Civilization and the Evolution of Short-Sighted Agents

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Abstract:

Are individuals within modern societies more short-sighted than in previous generations? If so, what are the plausible changes in the environment and composition of society that could yield such a result?

The model begins by assuming the population consists of two types (phenotypes) of individuals, (short-sighted/aggressive and foresighted/docile). These phenotypes interact with each other. These interactions provide payoffs to each type of individual. These payoffs measure evolutionary fitness. Evolutionary fitness determines whether a certain phenotype (or proportion of phenotype) will prevail. We propose to find the conditions under which the short sighted phenotype will be an evolutionary stable strategy, i.e. prevail. We model interactions as an “assurance” game to illustrate possible equilibria and steady-states with and without random shocks to the available resources. The model will then address the plausibility of conditions that could lead to the various equilibria.

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Introduction

Theories abound to explain the rise and fall of civilizations. This paper delves into the roles of cooperation and foresight in the evolution of societies. Modern, “successful” civilizations tend to adopt institutions or mechanisms to promote cooperation and also generally lead to greater longevity and perceived well-being. We postulate that long-run progress for a society depends on its members’ ability both to cooperate and to select actions that are consistent with the goal of maintaining the sustainability of resources over the long-run. We model behavior using a simple “assurance” game to illustrate that in the long-run, short-sighted and foresighted individuals will not coexist. Moreover, whether a society ultimately succeeds or fails depends critically on the initial proportion of types in the population. This further suggests that the impact of migration between or merging of societies can fundamentally alter their chances of success, and finally, increasing available resources or creating new technologies that do not alter a population’s foresight may not influence its overall success.

The Model

We model foresight and shortsightedness in the context of a “stag hunt” game. The stag hunt game is a somewhat fanciful name used to describe the general class of “assurance” games. Our choice stems from the interpretation of an assurance game as representative of a societal dilemma described in Rousseau’s *A Discourse on Inequality* (Poundstone, 1992, pp.218-221). Maurice Cranston’s (1984) translation describes the stag hunt dilemma in the following way:

“If it was a matter of hunting a deer, everyone well realized that he must remain faithfully at his post; but if a hare happened to pass within the reach of one of them, we cannot doubt that he would have gone off in pursuit of it without scruple and, having caught his own prey, he would have cared very little about having caused his companions to lose theirs.”

2 Read stag for deer in the translated excerpt.
A stag, the hunt for which requires intensive cooperation, can feed the entire village. Going after the hare would feed the individual. Thus an assurance game may be used to understand the nature of cooperation in society. Cooperation provides a way to understand delayed gratification. Hunting a stag requires time and cooperation but can feed the entire society. Going after the hare can feed the individual now.

We therefore model two kinds of people. One group of people can resist the temptation of going after the hare – that is they always stick to the cooperative plan of hunting the stag. In other words, these people are capable of making long term decisions. We will refer to this type as “Always Stag” because they possess the foresight to cooperate in endeavors that require patience to achieve an efficient outcome. Another group of people show their impulsiveness by going after the hare. Thus, the people who go after the hare make short term decisions, and are referred to as “Always Hare.”

In keeping with the general approach used in evolutionary game theory we proceed with a limited view of rationality. That is to say our actors are allowed to make mistakes whatever their type. Moreover, some people may be unwilling or unable to make the socially optimal choice even if it has consequences for their survival. Hence we have a distinction between those who cannot make long term decisions and those who can. However people can and do learn to use a particular decision making style if it benefits them.

In our game there are two possible strategies that people can play. Those who make short term decisions choose Always Hare and those who make long term decisions choose Always Stag. A certain proportion $x$ of the population follows the Always Stag strategy while a proportion $1 - x$ follows the Always Hare strategy. Of course, actors playing each type of strategy interact with both other actors playing the same strategy or a different one. Keeping in mind the assurance game we can therefore specify the payoffs illustrated in Figure 1. We assume that outcomes stem from random pair-wise matching of players.
However, we further differentiate between players choosing the Always Stag strategy and Always Hare strategy. The Always Stag types are patient and therefore have a lower discount rate ($r_S$) than that ($r_H$) of the impatient Always Hare types. In other words the Always Stag types discount their future less heavily than the Always Hare types. Say further that there is some chance that a meteor will hit the earth (or some other environmental disaster) and all human interaction will cease with probability $(1-p)$. Thus, Always Stag types discount the future with a discount factor $\delta_S = \frac{p}{1+r_S}$ and Always Hare types discount the future with a discount factor $\delta_H = \frac{p}{1+r_H}$. Note that $\delta_S > \delta_H$. After accounting for the future stream of payoffs, the game illustrated in Figure 1 may be represented by Figure 2.

### Figure 2

<table>
<thead>
<tr>
<th>Player 1</th>
<th>Player 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Always Stag</td>
<td>3, 3</td>
<td>0, 2</td>
</tr>
<tr>
<td>Always Hare</td>
<td>2, 0</td>
<td>1, 1</td>
</tr>
<tr>
<td>3($\frac{1+r_S}{1+r_S-p}$), 3($\frac{1+r_S}{1+r_S-p}$)</td>
<td>0, 2($\frac{1+r_H}{1+r_H-p}$)</td>
<td>0, 2($\frac{1+r_H}{1+r_H-p}$)</td>
</tr>
<tr>
<td>2($\frac{1+r_H}{1+r_H-p}$), 0</td>
<td>1+$r_H$($\frac{1+r_H}{1+r_H-p}$)</td>
<td>1+$r_H$($\frac{1+r_H}{1+r_H-p}$)</td>
</tr>
</tbody>
</table>

**Equilibrium Strategy**

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3 To this point, we implicitly assume that the probability that life continues for another time period is the same for both groups, and is independent of the behavior of each type.
We are particularly interested in Social breakdown. Therefore we would like to investigate the conditions under which cooperation is unlikely even when the game is repeated. We note here that cooperation is plausible in a simple assurance game upon a straightforward application of the Folk Theorem. We, however, find that under more realistic bounded rationality assumptions this may not be the case. In other words, even with a future – infinite or with the potential to end with a probability \((1-p)\) – there may not be enough people cooperating. This lack of cooperation is likely to lead to social breakdown and therefore the fall of civilization since the fully cooperative outcome is optimal for society. In other words, our model shows that the success or failure of a civilization is an artifact of pure chance given the proportion of people with a long term planning horizon relative to a short term planning horizon.

*Theorem 1.* The Always Hare strategy is an evolutionary-stable strategy (ESS) only if 
\[
x < \frac{1}{3(1-\delta_S)^{-1}-1}^4
\]

This theorem suggests that social failure depends crucially on the initial proportion of people who play the Always Hare strategy. This in turn depends on the discount factor of people with a long term planning horizon relative to a short term planning horizon. The condition in Theorem 1 does provide some hope for the success of societies. Since \(\delta_S > \delta_H\) and both are bounded between zero and one, we can say that \(x\) is between zero and one-half. The bigger the difference in discount factors, the closer \(x\) will be to zero. In other words, in the long-run, societies where the future is heavily discounted by the short-sighted individuals need relatively fewer foresighted individuals in order to “succeed.”

The expected payoff to those with who play Always Hare is higher on average than those who play Always Stag under the conditions listed in Theorem 1. People who play Always Stag benefit only when there are other Always Stag players around. Thus, the expected payoff from Always Stag is higher than that of Always Hare if and only if the proportion of players playing Always Stag is relatively large.

Since there are no à priori reasons to believe that the proportion of one type of actor relative to the other in a civilization will be large or small the success or failure of a civilization may be determined by pure chance! However, given the gift of self awareness there is also no reason why those with the benefit of

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4 See Appendix A for the formal proof.
foresight will not act to increase their numbers in the population through extensive education programs that emphasize the benefit of civic engagement. One may argue that the role of public education in the US is designed for precisely this purpose. The failure of the public education system without any plausible alternate avenue for teaching civic engagement may then lead to dire consequences.

**Corollary 1.** There is no stable polymorphic ESS.

The expected payoff to both types of players monotonically increases with respect to the proportion of Always Stag players. If $x < \frac{1}{3(1-\delta_H)^{-1}}$ then the expected payoffs favor the “Always Hare” type, i.e., $E(AH) > E(AS)$. In this case the population will be taken over by the AH strategy players. This occurs because we further assume that population growth of each type is tied to their relative payoffs. If $x > \frac{1}{3(1-\delta_H)^{-1}}$ then $E(AH) < E(AS)$. In this case the population will be taken over by AS strategy players. Thus very small mutations of behavior around $x = \frac{1}{3(1-\delta_H)^{-1}}$ will move the population towards a monomorphic equilibrium at Always Hare or Always Stag depending on whether the mutation favors Always Hare or Always Stag. In other words an equilibrium where $x = \frac{1}{3(1-\delta_H)^{-1}}$ is not stable. Let $x^*$ denote the proportion corresponding to this unstable equilibrium.

This result has important policy ramifications. For example in a society where there is a large proportion of people with short planning horizons those with a cooperative bent will gradually change their behavior to the society’s detriment until the entire population has a short planning horizon.

**Areas for Expansion and Model Enrichment:**

The next step is to address the relative importance of external shocks to the system. The critical shocks will alter the proportion of types in society. This could occur due to migration or a random event. The sections above show that at any given point in time either (a) the proportion of foresighted individuals is
greater than \( x^* \) is moving toward long-run success, or (b) the proportion of foresighted individuals is less than \( x^* \) is moving toward long-run inefficiency (failure). In either case, the importance – of a shock – for society lies almost entirely in whether or not the proportion \( x \) shifts to the other side of \( x^* \). Such a shift would cause a succeeding society to unravel toward inefficiency or short-sighted behavior, or vice versa. The relative possibility of this will depend on the speed at which the prevailing type propagates. In the next phase, we will define the speed of the change in the population proportion and relate it to \( x \).
Appendix A

Proof of Theorem 1

Expected payoff from the Always Stag (AS) strategy is

\[ E(AS) = 3x \frac{1 + r_S}{1 + r_S - p} \]  \hspace{1cm} (A1)

and from Always Hare (AH) strategy is

\[ E(AH) = 2x \frac{1 + r_H}{1 + r_H - p} + (1 - x) \frac{1 + r_H}{1 + r_H - p}. \]  \hspace{1cm} (A2)

The AH and AS strategy provide the same expected payoff when \( E(AH) = E(AS) \) i.e.

\[ 2x \frac{1 + r_H}{1 + r_H - p} + (1 - x) \frac{1 + r_H}{1 + r_H - p} = 3x \frac{1 + r_S}{1 + r_S - p} \]

Or

\[ 3 \left( \frac{1 + r_S}{1 + r_H} \right) \left( \frac{1 + r_H - p}{1 + r_S - p} \right) = 1 + \frac{1}{x}. \]  \hspace{1cm} (A3)

Now we have defined \( \delta_S = \frac{p}{1 + r_S} \) and \( \delta_H = \frac{p}{1 + r_H} \). Thus

\[ \frac{1 + r_S}{1 + r_H} = \frac{\delta_H}{\delta_S} \]  \hspace{1cm} (A4)

And

\[ \frac{1 + r_H - p}{1 + r_S - p} = \frac{1 + \delta_H}{1 + \delta_S}. \]  \hspace{1cm} (A5)

Substituting (A4) and (A5) into (A3) gives us

\[ 3 \left( \frac{\delta_H}{\delta_S} \right) \left( \frac{1 + \delta_H}{1 + \delta_S} \right) = 1 + \frac{1}{x} \]

Or

\[ x = \frac{1}{3 \left( \frac{1 + \delta_H}{1 + \delta_S} \right)^{-1}}. \]  \hspace{1cm} (A6)

Thus for AH to be preferred over AS

\[ x < \frac{1}{3 \left( \frac{1 + \delta_H}{1 + \delta_S} \right)^{-1}}. \]  \hspace{1cm} (A7)
(Abbreviated) References:

