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The evolution of time horizons for economic develpoment

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The evolution of time horizons and economic development

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Abstract

Individually costly but group beneficial traits may nevertheless be selected when the group is socially segmented or when group competition constitutes a second selection force. However, this is not a general result as it depends on the form of group competition. In this paper, we will show that depending on the type of competition – one shot versus repeated competition – even individually beneficial traits may not survive in a multi-group population when there is substantial uncertainty as to the outcome of group encounters. Moreover, competition may more directly affect the benefits the adoption of a certain trait brings about as it affects the risk distribution of the payoffs. These theoretical considerations are discussed using the example of the emergence of financial markets. It shows the importance of a stationary stochastic environment for economic development and the possibility for increasing returns to market development. Furthermore, we discuss these considerations using historical examples.

Keywords : multiple selection processes, group competition, financial markets, economic development

JEL-Codes : C73, E11, G20, N10, N20

1. Introduction

Recent research in evolutionary economics has started to focus on between-group competition as a complementary evolutionary force to within-group competition. In this respect, a number of articles have shown that reduced within-group competition may favor group survival by selecting group-beneficial but individually costly traits (Bowles, 1999, 2001). Usually these models confront, however, special types of competition in within and between groups selection. In particular, only competition with a stationary risk distribution is considered.

This may be a crucial assumption for the results presented in these models when widening the kind of individual traits under consideration. First, recent advancements in industrial organization has studied the various forms of competition and its impact on strategies pursued by competing firms (Boone, 2000). Not all types of competition are characterized by a stationary risk distribution and not all of them lead necessarily to a Pareto-improvement as is implicitly assumed by these evolutionary models. In particular, the stationarity of the competition process is an important factor in shaping expectations and strategies of the competing sides. Catastrophic unique events are highly unlikely to provide the necessary incentives to pursue new, innovative strategies.

Moreover, by restricting attention to particular types of individual traits, the results put forward in these evolutionary models may not prove to be as general as they are presented. In particular, traits targeting the transformation of the economic and social environment (in contrast to distributive traits) may deform the selection process itself and hence potentially undermine the condition of its existence. One of the most important traits that may have emerged historically concerns the transformation of a – perceived – uncertain world into a risky one[1].

Several historical episodes are known where societies managed to transform part of the uncertainty into risk by developing more or less sophisticated forecasting devices. These forecasting instruments relied partly on the development of mental abilities to take future events as depending on current activities and not completely determined by external – often divine – forces. These periods usually go hand in hand with a partly secularization as exemplified by the the reign of king Hamurapi of Babylon (1750-1700 ad.).

As this example shows, the emergence of longer time horizons and some minimal planning of the social and natural environment of human beings has not been limited to the experience of Western Europe over the last five centuries. Other societies in ancient times, the Roman Empire or Ancient Egypt had obtained remarkable skills in forecasting and planning, at least much more than their immediate competitors. Despite the simultaneous development of division of labor on a relatively large scale, these society failed once confronted against a serious outside competitor.

None of these historical episodes, however, have ever gone as far as in the West European case where ever more sophisticated instruments have been developed often accompanied by some technological advancements producing support devices such as calculating machines and computers. Moreover, some of these instruments necessitates strong mental capabilities in order to

[1] This distinction relies on the discussion by Knight (1921) and Keynes (1936) on the possibility to form probabilities on events. An uncertain world does not allow to form probabilities, either because some events are not known or because the probability distribution is not stationary.

be applied correctly. Even those that do not had individual mentalities modified by imposing consumption restrictions (“delayed gratification”) and a fundamental orientation towards the future.

These modifications and the emergence of instruments to make better predictions of future evolutions has had an important impact on economic development. Forecasting, planning and risk management are important devices for economic development and division of labor as coordination between various economic functions is made possible through time; moreover, insurance against repeated events supports more risk-taking behavior and innovative activity. Predicting risky outcomes and allowing diversification helps to channel investment into more risky and possibly more productive industrial projects (Saint-Paul, 1992; Acemoglu and Zilibotti, 1997). Furthermore, investment – and relatedly savings – may not come about without any future prospect of the realization of the fruits of investment.

Moreover, economic development relies on division of labor and factor input complementarity as one of the driving factors for increased profitability and productivity. Deepening the development of financial market may therefore allow an increased factor specialization and consequently a higher payoff from investment. Again, crucial to the existence of these spillovers is the presence of a stable macro-social environment. Singular events – and even more so unpredicted events – constitute a disruptive force likely to undermine the benefits of financial development. However, when financial development has become deep enough, the system may be able to cope with these shocks. Increasing returns, when they have had an opportunity to develop long enough may therefore constitute a stabilizing force for economic development.

Out of these considerations the model in this paper proposes planning horizons of individuals as emerging endogenously out of the non-random matching in a society. Given that these instruments are characterized by important externalities – as stabilizing social interactions and economic activity is beneficial for other individuals in the group as well – and hence individually costly, their emergence may not be granted through within-in group competition alone. In a first step – and in concordance with existing literature – we therefore show, under which conditions these traits can nevertheless emerge and produce a stable with-in group equilibrium. Given between group competition the positive impact on economic development coming from the coevolution of the development of these instruments together with the division of labor greatly enhance the productive capacities of a society and consequently the survival chances in external conflicts.

Moreover, during the process of the development of these traits, within group competition needs to decrease in order for division of labor to allow to reap the full benefits of the stabilization of the stochastic environment. As division of labor relies on technological complementarities, various factors have to be combined in a cooperative way. The first part of our model therefore concentrates on the coevolution of traits aiming at economic planning and social segmentation through division of tasks.

A second step of the paper tries to go beyond this first result by introducing various forms of outside competition and relating them to the interaction between planning horizons and economic development. Here, it will be shown that it is important to distinguish between different kinds of competition in order to make sense of the above mentioned historical experiences: hit-and-run competition may prove disastrous in this respect as outside competitors can negatively affect the risk distribution, reducing considerably the effectiveness of risk management systems. Continuous competition through regular matching, however, can contribute to the diffusion of these instruments, as this type of competition constitutes a regular and hence predictable shock to the community.

Hence, random matching – and therefore predictable matching rates – only constitute one type of between-groups competition. Historically more important is however the first type, i.e. catastrophic matching producing shocks to the society far too rare to be included in the available risk management mechanism. We will elucidate this point through this discussion of a number of historical examples in the last part.

The paper is organized as follows: the next part discusses with-in group selection of different traits and the important impact outside competition can have on the selection process. Section 3 introduces a variety of competition forms relying partly on recent advancements of industrial organization. Section 4 discusses the theoretical results in relation with some historical examples. Section 5 concludes.

2. Within-group competition

In a first step, we will consider the emergence of a certain trait in a (potentially segmented) population with non-random matching rates across different segments. We are mainly interested in analyzing the emergence of the trait in a particular segment without making any particular assumption about the competition among segments.

2.1 Segmentation and selection

2.1.1 Distribution of traits and encounter probabilities

In order to reduce the complexity of the evolution process we consider only two possible traits with respect to individual planning horizons: whenever individual *i* in group *j* makes a planning effort, he or she will save a certain amount of his current income, s_{ij}, in order to be prepared for future contingencies. Normalizing the individual income to unity, $n \cdot s_{ij}$ represents the available amount of savings in the entire population (where *n* the number of individuals in the population).

The frequency with which the "saving" trait appears in the population will be denoted with:

$$p_j = \frac{1}{n_j} \sum_i p_{ij}$$

where $p_{ij} \in \{0,1\}$ indicates whether individual *i* in group *j* possess the trait or not and n_j represents the size of group *j*.

Following Bowles (1998, p. 5), non-random matching can be represented by considering segmented groups and populations. In this case, the holder of a saving trait will encounter a like person with probability δ and will play against the population (or group average) with probability 1- δ. Hence, the probability for a "saver" to encounter another person with the same trait can be represented by the weighted sum of the two probabilities, μ_{ss}. The conditional probabilities for the other encounter possibilities can be deducted in a similar way:

$$\mu_{ss}=\delta+(1-\delta)\,p_j\,,\mu_{sn}=(1-\delta)(1-p_j),\mu_{ns}=(1-\delta)\,p_j\,,\mu_{nn}=\delta+(1-\delta)(1-p_j)\;.$$

Given these definitions, the payoffs can be constructed using the following considerations.

2.1.2 Technological choice and risk diversification

Each individual deposes of income *A* during the a period. It can either choose to keep the income or to save and invest in a specialized technology a range of $\eta\in[0,1]$ indicating the degree of specialization. The more specialized a technology is, the higher will be its realized output, but the higher is also its risk of failure.

Once the technology installed, it delivers an output $A(\alpha+\eta)\varepsilon$ where ε follows a normal distribution with unity mean and variance $\sigma^2(\eta)$ where $\partial\sigma^2(\eta)/\partial\eta>0$ and $\alpha<1$ represents the minimum technological specialization. The agent will consume at most $\underline{a}$ units of his output; below this level he needs to consume the whole amount to insure survival. The agent will choose the technology such as to maximize expected income exceeding his maximum consumption level:

$$\max_{\eta} A(\alpha+\eta)\int_{\underline{a}}^{\infty}\epsilon\, dF(\epsilon,\eta)\;.$$

Given that $\int_{\underline{a}}^{\infty}\epsilon\, dF(\epsilon,\eta)$ is decreasing with η, the optimal program has an interior solution, denoted $\hat{\eta}$. The expected income the agent can obtain is supposed to be inferior – due to lack of sufficient specialization – to non-investing when used individually:

$$(\alpha+\hat{\eta})\int_{0}^{\infty}\epsilon\, dF(\epsilon,\hat{\eta})<1$$

Now suppose that two agents meet where both have the possibility – and are ready to – invest a share s_{ij} in the other technology. In this case, and assuming that both technologies are independent, the variance of the portfolio diminishes and each agent faces the new optimal program:

$$\max_{\eta} A[s_1(\alpha_1+\eta_1)+(1-s_1)(\alpha_2+\eta_2)]\int_{\underline{a}}^{\infty}(\epsilon_1+\epsilon_2)\, dG((\epsilon_1+\epsilon_2),\eta_1,\eta_2)$$

where $G(\epsilon_1+\epsilon_2)$ denotes the joint distribution; in equilibrium the degree of specialization are supposed to be equal. As is well known the joint distribution will have lower variance than the individual distribution for either ε_1 or ε_2. Consequently, the individual will choose an optimal degree of specialization that is higher than in the individual savings case: $\hat{\hat{\eta}}>\hat{\eta}$. When risk can be sufficiently diversified, then the expected income may be higher than in the non-savings case:

$$[s_1(\alpha+\hat{\hat{\eta}})+(1-s_1)(\alpha+\hat{\hat{\eta}})]\int_{0}^{\infty}(\epsilon_1+\epsilon_2)\, dG((\epsilon_1+\epsilon_2),\hat{\hat{\eta}})>1\;.$$

In this case, a coordination game appears with two distinct equilibria: a non-saving equilibrium and a full-savings equilibrium. Let us denote the pure payoffs as follows:

$$\pi_{ss}^{e} \equiv \pi^{e}(\sigma, \hat{\hat{\eta}}) = A[s(\alpha_1 + \hat{\hat{\eta}}) + (1-s)(\alpha_2 + \hat{\hat{\eta}})]$$
$$\pi_{sn}^{e} \equiv \pi^{e}(\sigma, \hat{\eta}) = A(\alpha_1 + \hat{\eta})$$
$$\pi_{ns}^{e} \equiv \pi^{e}(\sigma) = A$$
$$\pi_{nn}^{e} \equiv \pi^{e}(\sigma) = A$$

with $\pi_{ss}^{e} > \pi_{ns}^{e} = \pi_{nn}^{e} > \pi_{sn}^{e}$. Hence, the agent is indifferent between the strategy his opponent is choosing when he selects the non-savings strategy, while it makes a big difference whenever he is investing in a specialized technology.

Given these expected payoffs to various encounters, the payoff for a saver and a non-saver conditional on the encounter probability can be represented as follows:

$$\begin{aligned} \omega_s(p;\delta) &= \mu_{ss}\pi_{ss}^{e}(\sigma, \hat{\hat{\eta}}) + \mu_{sn}\pi_{sn}^{e}(\sigma, \hat{\eta}) \\ &= [\delta + (1-\delta)p_j]\pi_{ss}^{e} + (1-\delta)(1-p_j)\pi_{sn}^{e} \\ \omega_n(p;\delta) &= \mu_{ns}\pi_{ns}^{e}(\sigma) + \mu_{nn}\pi_{nn}^{e}(\sigma) \\ &= (1-\delta)p_j A + [\delta + (1-\delta)(1-p_j)]A = A \end{aligned} \qquad (1)$$

Again, the non-saving strategy yields the same payoff independently from the trait of the opponent; hence the conditional payoff is independent from the encounter probability and the degree of segmentation in the population. Moreover – unsurprisingly – the conditional payoff for a saver is increasing in the degree of segmentation, $\partial \omega_s(\cdot)/\partial \delta > 0$, while the conditional payoff for the non-saver is constant.

2.2 The Evolution of Financial Markets

Given this payoff structure, we can now turn to a discussion of the emergence of financial markets and the analysis of the within group dynamics that may lead to multiple stable equilibria. For the moment, we continue to consider only the selection process within a given group j.

A selection process takes place whenever individuals can update their trait having met with another randomly drawn individual. In the simplest possible case, an individual changes his trait whenever his payoff is lower than the average payoff in the pool.

Following Weibull (1995, pp. 171-174), we can determine the replicator dynamics that are implied by the above payoffs. The increase of savers in the population can be represented by the following equation:

$$\dot{p}_j = [\omega_s - \omega_n] \cdot p_j(1-p_j) = \mathrm{var}(p_{ij})[\omega_s - \omega_n]\,. \qquad (1)$$

A similar equation can be set up for the evolution of the non-saver part of the population. Given this dynamical system describing the variation of the payoffs under the evolution of the composition of the population, it is straightforward to prove the following proposition that relates the characteristics of the payoff structure to the existence of multiple equilibria and the size of the basin of attraction of the arising equilibria.

Proposition 1: *For* $\pi_{ss} > A$ *there exists a non-degenerate financial market basin of attraction for the replicator dynamics such that for all*

$$p_j > \bar{p}_j \equiv 1 - \frac{\pi_{ss} - A}{(1-\delta)(\pi_{ss} - \pi_{sn})}$$

the dyanmics converges towards the all-savers equilibrium. The size of the basin of attraction can be characterized by: $1 - \bar{p}_j$.

This is a well-known outcome of any coordination problem and helps to understand the possibility for a savings equilibrium not to emerge even though it may constitute a Pareto-improvement over the initial situation. Whenever a sufficient large group of non-savers exists in the population, the switch to a saver trait proves to be too costly individually and hence will not – or not sufficiently occur.

One important difference, however, of the above replicator dynamics is its dependance on the degree of social segmentation, δ. We therefore have to turn our attention to the relation between social segmentation and the characteristics of the financial equilibrium as well as to questions of the endogeneity of the degree of segmentation.

2.3 The role of segmentation in the emergence of financial markets

Let us first concentrate on exogenous segmentation, represented by δ. Given the above characteristics of the conditional payoff function and the dynamics of the evolution of financial markets, the following proposition follows immediately:

Proposition 2: *The stronger the degree of segmentation, the larger the basin of attraction for the financial market equilibrium. For* $\delta=1$ *the financial market equilibrium is the only one.*

Proof. Plugging $\delta=1$ into yields the second part of the proposition while considering the derivative of ω_s with respect to δ yields the first part.●

Reducing competition within the group through increased segmentation hence allows to widen the range of values of *p* for which the financial market equilibrium is more attractive than the non-savings one. At the extreme, savers are only to meet their likes and will hence never encounter an unfavorable situation; given the higher payoffs they obtain in this case, it is attractive to switch to the savings trait for whatever composition of the population.

Given the increase of the attractiveness of the financial markets equilibrium under increased segmentation, one may also consider an endogenously determined rate of segmentation. People may want to engage more easily with like-minded individuals and hence prefer to reduce their non-peer related contacts to a minimum whenever there is only a small subgroup of savers. However, as the pool grows bigger, it may be too costly to pool together and more and more matching will occur on a non-segmented base; hence the degree of segmentation may decrease with an increase of savers.

In this case, the degree of segmentation varies with the composition of the population in the following way:

$$\delta=\delta(p_s),\delta'<0\ . \tag{1}$$

Moreover, we want to make the assumption that $\delta(0)=1,\delta'(0)=-\infty,\delta(1)=0,\delta'(1)=0$.

The payoff for savers conditional on the encounter probability evolves in the following way with the population composition:

$$\frac{\partial\omega_s}{\partial p_j}=\left[\frac{\partial\delta}{\partial p_j}(1-p_j)+(1-\delta)\right](\pi_{ss}-\pi_{sn})\ .$$

In this case, there exists a range of values for $p_j\leqslant\bar{p}$ with $\bar{p}=\arg\min\omega_s$ such that the derivative will be negative. Consequently, the following proposition holds:

Proposition 3: *Suppose that segmentation evolves endogenously and follows the restrictions imposed by . Then two cases can be distinguished:*

1. *Suppose that* $\omega_s(\bar{p})\geqslant\omega_n$ *. Then there exists only one equilibrium: the financial market equilibrium.*

2. *Suppose that* $\omega_s(\bar{p})<\omega_n$ *. Then there exist two stable equilibria: the financial market equilibrium and an interior with a non-degenerate composition of savers and non-savers in the group.*

Proof. Whenever $\omega_s(\bar{p})\geqslant\omega_n$ then $\omega_s\geqslant\omega_n\ \forall\ p_j$ and consequently $\dot{p}_j>0\ \forall\ p_j$. Moreover, given that $\delta(0)=1$, we have $\omega_s(0)>\omega_n$. Hence, even though $\omega_s(\bar{p})<\omega_n\Rightarrow\exists\ \tilde{p}\in(0,1)|\ \dot{p}=0$ and consequently the existence of multiple equilibria, the inferior equilibrium will be an interior one. ●

Given these results for the within-group selection process, we now can turn to a discussion of the effects of between-group competition on the frequency distribution in the whole population.

3. Between-group competition

One important difference between within-group and between-group interaction has to do with the frequency of the exchange. Groups can be defined as a mass of individuals with frequent, regular interactions, even though they may be segmented. Between groups, however, the interactions may be much less frequent or even singular events. When that happens, the impact of competition on the strategy selection may be different[2].

Group contests will be decided be the military superiority which derives itself from the possibility of economic development. Nevertheless, the relation between financial development, economic progress and military advancements is not a straightforward one but underlies considerable elements of chance. A less developed group may have the possibility to win a one-shot contest when chance and momentarily effort play a role and the two contestants are not too far apart in their relative economic performance (see Boone, 2000).

[2] See Boone, 2000, for a recent discussion on the relation between repeated interaction and the impact of competitive pressure on innovative strategies.

In the extended set-up we have to consider two different forces shaping the group frequencies of the financial trait: within a group the traits are still determined by the economic exchange, while the between group economic, cultural and military contests determine the population composition by potentially reducing an existing group's size.

3.1 Decomposition of selection processes

In order to formalize the influences of between and within group selection dynamics we use Price's (1970) general equation for the decomposition of selection processes. Let q_j represent the share of group j in the whole population, i.e. $q_j \equiv Q_j / Q$ with Q_j number of individuals in group j and Q size of the whole population. Then, $p = \Sigma q_j p_j$ represents the frequency of the financial trait in the whole population. Moreover, let Q_j^0 be the initial size of each group normalized to unity. Then, given N the number of groups, the expected average size $\bar{Q}^e_{t+1} = \frac{1}{N} \Sigma Q_j = \frac{Q}{N} \Sigma q_j = \bar{Q}_t \Sigma q_j = 1$ which can be seen by solving the recursive equation and using the initial condition $\bar{q}_0 = Q_j^0 = 1$. Furthermore, the group share in the population will raise proportionally with the ratio of the expected groups size to the average group size:

$$\frac{q^e_{j,t+1}}{q_{j,t}} = \rho \frac{Q^e_{j,t+1}}{\bar{Q}_t} .$$

Hence, given the above definition of p, the evolution in the population can be accounted for by the following:

$$\begin{aligned} \Delta p \equiv p_{t+1} - p_t &= \sum q^e_{j,t+1} p_{j,t+1} - \sum q_{j,t} p_{j,t} \\ &= \sum \rho q_{j,t} \frac{Q^e_{j,t+1}}{\bar{Q}_t} (p_{j,t} - \Delta p_{j,t}) - \sum q_{j,t} p_{j,t} \\ &= \sum \rho q_{j,t} \left(\frac{Q^e_{j,t+1}}{\bar{Q}_t} - 1 \right) p_{j,t} + \sum q_{j,t} \frac{Q^e_{j,t+1}}{\bar{Q}_t} \Delta p_{j,t} \end{aligned} \tag{1}$$

Repeating the exercise for $\Delta p_{j,t}$ and noting that $\Delta p_{ij,t} = 0$, equation can be rewritten as:

$$\begin{aligned} \bar{Q}_t \Delta p &= \sum \rho q_{j,t} \left(Q^e_{j,t+1} - \bar{Q}_t \right) p_{j,t} + \sum q_{j,t} Q^e_{j,t+1} \Delta p_j \\ &= \sum \rho q_{j,t} \left(Q^e_{j,t+1} - \bar{Q}_t \right) p_{j,t} + \sum q_{j,t} \left[\sum \left(Q^e_{ij,t+1} - Q_{j,t} \right) p_{ij,t} \right] \end{aligned}$$

Given that $\Sigma q_{j,t} \left(Q^e_{j,t+1} - \bar{Q}_t \right) p_t = 0$, one notes that the covariance between $Q_{j,t}$ and $p_{j,\mathrm{t}}$ writes as:

$$\begin{aligned} \operatorname{cov}(Q^e_{j,t+1}, p_{j,t}) &= \sum q_{j,t} \left(Q^e_{j,t+1} - \bar{Q}_t \right) (p_{j,t} - p_t) \\ &= \sum q_{j,t} \left(Q^e_{j,t+1} - \bar{Q}_t \right) p_{j,t} \\ &= b_j \operatorname{var}(p_j) \end{aligned}$$

with b_j the regression coefficient of $p_{j,\mathrm{t}}$ on $Q_{j,t}$. Similarly, it can be shown that $\operatorname{cov}(Q^e_{ij,t+1}, p_{ij,t}) = b_{ij} \operatorname{var}(p_{ij})$ with b_{ij} the regression coefficient of $p_{ij,\mathrm{t}}$ on $Q_{ij,t}$. Hence, the evolution of the financial trait in the population can be rewritten as:

$$\begin{aligned}\bar{Q}_t \Delta p &= \rho \operatorname{cov}\left(Q^e_{j,t+1}, p_{j,t}\right) + \sum q_{j,t} \operatorname{cov}\left(Q^e_{ij,t+1}\, p_{ij,t}\right) \\ &= \rho\, b_j \operatorname{var}(p_{j,t}) + \sum q_{j,t} b_{ij} \operatorname{var}(p_{ij,t})\end{aligned} \quad (1)$$

The direction of the evolutionary process will therefore be determined by the sign of the two regression coefficients that have to be determined in the following.

3.2 Group competition and encounter probability

Equation is unlikely to yield a closed-form solution. In this section we therefore analyze the local dynamics of the evolutionary process[3]. An important factor in determining the direction of the change will be played by the group encounter probability as it has a potential impact on the winning probability or the growth potential of the two groups as has been pointed out by Boone (2000, pp. 550-551).

Consider a small average payoff differential between two groups. Then a cultural, economic or military encounter will be more probably determined by elements of chance when it is only a one-shot encounter than when two groups meet and exchange regularly.

There are two more elements to this, however. First, the more singular an event, the fatter the tails of the corresponding distribution function, σ. This reduces the relative profitability of the financial trait as we have discussed it in the previous section[4]. Moreover, small payoff differences combined with a small encounter probability will set incentives for the less performing group to momentarily raise its effort level in order to win the contest (see Boone, 2000, p. 552-553). These mechanisms will obviously affect the dynamics of the population composition.

The group meeting is supposed to follow a Poisson process with flow probability γ and will affect the likelihood of the stronger group to win the contest. The winning group increases its size proportionally to its average fitness, given by $\pi_{ss} - A$, while loosing groups will reduce their size by ζA. The encounter probability will determine the chances of winning the contest and consequently whether the group is able to grow according to its potential or whether it will absorbed[5]: the higher the intergroup competition, the more likely the stronger group will take advantage. Then the expected group size is determined by:

$$Q^e_{j,t+1} \equiv E[Q_{j,t+1}] = 1 + \gamma \zeta\, p_j(\pi_{ss} - A) + (1-\gamma)\, p_j(-\zeta A) = 1 + \zeta\, p_j(\gamma \pi_{ss} - A)\,.$$

Hence, whenever $\gamma \pi_{ss} < A$ either the payoff from bearing the financial trait or the encounter probability are too low to guarantee a constant or increasing group size. Therefore, setting $\bar{Q}_{j,t} = 1$ and using equation , we obtain the following description of the local dynamics of the evolutionary process:

3 ***The final version of this paper will also contain some simulation results that analyze the global dynamics of the above equation.***

4 In the appendix we provide an example of how a regular chock may provoke a disruption to the payoff process that decreases in variance with the regularity.

5 One could also assume an endogenously determined winning probability and a fixed population increase as in Bowles (2001, p. 15) or endogenously determined winning probabilities and population increases; nothing substantial would be added to our argument.

$$\begin{aligned}\Delta p &= \sum \rho q_{j,t}\left(Q^{e}_{j,t+1}-1\right) p_{j,t}+\sum q_{j,t}\left[\sum \left(Q^{e}_{ij,t+1}-Q_{j,t}\right) p_{ij,t}\right] \\ &= \rho \sum q_{j,t}\left(1+\zeta(p_j(\gamma\pi_{ss}-A))-1\right) p_{j,t}+\sum q_{j,t}\left[\sum \left(Q^{e}_{ij,t+1}-Q_{j,t}\right) p_{ij,t}\right]\end{aligned}$$

Rearranging terms, dropping the time index and noting that $\sum q_{j,t}\, p^2_{j,t}=\operatorname{var}(p_{j,t})$ this can be simplified to:

$$\Delta p=\rho\zeta \operatorname{var}(p_j)(\gamma\pi_{ss}-A)+\sum_j [q_j \operatorname{var}(p_{ij})(\omega^s_j-\omega^n_j)] \tag{1}$$

The first term represents the influence of the group conflicts on the evolution of the financial trait while the second term reproduces the within group selection process as we have described it in the previous section. It is immediately clear from equation that a stable equilibrium that arises in within group competition may not survive between group competition for low encounter probabilities; whenever $\gamma\pi_{ss}-A$ is sufficiently negative, the evolutionary forces will drive down the density of the financial trait.

Therefore, in the case that financial development gives a constant return to the group, only a regular encounter can guarantee that the group will fully benefit from the presence of the financial trait. For low relative benefits and/or low matching probabilities the financial trait may not prove to be viable in the population. There is, however, one important qualification to these considerations as we will see in the following.

3.3 Financial development and increasing returns to market size

For the moment, we have not considered the size of the (financial) market to play any important role in our set-up. The benefits financial development could bring has been limited to the two person case. It is, however, straightforward to imagine that the relationship we exposed in the previous section will be deepened the more saving is available in an economy: a classical case of increasing returns to scale.

Bearing the financial trait, individual *j* has therefore a typical portfolio problem by investing in *n* different projects, where for simplicity we want to assume that there are as many projects as individuals with the financial trait:

$$s_{ij}=\arg\max \quad A\sum_{i=1}^{n} s_{ij}(\alpha_i+\hat{\hat{\eta}})\int_0^{\infty}\sum_{i=1}^{n}\epsilon_i\, dG\left(\sum_{i=1}^{n}\epsilon_i,\hat{\hat{\eta}}\right)$$

where $\sum_{i=1}^{n} s_{ij}=1$ and $\hat{\hat{\eta}}=\eta_1=\ldots=\eta_n$ is the symmetric solution to the problem:

$$\{\eta_1,\ldots,\eta_n\}=\arg\max \quad A\sum_{i=1}^{n} s_{ij}(\alpha_i+\eta_i)\int_{\underline{a}}^{\infty}\sum_{i=1}^{n}\epsilon_i\, dG\left(\sum_{i=1}^{n}\epsilon_i,\eta_1,\ldots,\eta_n\right).$$

Given that:

$$\operatorname{var}\left(\sum_{i=1}^{n}\epsilon_i\right) < \operatorname{var}\left(\sum_{i=1}^{n-1}\epsilon_i\right)$$

we observe that $\hat{\hat{\eta}}(n)>\hat{\hat{\eta}}(n-1)$ and consequently the benefits from financial development will be greater the more investment projects are available. Given that n represents the number of individuals bearing the financial trait we can introduce a shorthand for this relationship:

$$\hat{\hat{\eta}}=\eta(p_j),\eta'>0\Rightarrow\pi_{ss}=\pi(\sigma,\hat{\hat{\eta}})=\pi(\sigma,\eta(p_j)).$$

Concerning the within-group evolution nothing substantial changes as this case corresponds to the situation where the degree of segmentation varies with the presence of the financial trait (see proposition 3). However, the between-group dynamics will be affected as the outcome of the group competition will depend on how developed the financial market in the two groups are. Intuitively, the more developed a financial market in one group relative to a competing group is the better its capacity to win the outcome of the match, even in the case of a rarely occurring encounter.

$$\begin{aligned}\Delta p &= \rho\zeta\sum q_{j,t}p_{j,t}^2\big(\gamma\pi_{ss}(p_{j,t})-A\big)+\sum_j[q_j\operatorname{var}(p_{ij})(\omega_j^s(p_j)-\omega_j^n)]\\ &= \rho\zeta\big(\gamma\sum q_{j,t}p_{j,t}^2\pi_{ss}(p_{j,t})-\operatorname{var}(p_{j,t})A\big)+\sum_j[q_j\operatorname{var}(p_{ij})(\omega_j^s(p_j)-\omega_j^n)]\\ &= \rho\zeta\big(\gamma\operatorname{var}(p_{j,t}\sqrt{\pi_{ss}})-\operatorname{var}(p_{j,t})A\big)+\sum_j[q_j\operatorname{var}(p_{ij})(\omega_j^s(p_j)-\omega_j^n)]\end{aligned}$$

In this case – compared to equation – the between group evolution is directed by the weighted variance of the financial trait frequencies as given by the term $\operatorname{var}(p_{j,t}\sqrt{\pi_{ss}})$. The weight of the group frequency is the more important the stronger the financial development in this particular group is. Hence, the presence of increasing returns upward biases the evolutionary process in the group encounters.

Whenever this upward driving force is strong enough, the group may even overcome the negative effects of one-shot group encounters and still survive the competition.

The above discussion of within- and between-group selection processes can be summarized by the following (testable) hypotheses:

i. Endogenous forces – such as endogenous social segmentation – may lead to a poverty trap where the group gets stuck in an inferior equilibrium.

ii. Catastrophic – single encounter – between group contests may be decided independently of payoff differentials, giving non-saving groups a strategic advantage.

iii. Increased competition raises the chances of between group payoff differentials to be decisive for the outcome of the contest.

Given these fundamental results of the theoretical model at hand, the last section will ask whether they can help to the understanding of historical examples of economic and social development of major civilizations.

4. Historical examples

The preceding theoretical considerations give rise to the question whether they can help to understand some of the historical evolutions that historians and archeologists have succeeded to reconstruct. In the following we therefore briefly outline three different types of historical evolution that may be explained by the predictions of the above model. We concentrate on the most important aspects without entering into the details of the different processes; nevertheless, even on this rough level we are able to find some aspects of the theoretical selection process described in the model before.

4.1 Babylon

The reign of King Hamurapi (ca. 2000 BC.) marks the final point in the raise of the Babylon empire and a consolidation process of the entire area. Urbanization in Euphrates and Tigris already started some two thousand years before his rise to power but never led to the construction of anything resembling a territorial state (see Klengel, 1999, for a very interesting account of everyday's life during that period).

Usually, cities like Ur, Uruk, Susa or Babylon had concentrated their power on the fields and acres immediately around but never extended over more than a hundred kilometers. Difficulties of effective transportation and slow administration precluded anything more important than a city-state. Nevertheless, these cities have been much more advanced than any of the existing groups in Western Europe, Asia or America. First to develop a way of coding and writing, they developed important mechanisms to cope with the irregularities of life – such as mathematics and astronomy (Müller-Karpe, 1998, pp. 33-34).

This, obviously, has been a cornerstone for their urban development as it allowed an important degree of division of labor between handcraft, administrative tasks and farming. Despite these economic and social advancements, however, there is an evolution discernible between the first urban centers that developed at around the time of the writing of the Gilgamesch epos (ca. 4000 BC.) and the heydays of King Hamurapi.

Ever since the first settlements, priest and the clerical cast played an important role in organizing the social life and providing the necessary interpretation for understanding the surrounding world. People lived in a world dominated by various Gods and forces of nature that could not be understood by them. The various kings and princes were considered being Gods themselves, descended on earth to administer their fiefdoms.

Interestingly, Mesopotamian kings stopped using (adjunctions) to their names to indicated their God status from Hamurapi on (Müller-Karpe, 1998, p. 19). Klengel (1999) interprets this as an increasing self-confidence of the ordinary people that had developed over the centuries before. The increasing mastery of the physical forces and the ever more complex social life gave an important degree of autonomy to the individual or at least the individual family. The Hamurapi juridical code contains a fascinating number of contracts for financial transaction, starting with simple credit contracts and going even as far as forward contracting. This in itself implies that people at that time had a quite distinctive notion of the future and were able to anticipate the consequences of their present actions on future outcomes, a necessary condition for non-degenerate time horizons.

Despite the economic and social development, the various cities and people lived in constant competition over the available resources. Hamurapi himself had to construct various coalitions against his immediate enemies to win the outcome. Shortly after his son took over, the Babylonian empire deconstructed again and fell apart into its various parts. Interestingly here is therefore that the competition itself – even though it had been disastrous at times[6] – proved not to be an obstacle

[6] Often succeeding kings decided to erase the victims city entirely.

to long-run economic development. On the contrary, given their limited resources, the various kings had proved to be rather weak in exploiting their peoples' belongings. The constant competition exercised a pressure to allow at least partially an endogenous wealth creation process, quite similar to what can be observed for Western Europe three millennia later.

However, at the end of the reign of Hammurapi, this process had not allowed to create a sufficiently rich and developed region as to definitely outcompete civilizations that had developed independently at further distance. This happened in fact at around 1600 BC when the Hethiter king Muršili I. invaded Babylon, contributing the final breakdown of the empire and destroying much of its economic and social wealth. Here, a competing group with similar strength – the Hethiter were probably less developed but had invested in important military material – constituted a catastrophic event that could not be resisted by the then current state of social development in the Babylonian empire. Once the supporting structure destroyed, it took over 1000 years before anything similar to this economic, social and political structure reemerged in the form of the New Babylonian empire under Nebukadnedzar.

The role of group competition can therefore not be described as unanimously positive but has to be put in the particular context under which it took place: only, a regular competing process may have the power to allow the diffusion of pareto-dominant individual traits; the catastrophic, one-shot encounter, however, most likely contributes to a rapid decline when the outcome of these encounters is more determined by chance than by relative development. The next example in this respect shows a similar situation, albeit one where the endogenous wealth creation process has been hampered by other endogenous, negative forces.

4.2 Ancient Rome

On first sight, the decline of the Roman empire seems to give an example of a developed civilization that vanished under the constant and regular attack by outside forces. Ever since emperor Augustus lost his troops in the Teutoburg forest in 6 AD, the various German tribes on the other side of the *limes* constituted a regular threat to the existence of the West European part of the Roman empire. This threat increased from the second half of the second century, probably due to changing climate conditions in Northern and Eastern Europe. Fleeing from hunger and cold, various Slav and German tribes where pushing westwards, pressing against the established fief- and kingdoms and ultimately against the Roman empire itself.

It therefore came without surprise that the Western part finally ceased to exist in 476 AD when Alarich took over Rome and enslaved the last Roman emperor.

The decline of the Roman empire is therefore unlikely to give us new insight on the importance of between group competition on the survival of superior traits. It may, however, rise the question why the Romans did not manage to develop strongly enough their empire such as to integrate immigrating populations more easily and to outcompete those who attempted a military contest. Obviously, those forces have to be sought inside the Roman empire itself as the regular competition with outside forces points to a rather favorable environment, at least from the point of view of the above theory. Understanding various lock-ins and blockades within a group may help to better compare the differential success history gave to groups over time.

In fact, the example of the Roman empire seems to constitute a confirmation of the second part of proposition 3, relating an endogenous segmentation rate to the existence of a non-degenerate interior equilibrium. Here, the process of increasing diffusion of the financial trait got stuck in an inferior outcome: once the group reached this point, only a substantial change of a large subgroup would allow the evolutionary process to keep on pushing the savings trait throughout the entire group. Consequently, this explains that even when the trait exists within a group – given the small number only a slight advantages over competing groups can be expected.

In the case of the Roman empire, two forces may have prevented the trait to diffuse further; that it existed is well documented by the various episodes of capital-deepening throughout the entire history of the empire (see Rostovtseff 1957; De Martino, 1991, ch. 33). First, the sheer size of the empire may have precluded a sufficiently high degree of social segmentation to push the diffusion of the savings trait further upwards. In fact, the financial trait payoff will be affected the stronger by the group composition, the more negative the derivative $\partial \delta / \partial p_j$. Moreover, going in the same direction – the size of the empire required important fiscal transactions to sustain the border, something which led already at the end of the Roman republic to the actual disappearance of a middle class, susceptible to diffuse effectively any longer time horizons.

Secondly, and probably as important as the first point, the military success in the first two centuries of the empire led to an abundant supply of slave labor, something crucial for labor intensive – and by extension less demanding in risk management attached to capital investments – technologies. Consequently, the relative payoff difference between the financial trait and the non-financial trait may have been less substantial leading to a slower pace of diffusion. When the success story finally came to an end in from the second century on, there was a strong feeling for economic restructuring as the various decrees and measures taken by the central authorities showed (see Carrié and Rousselle, 1999). However, at the same time the outside pressure increased pushing the Roman empire into regular battles with enemies that did not necessarily lag much behind the Roman technological advancements.

Hence, despite the fact that Rome had been implied for a substantial part of its history in ongoing battles with its neighbors, endogenous forces may have precluded a sufficient diffusion of the financial trait and the superior technological, economic, and social structures it may have offered. As we will see in our last example, in the absence of these limiting endogenous forces, the same situation may produces substantially different outcomes.

4.3 Western Europe

The economic and psychological development of Western Europe over the last millennium has been amply described and debated in the available literature. Two determining factors – recurrently put forward by various authors – strike out as of particular importance: the regular and intense competition between various local governors and landlords and the tendency to monopolization and disciplinization of the elite – creating the psychological base for increased time horizons and capital accumulation (Elias, 1972; Kennedy, 1989). In the following we present a brief summary of the argument and relate it to our theoretical findings above.

Following the break-up of the Frank empire built up by Charlemagne and divided by his sons, the number of small and widely dispersed principalities, fiefdoms and kingdoms increased rapidly in Western Europe over the next two to three centuries. In Germany, the process of decomposition continued until the final breakdown of the Holy Roman Empire in 1806, but even before, the institutional structure hardly hide the existence of countless territories competing for influence and more often for survival.

In the western part of the Frank empire a consolidation process set in from 1200 on where the competition among local leaders led to a process of constructing (local) monopolies (Elias, 1972). However, it took over 6 more centuries before the consolidation process led to the final shape of France with the integration of the Savoy principality in 1860. From 1600 on or so, regional powers had consolidated themselves without giving up the struggle for the hegemony over the entire Western European hemisphere (as expressed in the 30 years war 1618-1648). France and Prussia spent considerable energy and money on the battlefield and Louis XIV had rarely a year without a major military excursion during his long reign.

The absence of any durable hegemony or dominant power in Western Europe over the last millennium and the limited resources of which all of the competing powers disposed created the base for regular, long-lasting conflict without any permanent winner.

At the same time, it provided sufficient incentives for the competing fiefdoms to gain access to even the smallest additional resources. Given the relatively evenly distributed natural resources across Western Europe, only endogenous wealth creation could have provided the necessary financial means to participate in this general power struggle. Long before the start of the industrial revolution, therefore, increasing investment in new forms of financial planning and increased saving helped to allow local leaders to gain (temporary) advantages over their competitors, as has been shown in much detail by Elias (1972).

This resulted in ever more sophisticated tools of financial and risk planning and the increasing importance of risk sharing through pooling of financial assets (Bernstein, 1998). As is clear from our theoretical considerations in the first part of this paper, only individuals with sufficiently long time horizons would have been able to do so, requiring a substantial degree of patience and self-restrain.

Moreover, local leaders had to be sufficiently aware of the endogeneity of the wealth creation process because otherwise simple expropriation would have led to a rapid breakdown of the mechanism. There is abundant evidence that property rights have been protected much less than perfect (a striking example is the rise and fall of the Fugger family from Augsburg, that went bankrupt after King Edward decided not to repay the substantial amount of debt he had run up during the war 1618-1648); however, nowhere a leader had been strong enough to systematically expropriate his subjects. That fact in itself provided still a sufficiently high amount of protection to guarantee minimum incentives for financial investments.

What is interesting with the Western European case is that competition proved not only not to be an impediment to the development of financial markets but moreover even an incentive and an important mechanism sustaining the financial and economic development. No local or regional leader had been strong enough to take over entirely, creating sufficient incentive for competitors to equal powers through innovation and imitation. Once the economic development reached a certain level, even catastrophic events during the twentieth century did not definitely disrupt this process.

5. Conclusion

The preceding paper argued for a differentiated view on the various between and within selection forces that drive the emergence of particular traits important for economic and social development. In particular, it analyzed the importance and evolution of an individual savings trait where agents are characterized by a relatively long time horizon and ready to invest in long-term assets.

The trait leads to multiple equilibria under within-group selection where the basin of attraction changes with social segmentation and depends on the relation between social segmentation and importance of the financial trait in the population. This dynamic is modified, however, by the competition that exists between groups. Group encounters may lead to the extinction of a group with particular high penetration by the financial trait. This may happen when groups meet less frequently, constituting a catastrophic event.

In this situation, even when the within-group selection forces are favorable for the development of the financial trait, the between group competition may lead to the extinction of the (pareto-dominant) trait in the population.

In the second part of the paper we provided some historical examples to underline the importance of these forces in the explanations of developments that have taken place in the last 6 millennia. In particular, we presented the case of the (Old) Babylonian empire, the Roman empire and the rise of Western Europe over the last thousand years. These examples seem to confirm the importance of between group competition – and its frequency – in the rise and fall of particular development-enhancing individual traits. Moreover, as could be shown by the Western European example, high frequency competition may lead to a even more favorable evolution of superior traits. This specific point should hence be stressed more in future work and needs to be developed to be integrated in the existing formal framework.

6. Appendix: Regular shocks and payoff distribution

Suppose a shock arriving at rate γ. Suppose moreover that bearers of the financial trait can build up an experience capital how to deal with these shocks. The learning rate will obviously be determined by the shock rate, hence learning will occur at rate γ as well. The experience capital will allow the saver to deal with the shock more quickly: the deviation from the mean will be reduces at increased speed the more experience capital has been built up. Let the deviation from the mean react to learning as follows:

$$D=\exp(-\gamma t)$$

where t represents the time after the shock has taken place. Then the sequence of shocks and reversals to the mean according to the level of experience capital is a compound Poisson process, $\Psi=\sum_{t=1}^{T} D_t$. As is well known these processes are characterized by the following first two moments (Ross, 1996, pp. 82-83):

$$E(\Psi)=\gamma E(D), \mathrm{var}(\Psi)=\gamma E(D^2)$$

which in our case evaluates to:

$$\begin{aligned} E(\Psi) &= \gamma E(D) &= \frac{1}{\gamma} \\ \mathrm{var}(\Psi) &= \gamma E(D^2) &= \frac{\gamma-1}{\gamma^3}. \end{aligned}$$

Therefore, an increase in the shock arrival rate not only reduces the expected impact of the shock (which is negative in our case) but also the variance, at least for arrival rates $\gamma \geqslant 3/2$. This will have an impact on the realization of the savings process as the new random process writes as: $\epsilon - \Psi$. Consequently, the outcome of the match between two savers writes as:

$$\tilde{\pi}^e_{ss} \equiv \tilde{\pi}^e(\sigma, \hat{\hat{\eta}}, \gamma) = A[s(\alpha_1 + \hat{\hat{\eta}}(\gamma)) + (1-s)(\alpha_2 + \hat{\hat{\eta}}(\gamma))]$$

with $\partial \hat{\hat{\eta}}(\gamma) / \partial \gamma > 0$ given that:

$$\{\hat{\hat{\eta}}_1, \hat{\hat{\eta}}_2\} = \arg\max A[s_1(\alpha_1+\eta_1)+(1-s_1)(\alpha_2+\eta_2)] \int_{\underline{a}}^{\infty} (\epsilon_1+\epsilon_2-\Psi)\, dG((\epsilon_1+\epsilon_2-\Psi), \eta_1, \eta_2, \gamma)$$

with $\hat{\hat{\eta}} = \hat{\hat{\eta}}_1 = \hat{\hat{\eta}}_2$ in the symmetric equilibrium and the fact that the truncated expectation of the random variable is increasing with decreasing variance – again at least for $\gamma \geqslant 3/2$:

$$\frac{\partial \int_{\underline{a}}^{\infty} (\epsilon_1+\epsilon_2-\Psi)\, dG((\epsilon_1+\epsilon_2-\Psi), \cdot\,)}{\partial\, \mathrm{var}(\epsilon_1+\epsilon_2-\Psi)} < 0.$$

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