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# The evolution of economic institutions as a propagation process

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**Abstract.** Based on some notions from recent game theoretic approaches to explain the emergence of institutions, a model is put forward which implies some generalizations and extensions. First, the evolution of institutions is interpreted as a diffusion process. This interpretation provides a general formal framework to cover both, the case of strategic and that of non-strategic interaction. Second, different forms of interdependency effects between the individuals involved are identified as making the crucial difference between the case where institutions emerge spontaneously in an unorganized form and the case where they do not.

## 1. Introduction

The focus of the present paper is on general, abstract regularities in the evolution of socioeconomic institutions. In its orientation, the paper follows recent contributions by Taylor (1976), Ullmann-Margalit (1978), Thompson and Faith (1981), Schotter (1981, 1986) that have been inspired by game theory. Although they differ in method, these recent contributions all follow more or less explicitly the tradition of what will be labeled here the *Smith-Menger-Hayek conjecture* of a 'spontaneous', i.e., unintended and unplanned, emergence of institutions. Adam Smith's notion of the "invisible hand" and Adam Ferguson's conjecture that institutions are "the result of human action but not of human design" express the basic idea. It has been restated independently by Menger (1883) and, more recently, has been extensively elaborated by Hayek (e.g. 1967, for a survey see Vanberg, 1986).

In what follows, an attempt is made to generalize the recent, game-theory-oriented debate in two directions. First, the theoretical background is extended so that cases where there is no strategic interaction at the basis of socioeconomic institutions can also be covered. This is achieved by interpreting the evolution as a diffusion process. It turns out that, in this process, the crucial, general regularies are interdependency effects between the decisions of the individuals involved. They take on systematically varying forms for different institutions.

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Second, on this basis an effort is made to subsume what may be labeled the *Olson-Buchanan-Tullock conjecture* on the emergence of institutions. According to this, certain institutions cannot be expected to emerge in the way assumed by the alternative conjecture: the interests pursued by the individuals involved do not necessarily lead them to 'spontaneously' create or support an institution. In this case, for the institution to actually emerge, some kind of collective action would be required. The basic idea has been outlined in the influential book of Olson (1965) and it also figures prominently in the Virginia School of economic thought (see, e.g., Buchanan 1965 and 1975; Tullock 1974).

The paper proceeds as follows. In Section 2 the propagation of an institution is modeled on the basis of some simple assumptions and the notion of the frequency-dependency effect is explained. Section 3 discusses the case of 'spontaneous' emergence of institutions where strategic interaction is absent. In Section 4, situations with strategic interaction are shown to be special cases of the suggested model. Section 5 is devoted to discussing the class of institutions whose propagation requires special forms of collective action. In the concluding section the results are used for a straightforward interpretation of institutional change.

## 2. Propagation of institutions and the frequency-dependency effect

The approach chosen in this paper is individualistic, that is, an attempt is made to reconstruct the theory of institutions from decision-making or, more generally, behavior at the level of the individual agent. Since the approach is intended as a general one, including both situations in which institutions result from strategic interaction and those where the individuals involved do not notice that their own decisions affect those of others, institutions are broadly defined as follows.

> *Definition*: An institution is a unique behavioral regularity spread out among individuals or a pattern of diverse, but coinciding, possibly even mutually dependent, behavioral regularities. It is displayed whenever the involved individuals are faced with the same constituent situation of choice.

Under this definition, many different forms of institutions can be imagined: those in the realm of markets (division of labor, exchange, use of money, and more specific organizational forms such as e.g., department stores, supermarkets etc.); those in the realm of non-market behavior (e.g., rules and mores, education, family conduct, hierarchical division of labor as in corporations, etc.); or those based on explicit agreements and regulations (e.g., interaction rules, traffic regulation, laws, standing orders, etc.). In any case, the fact that the regularities may be more or less spread out in a population of individuals (or of groups of interacting individuals) points to a crucial feature of institutions, their varying degree of propagation or relative frequency of adoption. For expository convenience assume that the decision to adopt (a) or not to adopt (n) is fully informed with respect to what kind of behavior is required, be it a unique and independent regularity or one that has, in a division of activities, to contribute to a pattern of coinciding regularities. The respective behavior may be adopted by none, some, or all of the involved individuals. Accordingly, if F(a) indicates the relative frequency of adoption, the propagation of an institution can be measured by F(a) on the unit interval.

The emergence and propagation of institutions are interpreted in this paper similarly to those of ordinary behavioral innovations, possibly ones that require coincident innovations on the part of other individuals. Since the focus is on the propagation rather than on the emergence of novelty, let us assume that the idea of a new behavioral regularity, the nucleus of a new institution, has somehow emerged. Its actual propagation depends, then, first on the particular communication processes by which the knowledge of the new form of behavior (new option of choice) is diffused throughout the population. Second, it depends on whether the new option is in fact chosen, i.e., the regularity is individually adopted (the institution supported, complied to etc.).

The first process may be a spontaneous, unguided diffusion along established communication networks between the individuals, or it may result from the activities of one or more "diffusion agents" (Brown, 1981) who, for self-interested motives, try to convince the potential adopters of the benefits of adopting the respective regularity. An obvious difference between the two cases is that, in the former, in contrast to the latter, the decisions on the part of potential adopters can be viewed as independent in the sense that no suasion, negotiations, or organizational measures take place. Let us start here by assuming the former situation (the 'independent' choice; we will come back to the latter in Section 5).

With respect to the question of whether the new behavioral regularity is actually adopted or not, an individualistic approach suggests to assume that an individual is more likely to decide in favor of the new option (rather than not conforming) the more he can expect to improve his position by doing so, given his current preferences, his perception of the choice set, and, where relevant, his assessment of the extent to what others contribute/comply to. More precisely:

*Assumption 1*: The individual probability of adopting a new behavioral regularity f(a) is the larger, the larger the individual net benefit from choosing a rather than n is assessed provided the net benefit is positive; otherwise $f(a) = 0$.

This hypothesis can be considered as a statistical reformulation of the standard (deterministic) opportunity cost theory according to which individuals always choose the best available alternative, no matter how much better it is compared to the next best alternative(s). A second hypothesis, crucial for the argument in this paper is:

> *Assumption 2*: The extent to which an individual is able to improve his position by adopting a behavioral regularity depends on the relative frequency F(a) with which other individuals in the population have already adopted (or in certain cases can be expected to adopt) the respective regularity or regularities.

This assumption is quite evidently satisfied wherever there are interdependencies among decision-makers.[1] Obviously, this is the case where the individuals have to contribute to a pattern of coinciding, mutually dependent behavioral regularities in order to successfully establish the institution. But even where a division of activities is not required, where, in fact, purely stereotypic behavior is concerned, there seem to be reasons why frequency-dependency may matter. For instance, whether a business man opens the first or the tenth supermarket in a small town makes a difference to the benefits he receives; but joining a production cooperative may be more beneficial if it has already a significant number of members. Furthermore, adopting *new* modes of behavior, i.e., behavior that deviates from previously established forms, may, as such, induce disapproving or even hostile (sometimes possibly also sympathetic) reactions from the environment. These reactions tend to fade away the more common the new mode becomes, that is, the more frequently it is adopted by the population.

If, for expository convenience, agents are assumed to behave identically, the probability f(a) of adopting a new behavioral regularity thus depends for each individual on the extent to what the respective regularity (or the pattern of regularities) is already represented in the population, i.e., on F(a). Written as a function:

$$f(a) = \phi\,[F(a)]. \tag{2.1}$$

For the population as a whole, however, each individual decision in favor of option a changes the composition of adopters and non-adopters. Since the outcome of each individual decision is assumed to be f(a) we have

$$\Delta F(a) = \psi\,(f(a) - F(a)) \tag{2.2}$$

where $\Delta F(a)$ is the change of the composition of adopters and non-adopters in the population and $\psi$ some monotonous, sign-preserving function such that the change of the composition is a function of the composition itself.

## 3. Frequency-dependency under non-strategic behavior

The assumptions in the previous section imply that the propagation of an institution is governed by the utility or the benefits to the potential adopters from taking on the constituent behavioral regularities. The utility has been argued to depend on the relative frequency of adopters in the population. It will now be shown that the kind of dependency may vary strongly between institutions so that they differ systematically with respect to the way and the extent to which they propagate. The exposition starts with the more easily handled situation where the agents do not strategically interact.

Assumptions 1 and 2 together imply the adoption function (2.1). Since, by the first assumption, f(a) monotonically varies with the individual net benefit from choosing a over n, various cases can be plausibly imagined as characterized by the following alternative assumptions:

*Assumption 3a*: $\phi$ [F(a)] $>$ 0 for F(a) $=$ 0 and in the entire interval [0,1]
(i) $\phi' > 0$, or
(ii) $\phi' < 0$, or
(iii) $\phi' = 0$.

*Assumption 3b*: $\phi$ [F(a)] $=$ 0 for F(a) $=$ 0 and $0 \leq \phi' < 1$ in the neighborhood of F(a) $=$ 0 such that the graph of $\phi$ [F(a)]
(iv) remains below the 45°-line in the interval [0,1] or
(v) intersects the 45°-line from below at a point F**, $0 < F^{**} \leq 1$.

The different cases can be illustrated by diagrams in which the graph of (2.1) is depicted for the different specifications such as in Figures 1–3. For expository convenience let us assume that the composition of the population changes continuously so that (2.2) becomes dF(a)/dt $=$ f(a) $-$ F(a). Figures 1–3 can then be interpreted analogously to the phase diagram of this first-order differential equation. Accordingly, all points on the 45°-line represent situations in which, in the mean, the prevailing relative frequency F(a) is just maintained by the individual decision, i.e., propagation equilibria F* of an institution. At all points on a graph above (below) the 45°-line the individual adoption probability is greater (smaller) than the already existing relative frequency of a, so that the latter in the mean increases (decreases) by the individual's decision. These tendencies are indicated by arrows on the graphs that have been depicted for exemplary purposes in the diagrams.

Consider Figure 1, where case (i) is exemplified. Adopting the behavioral regularity yields a net benefit to everybody from the very beginning. The further the institution propagates the more attractive it becomes, e.g., because of increasing reputation or some positive scale effects. As an example for this

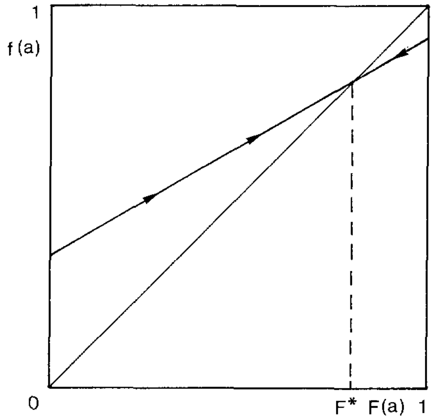


*Figure 1.* Propagation of an institution in case (i).

case, think of education or the use of some particular exchange medium (money). Depending on the absolute magnitudes the behavior constituent for the institution is, as shown in the figure, not necessarily adopted by the entire population. It is possible that a share 1-F* of the individuals finds alternative n more attractive after a share F* of the population has already chosen a. For instance, education might be a case in point. A differentiation of the educational system would have to be expected.

In Figure 2, representing case (ii), the net benefits develop differently in the propagation process: they steadily decline from an initially high value so that the individual probability of adoption is decreasing the more adopters there are already. Many market institutions seem to fall under this case as increasing adoption may mean increasing competition if the population is made up of the individuals on one side of the market. Department stores (on the supply side) or joint stock companies (on the demand side of the capital market) may be given as examples. The implication is, in general, only a partial propagation of the institution. The same holds true for the limiting case (iii) which is not depicted here. Taken together we obtain:

> *Proposition 1*: Given the cases of assumption 3a, an institution spontaneously propagates without any measures being taken and establishes itself in the population in the sense that any random deviation from F* resulting, e.g., from fluctuations in the population will be compensated for, i.e. $F^* \leq 1$ is a stable propagation equilibrium.

Now consider Figure 3 where a dotted graph is depicted for case (iv). The individual net benefit from adoption would still be increasing with the number of adopters but $\phi$ [F(a)] < F(a) for all F(a) > 0. The obvious consequence is

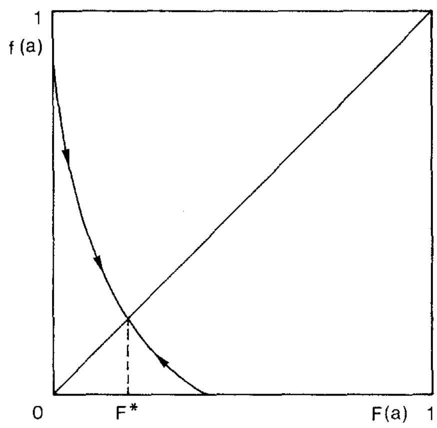


*Figure 2.* Propagation of an institution in case (ii).

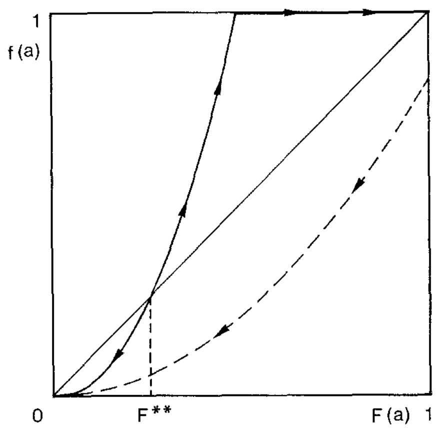


*Figure 3.* Propagation of an institution in case (iv) and (v).

that such an institution cannot gain a foothold in the population. By contrast, the solid curve, representing case (v), shows values of $\phi$ [F(a)] > F(a) for all F(a) > F**, F** therefore indicates a 'critical mass' or critical relative frequency: once F(a) happens to exceed F** it will propagate completely. (If the function is bounded from above such that it intersects the 45°-line at some F*, F** < F* < 1, from above, the relative frequency may also settle at an equilibrium level smaller than 1.)[2]

Clearly differing from the cases (i)–(iii) we now find:

*Proposition 2*: Given the cases of assumption 3b an institution will not spontaneously propagate unless the critical frequency F** is somehow exceeded. F** is an unstable propagation equilibrium which is not restored once F(a) deviates because of fluctuations in the population. The direction of deviation determines whether the institution will be established at a stable equilibrium $F^* \leq 1$ or will not gain a foothold at all.

## 4. Frequency-dependency under strategic behavior

Where an institution is constituted by the adoption of a pattern of coinciding, possibly mutually dependent, but divers behavioral regularities on the part of a group of agents, as in cases where a division of activities is required, it is most likely that the potential adopters strategically interact. Situations in which individuals decide on whether or not to adopt a behavioral regularity in view of the possible choices of the other individuals in the population are slightly more complicated. With some simplifications, it is not difficult to show, however, that systematically differing types of institutions as characterized by the various cases in the previous section are implied here, too. Consider a population of m agents involved in the m-person non-zero sum game

$$\Gamma = \{ (1, \ldots, i, \ldots, m), (S_1, \ldots, S_i, \ldots, S_m), (\Pi_1, \ldots, \Pi_i, \ldots, \Pi_m) \} \quad (4.1)$$

in which agent i has a strategy set

$$S_i = \{a, n\}, \; i = 1, \ldots, m, \quad (4.2)$$

and his pay-off, if he chooses strategy $s_i \in \{a, n\}$, is

$$\Pi_i = \Pi_i \{s_1, \ldots, s_i, \ldots, s_m). \quad (4.3)$$

As a simplification underlying the following considerations assume (4.3) is identical for all $i = 1, \ldots, m$, that is, $\Gamma$ is a symmetrical game. For any two agents i and j in the population, $i \neq j$, the game situation can then partially be represented in normal form by the $2 \times 2$ matrix

| | | j: a | j: n |
|---|---|---|---|
| i | a | Π(a, a)<br>Π(a, a) | Π(a, n)<br>Π(a, n) |
| | n | Π(n, a)<br>Π(n, a) | Π(n, n)<br>Π(n, n) |

Assuming random pairing for expository convenience, the expected pay-offs of the two strategies a (adopting the behavioral regularity constituent for the institution) and n (not adopting) are conditional on the relative frequency with which the strategies will elsewhere be adopted in the population:

$$E\,[\Pi_i\,(s_i = a \mid F(a))] = F(a)\,\Pi(a, a) + [1-F(a)]\,\Pi(a, n) \tag{4.4}$$

and

$$E\,[\Pi_i\,(s_i = n \mid F(a))] = F(a)\,\Pi(n, a) + [1-F(a)]\,\Pi(n,n). \tag{4.5}$$

Analogously to assumption 1, agent i is supposed the more likely to decide in favor of strategy a the higher the (positive) net benefit from choosing a rather than n. Hence the difference between (4.4) and (4.5) can be used as a criterion function that determines the individual probability of adoption f(a). Setting $\Pi_i(a, a) - \Pi_i(n, a) = D_a$ and $\Pi_i(a, n) - \Pi_i(n, n) = D_n$ we obtain:

$$f(a)\ \begin{cases} = \min\,[D_n + (D_a - D_n)\,F(a),\ 1] & \text{as long as } f(a) > 0, \\ = 0 & \text{otherwise.} \end{cases} \tag{4.6}$$

This is a special, piecewise linear form of (2.1).

On the basis of (4.6) we are now in the position to investigate the propagation of a certain strategy in symmetrical m-person games as a special case of the propagation of an institution. The analysis is similar to recent adaptations of game theory to the context of biology (see Maynard Smith, 1982, for an introduction) though the interpretation differs. In fact, for the symmetrical situation chosen here, any stable propagation equilibrium $F^* > 0$ represents what is labeled an evolutionary stable strategy (see Maynard Smith, 1982: 10–20; and Selten, 1983, for the latter) in pure strategies in the context of biological game theory.

In order to substantiate the above claim that institutions show similar differences with respect to their propagation conditions under non-strategic as well as strategic behavior let us now briefly review some numerical examples of well-known prototype games (see Ullmann-Margalit, 1978; Schotter, 1981, or the elementary text by Hamburger, 1979, for the taxonomy of games). Inserting the specification of the *convergence game* illustrated below (strategy a may, e.g., be product innovation, strategy n no product innovation) into (4.6)[3] yields the graph in Figure 4 and, thus, in almost trivial form, a stable propagation equilibrium $F^* = 1$ corresponding to the unique equilibrium in the underlying game.

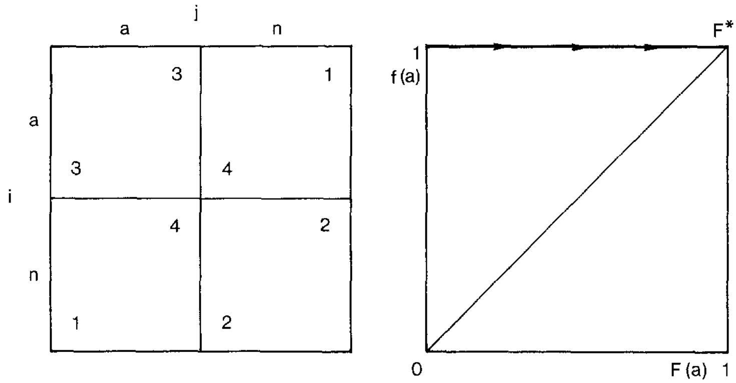


*Figure 4.* Pay-offs and propagation function for the convergence game.

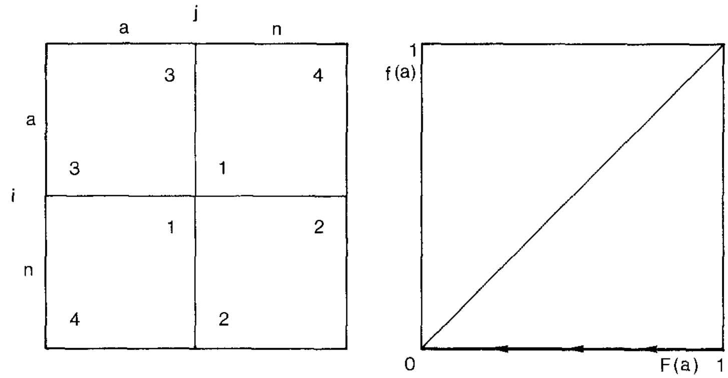


*Figure 5.* Pay-offs and propagation function for prisoners' dilemma game.

The *prisoners' dilemma game* with strategies a: cooperate, n: not cooperate, is represented in Figure 5 which exemplifies that, as expected, the cooperative strategy a cannot propagate in the population. Again, the equilibrium of the underlying game obtains in trivial form. For both games, covering case (iii) in the previous section, the frequency-dependency does not play a role.

More interesting insights can be gained from investigating games with less clear-cut equilibrium features as, for example, the '*chicken*' *game* (Figure 6) where strategy a might mean following some new form of honest trade convention as opposed to keeping to an established but somewhat corrupted form n. The game has two equilibria in pure strategies off the principal diagonal. As can easily be reconstructed, the propagation function $f(a) = 1 - 2F(a)$ intersects the 45°-line at a stable propagation equilibrium $F^*$, $0 < F^* < .5$, a situation similar to case (ii) in the previous section.

The '*pure*' *coordination game* where a may represent some set of conven-

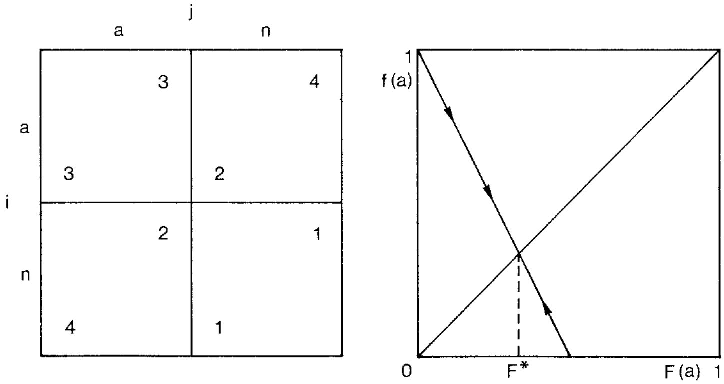


*Figure 6.* Pay-offs and propagation function for the 'chicken' game.

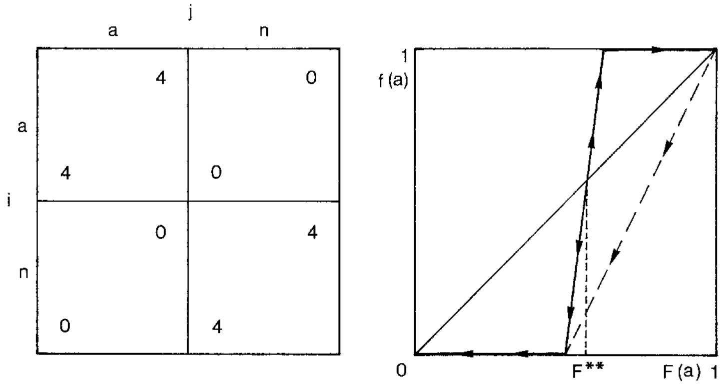


*Figure 7.* Pay-offs and propagation function for the pure coordination game.

tions (weights and measures, language, manners, traffic, etc.) and n another has no dominant strategies but two equilibria in pure strategies. The corresponding propagation function $f(a) = -4 + 8F(a)$ yields a positive branch which intersects the 45°-line from below in an unstable propagation equilibrium $F^{**}$, a critical frequency point, as depicted in Figure 7. Two stable equilibria situations prevail in $F(a) = 0$ and the stable propagation equilibrium $F^* = 1$. Note that the numerical specification is crucial for the existence of the critical frequency phenomenon. If 1 is inserted instead of 4, the propagation function remains below the 45°-line except in the unstable equilibrium point at $F(a) = 1$ (the dotted graph in Figure 7). This means that convention a cannot gain a foothold. With its varying specification, the game provides a piecewise linear analog to the cases (iv) and (v) discussed in the previous section.

As demonstrated, in the propagation of institutions under conditions of strategic interaction, two different modes can be distinguished analogously to the propositions 1 and 2 in Section 3: institutions may spontaneously establish themselves without further preconditions or they may do so only if it happens that a critical adoption frequency is somehow exceeded.

## 5. Agents of collective action and the propagation of institutions

The preceding discussions showed that the relationships between individual utility or benefits and the relative adoption frequency of an institution imply differing propagation patterns. Put into the perspective of the long-standing debate on how institutions emerge, this result has some interesting implications. As is well known, in this debate there are two competing positions. On one side, the *Smith-Menger-Hayek conjecture* of a spontaneous emergence of institutions holds that they are "the result of human action but not of human design". On the other side, it has traditionally been maintained, in particular in sociology and law theory, that institutions are a kind of created, shaped structure or corpus. Individuals are seen as joining in order to constitute an institution in a purposeful, organized action. As Vanberg (1983) has nicely pointed out, this interpretation becomes, in a specific economic and somewhat pessimistic blending, what might be labeled the *Olson-Buchanan-Tullock conjecture* underlying the theory of collective action.

The considerations in the previous sections indicate that the two forms of institutional evolution may be complementary, each occurring under different conditions. In fact, the *Smith-Menger-Hayek conjecture* seems perfectly covered by the cases in assumption 3a as summarized in proposition 1, and some examples used above have already been mentioned by Menger (1883) as cases in point. In this section it remains to be explained how the cases in assumption 3b and their properties as given in proposition 2 are indeed dependent on collective action and to which extent the rather pessimistic *Olson-Buchanan-Tullock conjecture*, which predicts an insufficient development of such institutions, applies.

The last sections have offered little which can explain the actual process of how institutions come about under the conditions of assumption 3b. From the graphs of the propagation functions in the Figures 3 and 7 it is clear, however, that it would be advantageous to all or most of the agents in the population if they adopted the new institution once the critical frequency F** is exceeded, an advantage that would induce them to support and maintain the institution in their own interest. (In the game version, this is equivalent to saying that the propagation equilibrium F* is an equilibrium point of the game from which nobody has an incentive to deviate.) Up to that point there is, however, a problem. For a new institution to be successful, it has first to reach F**, despite the fact that, up to this point, self-interest dictates that the new institution should not be adopted or supported. How is this problem overcome?

The answer suggested here is simple: by a special form of collective action being organized. The outlook for future self-reinforcement may attract organizers, leaders, agitators, moralists, intriguers, political entrepreneurs, in short agents who, for the most diverse motives, specialize in eliciting and arousing interest, producing agreements, and arranging alliances. They operate as "diffusion agents", engaged in the propagation of a new institution which, in effect, means doing away with the independence and isolation of the individual adoption decision (which has so far been assumed, see Section 2). All that these agents have to achieve is to induce a sufficient number of other agents to expect that collective adoption will come about, so that the expectation becomes self-fulfilling: just a little more than the critical mass.

Unlike those institutions covered by the *Smith-Menger-Hayek conjecture*, organized, intentional pursuit of a collective action by at least some agents is thus a prerequisite for an institution of the second kind to be established. If this is true, it seems straightforward, of course, to apply the *Olson-Buchanan-Tullock conjecture* to this kind of collective action. This is to argue that, at least in large populations, such an action does not (sufficiently) occur, since it requires the agents of collective action to provide a public good. Since the path-breaking book by Olson (1965), this is a corner-stone in the theory of collective action (for a more recent summary see Hardin, 1982). And, indeed, although the agents of collective action in the present context intervene only for the limited transition phase, and although it is not unlikely that their individual motives for acting are less oriented to material cost/benefit considerations than in Olson's examples, the validity of his argument cannot wholly be denied.

Once F** is exceeded, all agents may profit without incurring the costs of attaining this. Free-riding is possible and, if the costs are substantial, there may be no or not enough agents of collective action who are willing to provide the public good of organizing the transition. Confirming Olson's original thesis, this is more likely to happen in large populations if the costs of organizing increase with the number of agents. In larger populations it is then more 'expensive' to reach F** than in smaller ones, as the absolute number of agents who have to be convinced is greater. Increasing costs may, *ceteris paribus*, curb the individual willingness to act as agent of collective action.

What is not entirely clear is the question of how the costs and benefits of the various agents are actually structured in the situation before F** is reached (i.e., in a situation supposed to require the provision of a public good). It may be argued that, even in large groups, it is, in fact, best described as a 'chicken game' (see Fogarty, 1981; Lipnowski and Maital, 1983) with strategies engage (a) or not engage (n) as has been discussed in the previous section. In that case, there may be fewer agents of collective action than desirable, but – viewed as an evolving institution itself – it can be concluded from the example of Figure 6 that a significant number of them may appear: a stable propagation equilibrium may exist, which implies that in a population of potential agents of collective action, a positive share of them will in fact adopt the attitude and help in establishing institutions of the second kind.

Even under the *Olson-Buchanan-Tullock conjecture*, institutions involving some kind of organizational initiative can thus under certain conditions be expected to emerge. In a broader sense their evolution may as well be interpreted as a spontaneous one, since it depends on some individuals adopting the role of an agent of collective action which is itself a behavioral regularity of the first kind. Looking at the game-theoretic background of the institutions subsumed here under the second category, it becomes clear, however, that they consist basically of the class of coordination games (games with multiple equilibria in pure strategies in the principal diagonal of the pay-off matrix). Examples that are often given are all sorts of conventions, statutes, traffic regulations, standing orders, language rules, manners etc.

Not included are all those institutions that require a cooperative solution in a prisoners' dilemma game. This is a very large class which, certainly, is of utmost importance in the framework of the theory of collective action (see, e.g., Nabli and Nugent, 1989). Unfortunately, it is not as easily accessible with the frequency-dependency approach suggested above as the other cases that have been discussed. As shown in Figure 5, there is no critical frequency involved in the p.d.-game that would leave room for an immediate intervention of agents of collective action. The shape of the propagation function flatly turns down any hope of success, given the original pay-offs. Nevertheless, many such institutions can be empirically observed to exist. Any explanation for this (based on the assumption of individually rational behavior), it appears, has to include hypotheses that, in effect, transform the pay-off structure to make the dilemma vanish.

In this way, some more differentiated activities on the part of agents of collective action must be assumed. Imagine, e.g., an attempt is made, in a first step, to propagate retaliatory measures in case that, in a prisoners' dilemma, somebody offering cooperation has been cheated. If the attempt were successful, retaliation would reduce the offender's temptation pay-off. But, the costs of retaliatory action would have to be incurred by the victim reducing the sucker's pay-off still further compared to the original game. If the original (partial) pay-off matrix (Figure 5) were thus changed as follows:

| | |
|---|---|
| $\Pi(a, a) = 3$ <br> $\Pi(a, a) = 3$ | $\Pi(a, n) = 1$ <br> $\Pi(a, n) = 0$ |
| $\Pi(n, a) = 0$ <br> $\Pi(n, a) = 1$ | $\Pi(n, n) = 2$ <br> $\Pi(n, n) = 2$ |

agitation would have transformed the p.d.-game into a coordination game with a propagation function similar to the solid line in Figure 7. A critical frequency $F^{**}$, $0 < F^{**} < 1$, would occur that allowed room for organizing collective action in the sense above discussed.

Unfortunately, however, the attempt to overcome the prisoners' dilemma by convincing the people of the necessity of retaliatory action may itself induce a prisoners' dilemma and, thus, simply a regress. Chances for arriving at the above coordination game when starting from a p.d.-game seem bad, unless recourse to additional arguments can be made. It has been argued elsewhere that possibly genetically caused variance in individual preferences together with social learning (which is itself frequency-dependent) may ensure the transformation (Witt, 1986). Another, historical, conjecture might be that agents in command of measures of coercion that have otherwise come into existence tend to assume the role of agents of collective action. Since they often are able to extend the measures to new areas, they may be able to punish free-riding and thus to transform a prisoners' dilemma situation into a pure coordination game.

## 6. Conclusions: Regularities in institutional change

By interpreting the evolution of institutions as a diffusion process in which frequency dependency effects govern the adoption patterns, some characteristic differences between institutions emerging according to the *Smith-Menger-Hayek conjecture* and those resulting from collective action along the lines of the *Olson-Buchanan-Tullock conjecture* have been outlined. The discussion can easily be extended to explain regularities in institutional change. The propagation of an institution often not only means adopting or not adopting a new behavior but at the same time may imply turning away or not turning away from a previous behavioral regularity. Where this happens, an established institution n is declining according to the relation $F(a) = 1 - F(n)$ to the extent that a new institution a is propagating.

Decline, break-down, death of institutions is an almost trivial historical experience. (In fact, explaining the viability of larger economic systems may be an intricate theoretical problem; see Day, 1987.) The exposition above suggests the following: If new institutions spontaneously propagate according to case (ii) there will always be institutional pluralism (in biology this is called polymorphism). The established institution finds a niche for survival. In the cases (i), (iii), and (v) the extent to which this is possible depends on the numerical values. If, as in Figure 3 (solid curve), the critical mass phenomenon is associated with stable situations $F^* = 0$ or 1, the two institutions are mutually exclusive. A dramatic supersession can be expected to take place once the agents of collective action succeed in inducing slightly more than the critical mass to adopt the new institution.

Besides such dramatic forms of change there are, of course, the various possibilities for a creeping decline in which institutions prevailing in former times may be driven out of the population as a consequence of slow shifts in the parameter values. As a consequence of changing relative prices, redistributions, technical progress, but also of changing tastes and changing attention, the propagation functions may shift in such a way that niches for the old institutions are eliminated. As far as the cases (iv) and (v) are concerned, some of the activity of agents of collective action may indeed aim at redirecting attention, providing the 'right' information, and shaping tastes in such a way that the situation (iv) is gradually shifted into a situation (v). The dotted curve in Figure 3 then rotates upwards and F** moves to the left until the costs of convincing the critical mass are sufficiently low and F** can be passed.

The present paper has exclusively focussed on propagation processes. A theory of evolution is somewhat incomplete, however, without also considering the process of emergence of novelty. Where the ideas for possible new behavioral regularities come from, how they are selected, and who will be motivated to try them where – as a novelty – their implications cannot fully be anticipated is left open here. Needless to say, these questions may be of considerable importance in providing a full understanding of the regularities of institutional change as such change involves more than the adaptation process modeled above.[4] Future research should thus also focus on answering these additional questions.

## Notes

1. Such interdependencies can be more generally expected than they are in economics, particularly in price theory, where they are usually interpreted as being perfectly mediated by the market, i.e., prices (except in the case of 'true', i.e., non-pecuniary, externalities). Note that the outcome of individual interactions is no longer determined by the individual choices alone if there are interdependencies. The assertion that "the whole (i.e., aggregate behavior) is more than the sum of its parts" has something to it as the particular form and the sequence of interactions in historical time may shape the choices of the individuals in different ways.
2. Critical mass models have recently been given attention in various areas of economics, e.g., in the context of speculation about other individuals' behavior (Schelling, 1978), of the development of technical regimes (David, 1987), of interdependencies in consumption behavior (Granovetter and Soong, 1986), of solutions to the prisoners' dilemma by collective learning (Witt, 1986), of the stabilization of conservative attitudes against revolutionary ones (Kuran, 1987).
3. In principle, the pay-offs may be interpreted as utility indices in the usual way. In order to determine (4.6) numerically, they are, however, treated here like cardinal values. Note that the position and shape of the resulting propagation functions may change with the numerical specification of the pay-offs.

4. A discussion of the questions requires extensions at the foundations of economic theory and, thus, goes far beyond the present paper. The interested reader may be referred to Witt (1987) and (1989).

## References

Brown, L.A. (1981). *Innovations-diffusion – A new perspective.* London: Methuen.

Buchanan, J.M. (1965). Ethical rules, expected values, and large numbers. *Ethics* 76: 1–13.

Buchanan, J.M. (1975). *The limits of liberty.* Chicago: Chicago University Press.

David, P. (1987). Some new standards for the economics of standardization in the information age. In P. Dasgupta and P.L. Stoneman (Eds.), *Economic policy and technological performance.* London: Cambridge University Press.

Day, R.H. (1987). The evolving economy. *European Journal of Operations Research* 30: 251–257.

Fogarty, T.M. (1981). Prisoner's dilemma and other public good games. *Conflict Management and Piece Science* 5: 111–120.

Granovetter, M., and Soong, R. (1986). Threshold models of interpersonal effects in consumer demand. *Journal of Economic Behavior and Organization* 7: 83–99.

Hamburger, H. (1979). *Games as models of social phenomena.* San Francisco: Freeman.

Hardin, R. (1982). *Collective action.* Washington: Resources for the Future.

Hayek, F.A. (1967). Notes on the evolution of systems of rules and conduct. In F.A. Hayek, *Studies in philosophy, politics, and economics,* 66–81. London: Kegan Paul.

Kuran, T. (1987). Preference falsification, policy continuity, and collective conservatism. *Economic Journal* 97: 642–665.

Lipnowski, I., and Maital, S. (1983). Voluntary provision of pure public good as the game of 'chicken'. *Journal of Public Economics* 20: 381–386.

Maynard Smith, J. (1982). *Evolution and the theory of games.* Cambridge: Cambridge University Press.

Menger, C. (1883). *Untersuchungen über die Methode der Sozialwissenschaften und der politischen Ökonomie insbesondere.* Wien: Braumüller.

Nabli, M.K., and Nugent, J.B. (1989). *The new institutional economics and development: Theory and applications to Tunisia.* Amsterdam: North-Holland, forthcoming.

Olson, M. (1965). *The logic of collective action.* Harvard: Harvard University Press.

Schelling, T. (1978). *Micromotives and macrobehavior.* New York: Norton.

Schotter, A. (1981). *The economic theory of social institutions.* Cambridge: Cambridge University Press.

Schotter, A. (1986). The evolution of rules. In R. Langlois (Ed.), *Economics as a process,* 117–133. Cambridge: Cambridge University Press.

Selten, R. (1983). Evolutionary stability in extensive two-person games. *Mathematical Social Sciences* 5: 269–363.

Taylor, M. (1976). *Anarchy and cooperation.* London: Wiley.

Thompson, E.A., and Faith, R.L. (1981). A pure theory of strategic behavior and social institutions. *American Economic Review* 71: 366–380.

Tullock, G. (1974). *The social dilemma.* Blacksburg: Center for the Study of Public Choice.

Ullmann-Margalit, E. (1978). *The emergence of norms.* New York: Oxford University Press.

Vanberg, V. (1983). Der individualistische Ansatz zu einer Theorie der Entstehung und Entwicklung von Institutionen. *Jahrbuch für Neue Politische Ökonomie* 2: 50–69.

Vanberg, V. (1986). Spontaneous market order and social rules. *Economics and Philosophy* 2: 75–100.

Witt, U. (1986). Evolution and stability of cooperation without enforceable contracts. *Kyklos* 39: 245–266.

Witt, U. (1987). How transaction rights are shaped to channel innovativeness. *Journal of Institutional and Theoretical Economics* 143: 180–195.

Witt, U. (1989). *Individualistic foundations of evolutionary economics*. Cambridge: Cambridge University Press, forthcoming.