/T} B_i^0 < \sum C_i < \sum_{i=r}^{n/T} B_i(x^c),$$

where: $\sum_{i=1}^{n/T} B_i^0$ is the aggregate net investor benefit from a jointly optimal, i.e., initially cooperative, investment sequence; $\sum C_i$ is the constant aggregate overhead cost of cooperation; and $\sum_{i=r}^{n/T} B_i(x^c)$ is the aggregate benefit of cooperation to individuals r through n/T after individuals 1 through $r-1$ have made their simple noncooperative investments. The right hand inequality assures us that subsequent cooperation would be induced by a simple noncooperative investment sub-sequence while the left hand side tells us that the induced cooperation would necessarily leave someone with negative net benefits. Therefore, the potential cooperation constraint would always preclude the attainment of a simple noncooperative investment sequence, regardless of the economic surplus generated by such a sequence.

Finally, a related, more direct, theorem is the impossibility of solution investment sequences that are jointly efficient to the investors whenever cooperation costs lie in the "moderate" range. Cooperation costs are, by definition "moderate" whenever the aggregate resource cost of cooperative interaction: (1) Exceeds, as above, the aggregate net investor benefit from a jointly optimal investment sequence, $\sum B_i^0$, but (2) Falls short of the sum of (a) the aggregate, post-investment, coveted benefits from this sequence to the first $r-1$ investors, $\sum_{j=1}^{r-1} B_j'$, and (b) the net, joint returns to the subsequent investors, $\sum_{j=1}^{n/T} B_j^0$. I.e., under "moderate" cooperation costs,

$$\sum_i B_i^0 < \sum_i C_i < \sum_{j=1}^{r-1} B_j' + \sum_{i=r}^{n/T} B_i^0.$$

Given these inequalities, our general result — that efficient investment sequences are never chosen under moderate cooperation costs — is easily established. The right hand inequality implies that subsequent cooperation would be induced by an efficient investment sequence without initial cooperation while the left hand side assures us both that initial cooperation does not occur and that the induced cooperation must leave some investor with negative net benefits. Therefore, an optimal sequence is never undertaken when cooperation costs are moderate, even when it would be undertaken if cooperation costs were either above or below the moderate range. With

$$\sum_{j=1}^{r-1} B_j^0 < \sum_{j=1}^{r-1} B_j'$$

for all investment sequences, it also follows from the above inequalities that, for any jointly efficient investment sequence, there is a range of cooperation costs such that if actual cooperation costs fell within this range, the investment sequence would never occur.

III. APPLICATIONS AND POLICY

A. Underdevelopment

It is now easy to see how underdevelopment might characterize nineteenth and early twentieth underdeveloped countries adopting institutions similar to those of the developed countries. If communication and commitments were difficult to make because of language and cultural differences between the subgroups of a population, it would be plausible to assume that these groups would often fail to initially cooperate, via representative government or producer cooperation, on sequences of lumpy, complementary investments. It would, however, be plausible to assume that once a sequence of investments were made, certain groups would begin to cooperate in the expropriation of the early investors. Thus, the representative legislatures of the various underdeveloped countries, although initially unable to cooperate and thereby establish commitments providing definite rewards for various investments, would, once certain investments were made, vigorously work to expropriate the efficient returns from the investments. That this characterizes most of the representative legislatures of the large, poor countries of the past couple of centuries is undeniable. Underdeveloped countries have uniformly suffered from an initial lack of cultural cohesion (Eisenstadt), and so we would naturally expect less initial cooperation on their part. A natural policy for underdeveloped countries would therefore be to replace legislatures of local or special-interest representatives with authoritarian leaders, and, as private property systems also may suffer from pockets of underinvestment through the threat of potential private cooperation, to convert unsuccessful private property systems to ones with socialist planning of large-scale investments. However, once communication and cooperation abilities reach the

levels of the developed democracies, there is no reason for these centralist systems given the superior internal efficiency of mixed democracies such as the U.S. (Thompson, 1974, 1979).

For a recent review of the failure of alternative, "critical variable," theories of underdevelopment, see Papanek. Professor Papanek also emphasizes that the recent successes of free-market representative democracies of Korea and Pakistan have been due largely to dramatically improved entrepreneurial abilities. Recognizing that "entrepreneurial ability" is largely the ability to establish and communicate reaction functions, his theory to explain these development successes is similar in spirit to the theory developed here. Our theory differs from this and other, "cultural" theories (esp. Banfield) mainly in that our own is a more specific theory of the effects of costly cooperation and thus of how to remove the resulting underinvestment traps. For example, ours implies that: (1) Either reductions or increases in cooperation costs may help; (2) neither kind of change does any good until cooperation costs are brought either all the way down to a level at which pre-investment cooperation becomes profitable, or all the way up to a level at which post-investment cooperation becomes unprofitable, and (3) once either critical point is reached, the economy "takes-off" a la Rostow.

Our traps do not occur in private-property systems with sufficiently informed, interventionist, authoritarian leaders. Depending on observability conditions, such leaders can simply impose one of our three policy solutions to remove his system's underinvestment traps. Since we should not expect modern history's authoritarian leaders or their technical advisors to be capable of isolating, with any high degree of regularity, the typically complex underinvestment chains in their countries, we should not be surprised that authoritarian, largely capitalist countries in the twentieth century have

not fared much better than coarse, authoritarian, socialist countries in eliminating their inherited underinvestment traps.

B. Externalities

Regarding externalities and Pigouvian taxes, we attempt to answer the question of why zoning regulations and quantity controls are so often observed while Pigouvian taxes appear only when there is a large number of imposers and victims. Consider an almost fully developed residential neighborhood. A noisy, smelly plant might come in to complete its development, but its Pigouvian tax bill would be so high that its profit from operating in the neighborhood would be negative. Therefore, under a noncooperative, perfect information, Pigouvian solution, the plant would locate elsewhere and no inefficiency would be present. But, progressing from Section I to Section II assumptions by allowing potential cooperation, the plant builder could commit himself to build and pay his high Pigouvian taxes unless all of the neighboring home owners paid him, for his "air-purification services," their huge Pigouvian damages. Looking ahead to such air-purification bills, the land owners would never have invested there in the first place. Pigouvian policy, in failing whenever there is potential cooperation, should be replaced with quantity restrictions. The realistic possibility of such underinvestment inefficiencies has, we believe, led local policy makers and large land developers all over the world to reject Pigouvian taxation in favor of quantity constraints (i.e., zoning restrictions or restrictive covenants) that effectively eliminate the possibility of our inefficient, potentially cooperative solution. With such restrictions in force, and potential cooperation thus removed as a relevant economic constraint, our Section I model becomes empirically relevant. For this application, the model tells us

-- given appropriate zoning laws or restricting covenances -- that decentralized private building equilibria contain no underinvestment traps.

The application extends to external damages that are positive in the equilibrium. In particular, it applies to standard pollution externalities when there are small numbers of victims or imposers. Applying the general theorem of Section II, an efficient sequence of investments by pollution victims could easily subject them to the confiscatory reaction functions of destruction-threatening externality imposers. For example, an airport facing only Pigouvian taxes could easily, profitably, commit itself to concentrate its noise emissions in one particular region despite the slight increase in its Pigouvian tax bill unless the victims agreed to sell out below cost to the airport. So a suboptimal investment sequence may easily occur. This immediately provides an economic alternative to popular political explanations for the observed prevalence of externality regulation by quantity-imposition rather than taxation. The latter explanations typically rely on the greater profitability of quantity regulation to the imposers, who are politically more influential. (The clearest available political argument, that of Buchanan and Tullock, has the imposers a smaller, more easily cooperating, group than the victims.) Such arguments do not, however, explain the presence of zoning laws -- i.e., quantity regulation when equilibrium damages, and thus Pigouvian tax payments, are zero -- while our economic argument does.

It is neither necessary nor sufficient for the external damages in the above applications to be collective bads. The damages can be collective, private, or anything in between. It is, however, necessary that the victims be unable to collect damages through a compensatory liability system. (If pollution victims could collect for the damages done by the imposers, their prior investments would never be in jeopardy of a confiscatory reaction

function.) This inability to collect could be due to ordinary legal costs or to a related statutory abandonment of compensatory liability rules. As the compensatory private property systems familiar in western civilization obviously induce too little damage mitigation by victims of precontractual damages, legislatures have come to abandon these compensatory systems where severe precontractual damages have evolved. (See L. Friedman, Coase, Atiyah for some empirical examples, the earliest being the abandonment of railway liability because of insufficient damage-mitigation by victims of various kinds of railway-imposed damages.) In particular, legislatures, in responding to our increasingly severe precontractual damage problems, rather than relying on judges to impose the conditions of theoretically ideal, pre-investment contracts on the interested parties, have gradually replaced compensatory, private-property coverage with: (1) direct quantity regulation by professional governmental bureaucrats, thereby preventing imposers from threatening the uncompensated victims despite having to pay Pigouvian-taxes, whenever particular individuals are likely to impose substantial damages on others and (2) Pigouvian tax-subsidy systems whenever the external effects involve large numbers of both victim and imposers so that potential cooperation is not a relevant constraint (e.g., Thompson, 1974, 1979).

* * *

The above analysis has concentrated on only two basic empirical applications, both of which illustrated the reasonable use of direct, authoritarian, governmental investment or investment controls. In order to illustrate the reasonable use of each of our other two policies, we now broaden the economic environment to where potential cooperation constraints

may have created two additional, commonly observed, underinvestment tendencies.

C. Nonexistent Transactions

Economists have long observed -- and left unexplained within simple rationality paradigms -- that certain kinds of theoretically valuable trades practically never occur regardless of the values of these trades. Perhaps the most common examples are: (1) insurance against catastrophies such as floods or multimillion dollar personal accidents and (2) the absence of transactions providing high-risk, on-the-spot aid to victims of emergencies such as fires and critical health failures. In either example, refined, prior-to-service, specifications of the conditions under which compensation is to be paid is extraordinarily impractical so there are no substantial pre-service payment commitments. But, owing to the extraordinarily high realized values of the services, the private returns to making post-service commitments are several orders of magnitude greater than the returns from pre-service commitments. Our inevitable underinvestment solution, which in this case amounts to a zero-trade solution, emerges. Thus, catastrophe insurance is precluded because, once the initial "contract" is written and the rare catastrophe occurs, it pays the victim to cooperate with others (such as witnesses, professional damage-estimators, or insurance company employees) to receive the maximum damage unless the insurance company takes its own, correspondingly expensive, transaction-prohibiting precautions. And high-risk, on-the-spot, emergency aid transactions are precluded because once the aid is provided, the returns typically would justify the costs of claiming the entire value of the saved (or lost) asset as the appropriate payment and committing oneself to marshalling the resources necessary to prove the case unless a correspondingly

high payment is received. The initially sacrificing party would never be able to capture anything like the benefits of his investment. So, in the absence of one of our optimal policies, the efficient investment would simply never occur.

Apparently sensing these underinvestment solutions, governments around the world have come to provide (1) insurance against various catastrophies (especially floods) and (2) high-risk, emergency aid to victims of fires and critical health failures.⁴

Nevertheless, there are obviously many real world situations in which the government cannot determine ex ante who should provide emergency aid. In such cases, with direct governmental provision highly impractical, the judicially determined optimum would have a beneficiary paying the rescuer an estimate of the amount he would have received if the two could have initially, costlessly, contracted for the aid (unless this too is impractical, in which case an investment-increasing tax on the returns to later investments may provide at least a second-best solution.) However, in such cases -- say a passer-by can save someone from a burning building while the public fire department would be too late -- we find an historic refusal of common law courts to grant significant, value-dependent payoffs for noncontractual emergency aid, such payoffs being a necessary part of our optimal, judicially-determined, quasi-contract. Clearly there are many real world cases in which emergency aid is underprovided because of an absence of such compensation. The common law, by

⁴While government employees have underincentives similar to private providers of incomplete, pre-emergency service contracts, the government can, and apparently does, partially compensate for this by supplying employees with additional inputs that are exceptionally complementary with the production of high-risk emergency services. Thus public fire departments supply many more full-time firemen than their private counterparts (Poole).

perversely discouraging the efficient, early investments in an emergency aid sequence, works to aggravate rather than relieve the underinvestment problem.

An important exception to this absence of significant, value-dependent compensation for emergency aid occurs in admiralty law dealing with salvage on navigatable waters. Here, rescuers are paid amounts dependent on the values of the saved property, and the amounts are determined by the amounts the rescuers would have received in a hypothetically competitive, pre-service contract (see, e.g., Gilmore-Black, or Landes-Posner). Since governmental investment is not a practical alternative to private investment in these cases, this amounts of an adoption, in principle, or our best policy solution. Note that our admiralty law, being a descendant of the Roman Civil Law, English Military Law, and Parliamentary decision, is an historic rival of our judge-made, common law (Gilmore-Black). The superior efficiency of the legislatively evolved system provides fairly clear evidence against what might be labelled "the intellectual's favorite hypothesis," viz., that laws and policies constructed from evolving social wisdom are superior to those arising from the chaotic battles of self-interested politicians and special interest groups. (Landes and Posner, fairly avid supporters of the intellectual's favorite hypothesis, neglect to mention the unique statutory source of the uniquely efficient law of rescue.)

D. Crime and Judicial Discrimination

A "criminal" is someone who does not have the wealth to pay for the expected damages he inflicts on others without their prior consent. A first-best, pure Pareto optimum is generally impossible to achieve in such cases. This is because imposing corporal punishment on the criminal, which is generally necessary to give him correct incentives, itself imposes a

deadweight loss on the system by directly reducing the utility of the criminal without increasing the utility of others.⁵

We are thus stuck with an unavoidable myriad of justifiable, second-best, policy interventions in related sectors, the only qualitative discipline on which is that optimal interventions must serve to induce reductions in the crime rate (Faith-Thompson). But we do not wish to discuss here the corresponding, observed myriad of indirect government policies (e.g., public

⁵This deadweight loss does not appear in a social optimum in the special case that the optimal quantities of a criminal's damage-creating activities are zero (and there is correct third-party information regarding the existence of such activities). For in such a case, all crimes are perfectly deterred in an optimum by the threat of corporal punishment. To prevent this from being the only case, we permit criminal activities to generate utility to the criminal. The classic study of Becker employs a very similar assumption to avoid essentially the same problem.

While Becker, and subsequently Stigler and Posner, also assume somewhat imperfect information regarding the identity of the criminals in a given crime -- and indeed treat this uncertainty as the defining feature of "crime" -- such uncertainty adds nothing to standard Pigouvian tax principles as long as fines (and subsidies) are suitably expanded to reflect governmental collection cost and the lower-than-unity probability of detection and conviction. To avoid discussing this relatively trivial issue in the text below we simply assume that there is an optimal governmental devotion of resources to detection and conviction for any externality, referring the reader to Becker's study for an indication of the similarity between actual and optimal detection and conviction expenditures. (Most obviously, actual as well as optimal expenditures on detection and conviction increase with the severity of the external damage. Stigler's study, however, provides other evidence indicating that the matter is still in doubt.)

The basic defect in these studies is that they do not recognize that once a bankruptcy of externality imposers is admitted, the problem is not simply a Pigouvian tax problem with uncertain detection and government administrative costs added onto the usual external loss and thus tacked onto the Pigouvian tax rate. Familiar-type marginal conditions for Pareto optimality are no longer applicable because of the unavoidably positive resource costs of taxation itself prevents this. In terms of second-best theory, there is a tax-based inability to "control" the crime sector, even under perfect knowledge of criminal activities, and thus a legitimate, "second-best," intervention problem. (See Faith-Thompson, esp. fn. 4. In fact, crime provides the only legitimate empirical example of a second-best problem in that the political constraint implicit in the usual (no-bankruptcy) second-best problem implies an extension of the constraint on the uncontrollable sectors to related sectors and therefore a laissez faire policy.)

morality education, welfare-to-the-able, gun control laws, incomplete compensations of the victims of crime, etc.) economically rationalizable only in that they induce reductions in the crime rate. Rather, in order to isolate the issue of efficient punishment, we simply assume that subsidies to crime-substitutes and taxes on crime-complements are set at their ideal, second-best levels.

Similarly, the level of utility-reduction imposed on any given criminal is taken as given at its socially optimal level. The familiar economic literature on the theory of crime and punishment, which has concentrated on characterizing these optimal punishment levels, has produced no serious efficiency violations in observed government policy.⁶

Having set both the levels of pecuniary taxation and subsidization for crime-related activities and the levels of punishment for criminal activities, we leave open only the problem of determining the form of punishment. An optimal form of punishment is simply one that minimizes the social cost of

⁶See, esp., Becker. While the subsequent studies of Stigler and Posner conclude that observed, statutory punishment levels are typically inefficient (usually too low), this stems from a basic analytical error common to both discussions: Both assume that their assumptions imply that the efficient level of punishment occurs where the expected level of punishment costs faced by a prospective criminal is never less than the expected external damages from his crime. But, with a positive social cost of imposing punishments, there is a positive net benefit of reducing the total quantity of punishments from a point at which the expected punishment equals the external damage from a crime. A marginal increase in crime, starting from the equality, creates equal but opposite expected benefits to the criminal and victim and therefore no substantial change in social benefit while the corresponding reduction in total corporal punishment, given a punishment elasticity of crime that is below unity, creates a clear social benefit. For example, the optimal level of punishment is obviously zero for criminals who are impoverished ex ante and have perfectly inelastic punishment supply curves of criminal activity. (Whether or not this optimal policy has been followed in practice is not at all clear; the observed, lengthy incarceration of incorrigibles may not represent overpunishment; it may be merely an optimally preventative, second-best, tax-subsidy policy.)

reducing a guilty defendant's utility by the given amount. To characterize this optimum, first let us assume that the several evaluators of an alleged ill-doer's guilt have no significant individual interest in the evaluation and, although they may have a significant joint interest, interact noncooperatively so that no evaluator's judgment is significantly affected by the joint pecuniary effect of a guilty sentence. Guilt evaluations, being uninfluenced by pecuniary effects, can then be assumed to be objective. With objective evaluations, an optimal punishment system should never apply corporal punishment without first demanding transfers that actually bankrupt the guilty defendant (Becker). For the only effect of replacing corporal punishment with utility-equivalent transfers until no longer possible is to raise the utility of the rest of society without altering the utility of the alleged criminal. Yet we observe that numerous criminals (e.g., robbers, thieves, murderers, rapists, and anti-trust violators) are not treated in this manner. Criminal justice systems around the world have long been prevented from imposing large fines on wealthy offenders. Judges have been left with no alternative but to punish wealthy offenders with socially costly prison sentences even though the social cost of imposing the same punishment on the offenders via fines is zero. This practice has been criticized as a serious economic inefficiency since Bentham. Even Becker and Posner, typically defenders of our legal system, sharply criticize this tradition. A second, related characteristic of an efficient form of punishment is that prisoners should be allowed to provide useful labor for the state while in prison and thereby reduce the social cost of their interment. Yet this apparently

obvious efficiency has likewise been prohibited by statutory intervention throughout our most advanced civilizations.⁷

What makes these peculiar statutory constraints appear to be so obviously inefficient is the observation of objectivity on the part of our judges, juries, and witnesses. However, if the peculiar constraints did not exist, the payoff to cooperative interaction would be much higher. Guilt evaluators would be much more likely to conspire to bias their judgment toward guilt in order to confiscate: (1) The real capital of the wealthy through heavy pecuniary punishments and (b) the human capital of groups not significantly represented in the judicio-legal system.

A fairly clear example of the latter occurred in our antebellum South. Here, the ability to lease out prison labor crews to private employers give local decision makers an incentive to conspire against black workers in imposing harsh sentences for minor and dubious violations (Cohen). Subsequently, during the first half of the twentieth century, statutes arose that uniformly prohibited the leasing of convict labor and restricted the use of convict labor to where it was not generally profitable (Cohen).

Legal history also provides a similarly clear example of how induced cooperation problems led to the replacement of a straightforward pecuniary punishment system with corporal punishment. The well-established reliance on heavy pecuniary fines developed in early mideaval England was, after the Norman Invasion of 1066, exploited for about a hundred years by French

⁷So far, the above analysis of crime is almost identical to the last section of my lengthy, 1969 manuscript, "A Reformulation of Orthodox Value Theory." The analysis there similarly works up to the above conclusion that present forms of criminal punishment are grossly inefficient. I was then, as others, blissfully unaware of the more subtle interactions we are about to discuss.

tribunals through huge, discretionary jump in the levels of both fines and prosecutions (Pollock and Maitland). The result, the 12th century legal revolution in response to a continual public clamor against such judicial discrimination, replaced the "murder fine" and the like with a Roman-type corporal punishment system (Pollock and Maitland).⁸ (This legal revolution also introduced the use of juries. This apparently served to prevent the judicial blackmail of wealthy criminal defendants through threats of corporal punishment, such transactions being presumably too costly when requiring several cooperating blackmailers.)

In both of the above empirical examples, the end of judicial discrimination marked the approximate beginnings of eras of substantial investment increases by the victimized groups. However, our above second-best, policy rationalization is probably not applicable to modern economics. The huge growth in the numbers of people that typically share the revenues from fines makes largely obsolete the potential cooperation argument against imposing huge fines on the wealthy perpetrators of serious crimes. And the integration of racial minorities into our legal system makes largely obsolete the potential cooperation argument against convict labor. Nevertheless, similar rationalization of these anomalous characteristics of current legal

⁸The transition away from the inefficient system of fines, being based on gradually accumulating public dissatisfaction, much in the way of modern legislation, represents a sharp contrast to common law evolution, which is much more an evolution of social thought. In the previous section, we found a fairly clear example of the inefficiency of common law and the contrasting efficiency of statutory law. Here too, we find such an example. Probably the first major change evolved by the fledgling common-law criminal system of the 12th and 13th centuries was the replacement of the then-popular system of torture and mutilation with imprisonment. While imprisonment may be sometimes superior to torture through an induced reduction in the crime rate, there obviously exist numerous criminals whose lifetime supplies of crime have not been significantly reduced by incarceration.

systems — one based solely on the inability of government authorities to precommit to the citizenry -- exists. It is that the ex post, social-welfare-maximizing decisions of the authorities would differ from their efficient, committed, ex ante decisions in that the former would be biased against both the wealthy and, in certain regions, the socially "inferior". In such cases, it would increase ex ante social welfare to impose artificial costs on society, and therefore on the authorities, of administrative decisions biased toward the policy-makers ex post social welfare function (Thompson, 1981). Increasing the social cost of imposing a given punishment on the "undeserving" wealthy or on the "inferior" minorities helps bring down the excessive, biased punishment levels imposed by legal authorities who maximize ex-post social welfare.

IV. SUMMARY AND CONCLUSIONS

Economists have long been aware of the force of potential competition. Potential competitors in simple, all-private-goods economies, by flattening out industry demand or supply curves, provide an invisible force toward efficiency in private-property systems. But there is also a force of potential cooperation, an invisible force toward inefficiency in private property systems.

By eliminating the profit from what would otherwise be the early investments in a efficient sequence of investments and leaving a private-property economy looking as if its interactions were simply innocent, noncooperative interactions, the force of potential cooperation creates grossly Pareto-inefficient, underinvestment traps detectable in long-run equilibrium only by the observation of exceptionally low investment levels. Left unattended, these traps may, for example, easily create: (1) underinvestment by potential pollution victims; (2) underinvestment by providers of all sorts of emergency aid; (3) underinvestment by the potential victims of judicial discrimination; and, most severely, (4) extreme aggregative underdevelopment.

Regarding the first three underinvestment problems, governments sensitive to the separate benefits of its various special interest have quickly evolved qualitatively efficient policies. In particular, they have: (1) adopted zoning laws and quality controls on pollution to prevent underinvestment by potential pollution victims; (2) adopted local provision of police, fire and emergency medical care, as well as national flood insurance, to prevent extreme underinvestment by high-risk emergency aid providers; and (3) eliminated profitable conflict labor and large pecuniary fines to wealthy law-

breakers in order to eliminate underinvestment by the potential victims of judicial bias. The fact that traditional economic thinking argues unambiguously against essentially all of these observed policies is indicative of a complete absence of the constraint of potential cooperation from existing economic thought on efficient government policy.

Underinvestment traps significant enough to produce aggregative underdevelopment present a more complex policy problem. With sufficiently large investments, governments sensitive to the separate benefits of their various special interests -- in particular modern representative democracies -- themselves become subject to potential cooperation problems. Sufficiently large aggregate investments by the constituents of some representatives may easily create a positive profit to forming commitments to engage in confiscatory redistribution by the previously uncommitted representatives of other constituents. While this is probably a more severe problem in low-income countries, where there is relatively poor communication of prior commitments among the various representatives, democracy is ill-suited and seldom-used in low-income countries anyway because of the much greater parental malincentive problem when incomes are low (Thompson-Ruhter). With low-income, authoritarian, governmental forms dependent on the "system wisdom" of social planners rather than grounded on the possibly enlightened self-interest of interacting political interest groups, it is not surprising that such governmental forms have had only mixed success in the real world despite their unique theoretical ability to eliminate aggregative underinvestment traps based on the force of potential cooperation.

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