# INDIRECT EVOLUTION VERSUS STRATEGIC DELEGATION:

## A Comparison of Two Approaches to Explaining Economic Institutions*

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*Abstract:* Two major methods of explaining economic institutions, namely by strategic choices or through (indirect) evolution, are compared for the case of a homogenous quadratic duopoly market. Sellers either can provide incentives for agents to care for sales, or evolve as sellers who care for sales in addition to profits. The two approaches are conceptually quite different, yet similar in the sense that both allow certain kinds of commitment. We show that when the two models are set up in intuitively comparable ways strategic delegation does not change the market results as compared to the usual duopoly solution, while indirect evolution causes a more competitive behavior. Thus the case at hand underscores the differences between the two approaches in explaining economic institutions.

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## 1 Introduction

For a given institutional design one often can derive results concerning the nature of strategic interaction by applying tools of game theory. However, the bulk of economic analysis does not address the question of why certain institutions prevail. In this study an attempt is made to compare two methods of explaining institutional designs, instead of assuming them as exogenously given.

The first approach, to which we refer as *strategic delegation*, has a long standing tradition in the social sciences. People do not only decide within certain institutions, but they decide upon institutional design. A famous example is, for instance, the *contrat social* (Rousseau 1762), to which one often refers when justifying constitutional design. Clearly, such a contract is only a fiction. But there are more realistic examples, e.g. when changing legal rules by qualified majorities, for instance, by unanimous approval.

More specifically, let an *institutional design* be represented by the rules of a final subgame and assume that earlier choices in the game allow to rule out certain subgames. By solving the game one does not only determine the behavior in final subgames, but also the choice of subgames, i.e. *institutional choice*. In the context of our example with strategic delegation, the final subgame is characterized by the motivation structure of the interacting agents, and principals strategically design the incentives of their agents.

The second method we discuss is the indirect evolutionary approach, in which an *evolutionarily stable institutional design* is derived via evolutionary rather than strategic considerations. More specifically, an indirect evolutionary analysis first determines the solution for any institutional arrangement, and then selects among various such structures in an *evolutionary model* with institutional design constellations as mutants.

We compare the two approaches of strategic delegation and indirect evolution for the case of a simple duopoly example where sellers on a homogenous goods market might want to care also for sales in addition to profits. Strategic delegation requires a team consisting of a principal and his agent, whereas under indirect evolution sellers may evolve to develop an "evolutionarily stable" concern for sales themselves.

The two approaches are conceptually very different. Whereas under strategic delegation institutions are *chosen*, with the indirect evolutionary approach decision or game theory is restricted to predicting the choice behavior *within* a given institutional setup. Moreover, strategic delegation involves a richer social setting than does the indirect evolutionary approach, since strategic delegation includes agents that are absent in the other approach. For these reasons one might suspect the two approaches will lead to very different results.

On the other hand, there is also a similarity between the two approaches. ”Modeling evolution"—by specifying a (geno)type space and an evolutionary dynamics or a static evolutionary stability concept guaranteeing dynamic stability (see Hammerstein & Selten (1994) as well as Weibull (1995))—poses a challenge similar to that of ”modeling the overall game" as in strategic delegation. In each case a certain kind of *commitment* is involved. Under strategic delegation the principal may commit to a certain behavior by designing appropriate incentives; under indirect evolution the players' preferences are shaped by evolution, and these preferences may serve as commitment devices.[1] Therefore, one may suspect that the two approaches should yield similar results.

We shall shed some light on these issues, and in particular present results that underscore the differences between the two approaches. In Section 2 we specify the basic features of the market model we analyze throughout. In Section 3 we present a benchmark model of indirect evolution which allows producers to care for sales, and derive a unique evolutionarily stable concern for sales. In Section 4 we consider the effect on market interaction by allowing strategic delegation when agents may be induced to care for sales. In Section 5 we compare the results of the foregoing two sections and show that indirect evolution tends to generate

[1] This observation explains why applications of the indirect evolutionary approach sometimes prompt questions whether the indirect evolutionary approach is the same as the strategic delegation approach. The typical argument made is that in a social dilemma situation, due to the scope for individual opportunism, cooperative results can be assured by commitments (not to behave opportunistically) and that strategic delegation and indirect evolution provide just two stories how such commitments may result.

more competitive outcomes than does strategic delegation with hired hands. In Section 6 we allow for a more general class of strategic delegation contract than in Section 4, and show that the basic results do not change. We also discuss a particular restriction on that general class of contract that leads to the same outcome as under indirect evolution. In Section 6 we comment on how our results change if preference parameters/contracts are not observable. Section 7 concludes.

## 2 The market model

In a homogenous duopoly market sellers $i$=1,2 simultaneously choose their sales amounts $x_i \geq 0$. Assuming a linear demand function and normalizing it appropriately allows us to write seller $i$'s revenue as

(2.1) $$x_i \cdot (1-x_i-x_j) \quad \text{for } i=1,2 \text{ and } i \neq j$$

The market price is $(1-x_i-x_j)$ We do not a priori exclude the possibility of negative prices, but such outcomes will in fact not be viable under either of the two approaches to be discussed. The costs of production are assumed to be given by

(2.2) $$½\, c\, x_i^2 + C \quad \text{with } c,C > 0$$

According to the structural relationships (2.1) and (2.2) the market is symmetric. The profit $\pi_i(x_i, x_j)$ of seller $i$=1,2 for sales amounts $x_i$ and $x_j$ with $i \neq j$ is determined by

(2.3) $$\pi_i(x_i, x_j) = x_i\,(1-x_i-x_j) - ½\, c\, x_i^2 - C$$

## 3 Indirect evolution

The indirect evolutionary approach allows to endogenously derive the rules of the game (see Güth & Yaari 1992), and it can therefore be viewed as a way to generalize neo-classical theory which traditionally assumes that such rules are exogenously determined. Unlike in direct evolutionary analysis or usual evolutionary game theory (where one assumes behavior to be genetically determined (see Hammerstein & Selten (1994) for a survey), or acquired phenotypically, e.g. via learning or by cultural evolution (see, for instance, Boyd & Richerson (1985)) one does not study directly the evolution of behavior. Instead, some more basic feature of the game, in our case preferences, is the object of evolution. Rational behavior is taken for granted, but behavior may nevertheless be indirectly affected if preferences change.[2]

If in a bilateral encounter behavior may be guided by an additional incentive, one first solves all the games resulting from such incentives for both players. With the help of these results one then defines an evolutionary model with the possible incentives as strategies or mutants, and one then derives the evolutionarily stable incentive constellation.

### *3.1 Incentives for sales*

It is often claimed that sellers are not only interested in their profits, but also in their prestige as sellers (see for example Williamson (1964)). This one can measure by their sales (quantity amounts).[3] In general, there may be many ways to include such concerns. Here we will rely on the most simple way of doing so, namely by relying on utilities

(3.1) $$u_i(x_i, x_j) = \pi_i(x_i, x_j) + \beta_i x_i$$

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[2] For the same type of (duopoly) market environment, Bester & Güth (in press) analyzed whether altruism is evolutionarily stable whereas Güth & Huck (1997) allow for all possible quadratic profit functions and show that monopolistic competition (in the sense of neglecting mutual dependency) can be stable.

[3] Since profits are usually private information whereas sales are often widely known, it is much more likely that the prestige of a seller depends on sales rather than on profits. Larger sales often require large production amounts and thereby an increased or more stable use of the labor force, suggesting that a concern for sales might result from more basic interests.

where $\pi_i(x_i, x_j)$ is as defined by equation (2.3) and where $\beta_i \in R$ is a constant which measures *i*'s predisposition to care for sales. We refer to $\beta_i$ as seller *i*'s *concern for sales*. The main restriction of (3.1) is that it combines *i*'s concerns for profits and sales in an additive way.

The first step of our indirect evolutionary analysis requires us to determine the market results for all $(\beta_1, \beta_2)$ constellations, not necessarily with $\beta_1=\beta_2$. With the help of these results we then define an evolutionary game with mutants/strategies $\beta_1$ and $\beta_2$. The success of a mutant is measured by the profit it makes.[4] Determining an evolutionarily stable mutant thus answers the question whether and to what extent sellers evolve in such a way that they care for sales in addition to profits.

### *3.2 Market interaction with a direct concern for sales*

Our model has been chosen to simplify the derivation of market equilibria. From

$$(3.2) \qquad \frac{\partial}{\partial x_i} u_i(x_i, x_j) = 1 + \beta_i - (2+c)\, x_i - x_j = 0$$

and

$$(3.3) \qquad \frac{\partial^2}{\partial x_i^2} u_i(x_i, x_j) = -(2+c) < 0$$

for $i$=1,2 and $j \neq i$ one derives equilibrium sales amounts as functions of $(\beta_1, \beta_2)$:

$$(3.4) \qquad x_i^* = x_i^*(\beta_i, \beta_j) = \frac{1+c-b_j+(2+c)b_i}{(1+c)(3+c)}$$

Note that we use $x_i^*$ both to refer to a specific optimum choice of $x_i$ for given preference parameters, and to refer to the function describing this connection. In many cases below we make an analogous abuse of notation because this simplifies the presentation greatly.

[4] For genetical evolution this is rather obvious: The material success is monotonically related to reproductive success in the sense of the expected number of offspring. In case of cultural evolution (Boyd & Richerson, 1985) the justification is that adaptation should depend on interpersonally observable success measures like profit, and not on individual satisfaction measures which cannot be observed by others and do not matter for them.

### *3.3 The evolutionary model*

If one inserts the solution (3.4) into the profit function (2.3) one can derive each firm's profit as a function of ($\beta_1$, $\beta_2$) and obtain for $i$=1,2 with $j \neq i$

(3.5) $$\pi_i^*(\beta_i, \beta_j) = x_i^* (1-x_i^*-x_j^*) - \tfrac{1}{2} c (x_i^*)^2 - C$$

(3.5) is a profit function expressing market success as a function of the possible incentives for sales. We refer to equation (3.5) as the seller *i*'s reproductive success from the incentive constellation ($\beta_i$, $\beta_j$).

By

(3.6) $$\Gamma = (M, \pi_i^*)$$

with M (the mutant space) equal to $\mathbb{R}$ (the set of real numbers), and $\pi_i^*$ defined by equation (3.5) for all possible incentive constellations $\beta_i,\beta_j \in M$ we have defined an evolutionary model whose evolutionarily stable strategies we now want to determine.

### *3.4 The evolutionarily stable concern for sales*

An evolutionarily stable concern for sales can be defined as an *evolutionarily stable strategy* (ESS) of the evolutionary model defined in (3.5). Thus $\beta^*$ is an ESS if

(3.7) $$\pi_i^*(\beta^*, \beta^*) \geq \pi_i^*(\beta, \beta^*) \qquad \forall \beta \in M$$

and if

(3.8) $$\pi_i^*(\beta^*, \beta) > \pi_i^*(\beta, \beta) \qquad \forall \beta \in M \text{ such that } \pi_i^*(\beta^*, \beta^*) = \pi_i^*(\beta, \beta^*)$$

For the case at hand it suffices to look at condition (3.7), since the best reply is unique in every symmetric equilibrium ($\beta^*$, $\beta^*$) of the symmetric evolutionary model $\Gamma$.

From

(3.9) $$\frac{\partial}{\partial \beta_i} \pi_i^*(\beta_i, \beta_j) = 0$$

(3.10) $$\frac{\partial^2}{\partial \beta_i^2} \pi_i^*(\beta_i, \beta_j) < 0$$

as well as from $\beta_i = \beta_j$ one obtains

(3.11) $$\beta^* = \beta^*(c) = \frac{1}{5 + 5c + c^2}$$

Note that $\beta^* > 0$. A pure preference for profit maximizing behavior, i.e. $\beta_i = 0$, is *not* promoted by evolutionary forces. Only for extremely large values of $c$ will the market evolve in such a way that sellers do not care for sales directly. When $c \to 0$ the parameter $\beta^*(c)$, expressing a direct concern for sales in the sense of the utility function (3.1), increases to 1/5. Our results can be summarized by

*THEOREM 1 If on the symmetric market with profits (2.3) sellers can develop incentives of the form (3.1) and if the incentives of both sellers are commonly known, the only evolutionarily stable direct concern for sales is* $\beta^*$*, defined by equation (3.11).*

## 4 Strategic delegation

In Section 3 we analyzed how evolution may select a concern for sales. We now investigate the consequences of letting sellers induce a concern for sales via strategic delegation. The approaches are then compared in Section 5.

Unlike indirect evolution strategic delegation relies on a richer social structure of the market. The two seller firms $i,j=1,2$ with $i \neq j$ are now to be represented by two teams ($P_i$, $A_i$) and ($P_j$,

$A_j$) of principals $P_i$ and $P_j$ and their respective agents. Strategic delegation[5] typically assumes the form that first the two principals propose contracts which then, if accepted by the agents, guide behavior in the market. In fact, from now on, we presume that agents always accept their contracts, but that these contracts must net each agent zero payoff in the end (in subgame perfect equilibrium). By rigging the model appropriately, this can be justified by assuming outside options of zero worth for the agents, and presuming that each principal makes a take-it-or-leave-it offer to his agent. Since agents will make zero payoff, whatever profit is generated in the market goes to the principals. This facilitates a clear-cut comparison between the outcomes under strategic delegation and indirect evolution.

### *4.1 The two-stage game model*

In this section we assume that principal $i=1,2$ can only propose linear contracts of the following form:

(4.1) $$(G_i, \beta_i) \qquad \text{with } G_i, \beta_i \in \mathbb{R}$$

We refer to $G_i$ (a direct transfer from the principal to the agent which may be negative), as agent $A_i$'s *salary*. This transfer has no effect on the agent's incentives, but it puts all the bargaining power in the hands of the principal. Since the agent can earn only zero outside the firm, the principal can reap all profits available, just like in the evolutionary model where no agent was present. We refer to $\beta_i$ as $A_i$'s *sales incentives*. The set of strategic delegation contracts allowed is comparable to the mutant space under indirect evolution in the following sense: Under indirect evolution sellers could develop a concern for sales themselves via evolution. Under strategic delegation principals may develop a similar concern via their agents. The set of contracts (4.1) is the simplest we can think of that allows a comparison with

[5] Different aspects of strategic delegation have been analyzed by Baik & Kim (1997), Caillaud, Jullien & Picard (1995), Fershtman & Judd (1987), Fershtman, Judd & Kalai (1991), Fershtman & Kalai (1996), Gal-Or (1996), Green (1990), Katz (1991), and Rotemberg (1994). For an experimental study see Fershtman & Gneezy (1996).

these features being prevalent. However, in principle one can imagine other sets of strategic delegation contracts. In Section 6 we consider a more general class and show that the result of this section essentially remain unchanged. We also consider a particular way of restricting that general set of feasible contracts which brings about a different result.

To determine the results of strategic delegation one simply has to solve the two-stage game for the subgame perfect equilibrium (which is unique). First principals choose contracts as described in (4.1) and then, knowing both contracts, each agent $i$=1,2 chooses $x_i$ to maximize

(4.2) $$u_i(x_i, x_j) = G_i + \beta_i x_i - ½\, c\, x_i^2 - C$$

as determined by his contract ($G_i$, $\beta_i$). When choosing a contract ($G_i$, $\beta_i$) principal $P_i$ is, of course, motivated by his profit net of his agency cost. That is, principal $P_i$ will maximize

(4.3) $$R_i = x_i\,(1-x_i-x_j) - G_i - \beta_i\, x_i$$

## *4.2 The results of strategic delegation*

It can be easily seen that the agents face independent maximization tasks. More specifically, the payoff $u_i(x_i, x_j)$ depends only on $x_i$ and not at all on $x_j$. Maximization of $u_i(x_i, x_j)$ as defined by (4.2) by choice of $x_i$ yields

(4.4) $$x_i^+ = \beta_i/c \qquad \text{for } i=1,2$$

For a clear-cut comparison with the results of indirect evolution, we assume that agent $A_i$ will only accept to work for principal $P_i$ if $u_i \geq 0$. Principal $P_i$ will choose $G_i$ such that $u_i$=0. Inserting (4.4) into equation (4.2) and setting $u_i$=0 yields

(4.5) $$G_i^+ = G_i^+(\beta_i) = C - \frac{b_i^{\,2}}{2c} \qquad \text{for } i=1,2$$

Inserting all these values into (4.3) results in

(4.6) $$R_i^+(\beta_i, \beta_j) = \frac{\beta_i}{c^2}(c-\beta_i-\beta_j) - \frac{\beta_i^2}{2c} - C$$

for $i,j$=1,2 and $i \neq j$. Since due to the definition of $G_i^+(\beta_i)$ participation of the agent is guaranteed, principal $P_i$ can design an optimal contract ($G_i$, $\beta_i$) by maximizing $R_i^+(\beta_i, \beta_j)$ with respect to $\beta_i$. From

(4.7) $$\frac{\partial}{\partial \beta_i} R_i^+(\beta_i, \beta_j) = \frac{1}{c^2}(c-2\beta_i-\beta_j) - \frac{\beta_i}{c} = 0$$

and

(4.8) $$\frac{\partial^2}{\partial \beta_i^2} R_i^+(\beta_i, \beta_j) = \frac{-2}{c^2} - \frac{1}{c} < 0$$

one obtains

(4.9) $$(2+c)\,\beta_i = c - \beta_j$$

for $i,j$=1,2 and $i \neq j$. Letting $\beta^+=\beta_1=\beta_2$ we get

(4.10) $$\beta^+ = \beta^+(c) = c/(3+c)$$

Thus each principal $P_i$, who is restricted to contracts of the form (4.1), will choose a positive incentive parameter $\beta^+$. Notice that for all $c>0$ the optimal incentive parameter $\beta^+$ satisfies $0<\beta^+<1$. We summarize our results by

THEOREM 2 *Strategic delegation in the form of (4.1) results in contracts ($G_i^+$, $\beta_i^+$) of both sellers with*

$$\beta_i^+ = \frac{c}{3+c}$$

*and*

$$G_i^+ = C - \frac{c}{2(3+c)^2}$$

*for the sellers* $i$=1,2.

## 5 Comparison of indirect evolution and strategic delegation

Let us recall that the usual result for the market with profit and utility functions (2.3) and no strategic delegation (Cournot, 1838) implies that, respectively, equilibrium sales, price, and profits can be derived as

(5.1) $$\tilde{x}_i = \frac{1}{3+c}$$

(5.2) $$\tilde{p} = \frac{1+c}{3+c}$$

(5.3) $$\tilde{p}_i(\tilde{x}_i, \tilde{x}_j) = \frac{1+\frac{c}{2}}{(3+c)^2} - C$$

for $i$=1,2. For indirect evolution and strategic delegation the corresponding results can be determined by inserting $\beta^*=\beta_i=\beta_j$, respectively $\beta^+=\beta_i=\beta_j$, into equation (3.4), respectively (4.4). Thus for $i$=1,2 one gets in the case of indirect evolution

(5.4) $$x_i^* = \frac{1+b^*}{3+c} = \frac{6+5c+c^2}{(3+c)(5+5c+c^2)}$$

(5.5) $$p^* = \frac{3+5c+c^2+c(5+5c+c^2)}{(3+c)(5+5c+c^2)}$$

(5.6) $$\pi_i^*(x_i^*, x_j^*) = p^* x_i^* - \frac{c}{2}(x_i^*)^2 - C$$

and in the case of strategic delegation

(5.7) $$x_i^+ = \frac{1}{3+c}$$

(5.8) $$p^+ = \frac{1+c}{3+c}$$

(5.9) $$R_i^+(x_i^+, x_j^+) = \frac{1+\frac{c}{2}}{(3+c)^2} - C$$

It may or may not surprise the reader that strategic delegation implies the same result as the case of usual profit maximization. In an optimal contract a seller chooses the incentives for his agent just so that the agent will react optimally to the other seller's behavior. Although agent *i* himself is not at all concerned about firm *j*'s sales $x_j$ with $j \neq i$, the incentive $\beta_i$ is selected as to induce an optimal reaction $x_i$ to $x_j$.[6] That also profits $\tilde{p}_i(\tilde{x}_i, \tilde{x}_j)$ and residual claims $R_i^+(x_i^+, x_j^+)$ agree depends, of course, on the fact that the participation constraints of the two agents are of the form $u_i=0$. Principals therefore have to compensate just for the cost of production.

Comparing indirect evolution and strategic delegation therefore amounts to comparing the evolutionarily stable incentive constellation $\beta^*$ more or less to the usual duopoly solution. By comparing (5.1) and (5.4) one derives

(5.10) $$\frac{x_i^*}{x_i^+} = \frac{6+5c+c^2}{5+5c+c^2}$$

showing that the market results from evolution are more competitive than those from strategic delegation. This difference will, furthermore, increase when *c* becomes smaller and disappears when $c \to \infty$.

Instead of comparing directly market results one may be more interested in the motivational structure, as expressed by the parameters $\beta^*$ and $\beta^+$ of the two approaches (see (3.11) and (4.10)). Clearly, for $c=0$ one has that $\beta^* > \beta^+$, whereas for any large enough *c* the opposite is true. Since $\beta^*$ is monotonically decreasing and $\beta^+$ is monotonically increasing with *c*, there exists a unique parameter value $c' > 0$ with $\beta^*(c') = \beta^+(c')$. Below *c'* indirect evolution induces a higher sales motivation than strategic delegation, above *c'* the opposite is true.

[6] One might wonder why the principals $i=1,2$ do not order their agents directly to sell $x_i^+$. A reason could be that principals do not observe sales amounts (if customers pay $\beta_i$ per unit to the agent, the principal would deduce from his profit $R_i$ the sales $x_i$ only when $x_j$ would be known). Many principal-agent models (see for example Holmström, 1979) assume that production is stochastic and that only agents learn about actual output levels. Since small uncertainties will shift the results only marginally, the discrepancy in the results for indirect evolution and strategic delegation would remain. We thus could justify that the principals set sales incentives $\beta_i$ and do not order sales amounts directly by—for principals—unobservable sales amounts.

REMARK We note that our results cannot be criticized by the argument that we have concentrated on a special case where strategic delegation leads to the usual duopoly solution (Cournot, 1838) and where it—so to say—does not matter.[7] Strategic delegation matters in the sense of changing market behavior. Consider, for instance, the case where only seller *i* can commit his agent to a contract of the form ($G_i$, $\beta_i$), whereas seller *j*, or his agent, maximizes profit. Clearly, (4.4) and (4.5) remain true for seller *i*. For *j* we get

(5.11) $$x_j = \frac{c - b_i}{(2+c)c}$$

Maximizing

(5.12) $$R_i(\beta_i) = \frac{b_i}{c}\left(1 - \frac{b_i}{c} - \frac{c-b_i}{(2+c)c}\right) - \frac{b_i^2}{2c} - C = \frac{1+c}{c^2(2+c)} b_i (c - b_i) - \frac{b_i^2}{2c} - C$$

then yields the optimal choice of $\beta_i$ for $P_i$ as

(5.13) $$\beta_i = \frac{c(1+c)}{c^2+4c+2}$$

and the agent's induced optimal choice of sales by $A_i$ as

(5.14) $$x_i = \frac{1+c}{c^2+4c+2}$$

The sales as given by (5.14) *exceed* those given in (5.1). One can verify that (5.14) corresponds to the optimum choice of the first mover in a Stackelberg duopoly game. Thus strategic delegation induces a more competitive sales policy. It is only the competition in strategic delegation which offsets its effect. To understand this result, notice that the net cost of an agent is always zero in the sense that the value of his outside option is zero and the principal can induce this level of effort cost by making an appropriate take-it-or-leave-it offer.

[7] In this respect our results on strategic delegation differ from many classical results (Fershtman & Judd (1987) and others) because we work with a different sets of possible strategic delegation contracts.

Thus the principal will induce such a sales amount which is a best reply to the sales amount of his competitor. And this is possible by an appropriate choice of $\beta_i$.

## 6 Motivating agents by profit

In Section 4 contracts were restricted to the special class of linear reward schemes ($G_i$, $\beta_i$) specifying a lump sum payment $G_i$ and a parameter $\beta_i$ representing how much agent $A_i$ gains by selling one unit more. Motivating agents by giving them incentives for increasing sales is, of course, only a special form of incentive scheme. For a non-stochastic market environment our result is, however, rather typical. To demonstrate this, let us consider the more general incentive scheme of the form

(6.1) $$(G_i, \alpha_i, \beta_i) \text{ with } G_i, \beta_i \in R \;, \alpha_i \geq 0$$

allowing for a share $\alpha_i$ by which the agent $A_i$ participates in the revenues $x_i\,(1-x_i-x_j)$ of seller $i$. The payoff resulting from such a contract is therefore

(6.2) $$u_i(x_i, x_j) = G_i + \alpha_i\, x_i\,(1-x_i-x_j) + \beta_i\, x_i - ½\, c\, x_i^2 - C$$

From maximizing $u_i$ with respect to $x_i$, and solving for equilibrium, one obtains

(6.3) $$x_i^+ = x_i^+(\alpha_i, \beta_i, \alpha_j, \beta_j) = \frac{a_i a_j + c a_i - a_i b_j + 2 a_j b_i + c b_i}{3 a_i a_j + 2c(a_i + a_j) + c^2}$$

for $i,j$=1,2 and $i$¹$j$.

One can again use the participation constraint $u_i$=0 in order to find the (subgame perfect) equilibrium values for $G_1$ and $G_2$:

(6.4) $$G_i^+(\alpha_i, \beta_i, \alpha_j, \beta_j) = -\,\alpha_i\, x_i^+\,(1-x_i^+-x_j^+) - \beta_i\, x_i^+ + ½\, c\,(x_i^+)^2 + C$$

for $i$=1,2 and where $x_i^+$ and $x_j^+$ are determined by (6.3). Seller $i$'s rewards are then

(6.5) $$R_i^+(\alpha_i, \beta_i, \alpha_j, \beta_j) = x_i^+\,(1-x_i^+-x_j^+) - ½\, c\,(x_i^+)^2 - C$$

This, however, is the profit of the firm, i.e. of an owner who is self-producing (without hiring an agent). It is straightforward to verify that $P_i$ can always find incentives $\alpha_i$ and $\beta_i$ resulting in the best conceivable reply $x_i^+$ to any $x_j^+$.[8] Thus, as in Section 4, the result of strategic delegation is the one of profit maximization without delegation. The results of Section 4 and the comparison in Section 5 is thus far more general than indicated by the narrow class of contract forms on which Section 4 is based. (Of course, in a stochastic environment the assumption of linear incentive contracts would be a serious restriction since one may want to induce different sales amounts in different states of nature.)

We finally note that a way to get the outcome under strategic delegation in line with that under indirect evolution is to consider the restriction of (6.1) to contracts with $\alpha_i$=1. Then the agents' incentives under indirect evolution will exactly match those instigated by (3.1) under indirect evolution, and the calculations leading up to (3.11) and (5.4) match too. It is noteworthy that although all the contracts that would be possible with this set-up are also possible when (6.1) is unrestricted, these contracts are never used in the general case.

## 7 Privately known types

Our analysis has so far assumed that the relevant "type" parameters ($\beta_i$ ,$\beta_j$) are commonly known when sales decisions are made. A very different informational assumption would be that these parameters were private information (each *i* knows only his own $\beta_i$ in the indirect evolutionary approach, each principal $P_i$ and agent $A_i$ knows only the contract he has signed

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[8] The easiest way to see this is to inspect (6.3) and verify that this can in fact be achieved through contracts with $\alpha_i$=0. However, typically, there exists a manifold of contracts ($G^+$, $\alpha^+(\beta)$, $\beta$) which all imply the same market results. From $\frac{\partial}{\partial \alpha_i} R_i(\alpha_i,\beta_i,\alpha_j,\beta_j)=0$ and $\frac{\partial}{\partial \beta_i} R_i(\alpha_i,\beta_i,\alpha_j,\beta_j)=0$ as well as $\alpha=\alpha_i=\alpha_j$ and $\beta=\beta_i=\beta_j$ one obtains $\alpha^+$ =

$$\alpha^+(\beta) = \frac{3-4\beta+\frac{24\beta-3}{1-2c}-2c}{8} - \frac{\sqrt{29\beta^2-(8\beta-20\beta^2)c-18\beta c^2-4(1+\beta)c^3+c^4}}{2c-1}.$$

in the strategic delegation case). In the following, we briefly comment on how our results are affected in this case.

In the indirect evolutionary approach, suppose the seller's beliefs concerning the other firm's $\beta \in M$ are determined by the true distribution in the population. This is a standard case with private information (see e.g. Güth (1995)). Then (see Güth & Peleg (1997) for a general analysis) only $\beta^*=0$ can be evolutionarily stable. The reason is that if a particular seller *i*'s type would change only *i* would react. It follows that only a best reply in terms of market success (i.e., with no independent weight for sales) can be evolutionarily stable. $\beta^*=0$ is best against $\beta^*=0$ and thus evolutionarily stable.[9]

For strategic delegation a similar extension of our analysis to privately known types yields the same results. If a principal cannot publicly announce the incentives of his agent, the incentives guaranteeing best replies in terms of market success are clearly best. Thus also in this case the standard Bayesian equilibrium results.

Hence, indirect evolution and strategic delegation lead to the same market results with private information about types. This explains why in this paper we have focused instead on the opposite polar case where types are common knowledge.[10]

## 8 Conclusion

To explain institutions, one can refer to a pre-institutional decision stage where players decide strategically about the future institutional set up. An example for this is the well-known, nevertheless fictitious *contrat social*, but also the stage of mechanism choice in the theory of

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[9] Here, of course, we implicitly rely on the usual assumption (in evolutionary game theory) that sellers interact only once in the market. If "before reproducing" the same sellers would repeatedly sell on the market, former sales choices might signal one's own $\beta$-incentive. That is, private information could be revealed. Conceivably it may then be important to have other incentives than $\beta=0$. Just as in the case where incentives are commonly known, the other firm's behavior may change.

[10] Compare Güth & Kliemt (1994) who (in a different economic context) apply an indirect evolutionary approach and discuss also informational assumptions which are intermediate to the polar cases where types are common knowledge and private information respectively.

mechanism design which assumes that certain individuals can decide about the mechanisms to be applied later.

An alternative approach is that of (indirect) evolution where no one intentionally designs the future set up. The precise structure is rather determined by the relative success of the alternative designs in the given institutional environment. This reveals an essential difference of the two approaches. Whereas the first approach needs an all encompassing game model the second one does not require this, as the strategic choice of future rules is replaced by modeling the evolution of such rules.

Here we scrutinized the argument that these conceptually very different approaches yield the same outcome just because they both allow for commitment in the sense of making sure that future behavior will guarantee certain conditions. Here such commitments take either the form of certain incentive contracts in the case of strategic delegation, or they evolve with certain incentives. By our example it is shown that the two approaches may nevertheless yield very different results. More specifically, strategic delegation does not change the results at all whereas (indirect) evolution implies more competitive market results.

In our view, this demonstrates that (indirect) evolutionary analysis offers a new and innovative perspective to explain economic institutions. Like strategic delegation, the approach does not deny that decision makers are rational. Unlike strategic delegation it does not require an all encompassing game model which has to specify e.g. the incentives, the information conditions, and the strategic possibilities of those who decide about the future institutional set up. One does not have to model a pre-institutional decision stage, but rather the evolution of economic institutions.

The fact that strategic delegation and indirect evolution are conceptually different suggests that these are in no way competing approaches. Rather the two shed independent light on how economic institutions can be explained. In principle, the two approaches can even be employed together, e.g. by assuming a market with strategic delegation and by deriving the evolutionarily stable rules of strategic delegation (principal and agent may, for instance, develop a feeling of corporate identity which could be captured by mutual altruism as in Bester & Güth (in press)).

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