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Entanglement by Genes or Shares Hamiltons rule of kin selection revisited

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Entanglement by Genes or Shares

Hamilton's rule of kin selection revisited

Abstract

Help within genetically related and unrelated organisms as well as investments of investors holding shares to different degree including charity can be understood within the ensemble concept. In an ensemble transfer of substrate from a source to a sink may result in superadditivity as well as subadditivity. The ensemble with the better net profit will prevail. Source and sink may be entangled by genes or shares. The degree of entanglement is expressed by an entanglement factor between zero and one. This entanglement factor may be (over)compensated by a success factor. In non-entangled parties a higher success factor is necessary for partial compensation. However, the over-compensation is only a local phenomenon. In entangled parties a higher success factor will completely over-compensate lower entanglement. The redistribution of substrate from source to two different sinks is an example of a target conflict between maximal yield and maximal yield increase. The success factor is a complex amalgam of unknown but interrelated equations and values. Besides transfer efficiencies, survival probabilities and number an important part of the success factor is the time frame. In organisms costing help for offspring is due to genetic entanglement and a longer lifespan of the young offspring versus the old parent. Exceptions from this rule (filial cannibalism) are completely encompassed by the concept. Long term investments will outperform short term investments always on the long run - in case they manage to survive on the short run!

Keywords: ensemble, source, sink, net profit, Hamilton's rule, success factor, entanglement factor, genetic reciprocity, inclusive fitness, charity, altruism, quantity, quality, hidden variable, group selection, target conflict

Introduction

Imagine the following situation: You are the owner of two companies. You hold 100% of the stocks of company A and - as a joint venture - 50% of company B. The factories of both companies are identical and run out of raw material simultaneously. You have to buy new raw material but there will be only one batch. You have to decide which company will receive this batch. No other restrictions are known. The best decision is to give the raw material to the wholly owned company. This is business! But how do you decide in case you know that the 100% owned factory will be completely destroyed this night?

Let us now consider you are a parent. You are 100% genetically related to yourself. Your offspring is genetically 50% identical to you. Both of you are hungry but there is only one portion of food. Parents give the food to the offspring. This is altruistic and genetically founded self-sacrificing love.

Are business and parenthood really that different or are considerations and restrictions implied we are not aware of? In addition, life teaches that not all parents under all circumstances are that self-sacrificing.

Economy is shaped by an organism and Biology is influenced by economic concepts (1, 2). Altruism and selfishness are important concepts in Biology, Economics and Philosophy. However, altruism is a harmful behaviour as this concept implies the separation of benefit and cost. One party is paying the cost while a different party receives the benefit. Such a trait should be lost in evolution – and everywhere else, too.

Hamilton introduced in two papers in 1964 (3, 4) the idea that altruism (leading to a negative benefit) would be stable in case both parties were

genetically related. For an altruist the ratio of benefit to cost ($b/c=k$) should exceed the reciprocal value of the average relatedness (r°) between altruist and altruism recipient:

$$-k > 1/r^\circ \quad (|k| > 1)$$

The contemporary spelling of Hamilton's rule is: $r*b > c$. The small inequality teaches: genes should increase in frequency when the genetic relatedness (r) of the recipient to the actor times the additional reproductive benefit (b) gained by the recipient of the altruistic act exceeds the reproductive cost (c) to the individual performing the act.

Both statements surprisingly differ very much. In Hamilton's original statement we look at the negative benefit to cost ratio of a parent and compare this ratio with the degree of genetic relation to the offspring. In the now commonly used interpretation of Hamilton we look at the benefit of an offspring rated by the genetic distance in comparison to the cost of a parent. However, both viewpoints are incomplete and therefore must lead to wrong conclusions!

Lex parsimoniae

This law - also known as Ockham's razor - suggests that among competing hypotheses, the hypothesis with the fewest assumptions should be selected. Hamilton's rule $-k > 1/r^\circ$ and $r*b > c$ follow the *lex parsimoniae* as they are very simple. However, they compare a negative benefit (malefit) per cost with a distance or benefit times a distance with a cost – things with different units. They are simple but wrong!

In the real world we deal everywhere with physical quantities. A physical quantity is a numerical value times a dimensional unit. In physics it does

not make sense to compare basic units like volume (m^3) with mass (kg) directly. It is also not possible to convert volume into mass. Therefore, a derived unit is used – density ($\rho=kg/m^3$). With the unit density it becomes easy to judge and understand whether a $1m^3$ solid block of steel or $1m^3$ solid block of wood will sink or float in water – and why a boat made of $1m^3$ steel will float, too.

To match that basic scientific requirement in Biology it is necessary to compare different parties on their benefit to cost ratio or net profit weighted by the relatedness (an inverse, normalized distance). Relatedness is a value between 1 (100% identity, no distance) and zero (an infinite distance). Relatedness will later be called “entanglement” and is also called genetic reciprocity in Biology. The parties are entangled by the degree of informational identity.

Let us use “b” as the dimensional unit of benefit and “c” as the dimensional unit of cost. A benefit to cost analysis in strangers (only self-related, no entanglement) will now look this way:

$$\text{party A: } 90b/10c \text{ (9 b/c)} > \text{party B: } 120b/20c \text{ (6 b/c)}$$

In all my later considerations cost is a linear function of the substrate concentration and benefit is a saturating function of the substrate concentration according to the Michaelis-Menten equation. In case we compare both parties it is obvious that party B with a steep cost function has a smaller b/c ratio although the benefit is higher than in party A.

In parent and offspring only about 50% of the genes are identical. And all genes are in two complete different metabolic and developmental states. Therefore, we have to compare at least the reproductive benefit of a parent per reproductive cost of a parent with the reproductive benefit of

the offspring per reproductive cost of the offspring. In addition, both sides of the equation have to take the relatedness into account.

Furthermore, I do not compare single parties. In past and the present paper I compare ensembles of parties transferring or not transferring substrate at different substrate concentrations. Active and inactive ensembles may be compared in the ensemble space (the three axes are the b/c ratio of ensemble and source and sink) or the transfer space (the three axes are substrate concentration in source and sink and net profit (b-c) of the active or inactive ensemble). Here I concentrate on the transfer space. The observations within this space are more direct as two axes are linear.

Benefit and cost have aspects of quantity and quality. If source and sink share the same quality with respect to benefit and cost the transfer space and net profit are used. The difference of benefit and cost (b-c) is known as net profit. If quantity and quality of benefit and cost are different in source and sink the ensemble space is used. This is especially necessary when source and sink produce different benefits from the same substrate. The derived unit benefit cost ratio (b/c) is used here and could be called “bensity” or “bencosty” to remind us of the similarity to density.

Basic assumptions and equations

The structure of an ensemble has been described earlier (5, 6). In brief: An ensemble consists of a “source” (so), a productive entity where substrate may come from and a “sink” (si), a productive entity where substrate may go to. Both parties use the same substrate and may or may not transfer this substrate. The source will “give” or “give not”, the

sink will “take” or “take not” the substrate depending on the degree of the actual benefit (b) to cost (c) ratio (source gives at $b_{so}-c_{so}<0$ ($b_{so}/c_{so}<1$), sink takes at $b_{si}-c_{si}>0$ ($b_{si}/c_{si}>1$)). In an inactive ensemble no substrate is transferred, in an active ensemble substrate is transferred.

Besides inactive and active ensembles there are independent and dependent ensembles. In an independent (autonomous) ensemble (6) varying amounts of substrate are transferred only from the source in the condition $b_{so}-c_{so}<0$ ($b_{so}/c_{so}<1$) to the sink in $b_{si}-c_{si}>0$ ($b_{si}/c_{si}>1$). The transfer stops when one or both sides reach $b-c=0$ ($b/c=1$). In a dependent ensemble (5) a constant amount of substrate is taken away from the source and given to the sink. This type of transfer is also enforced under non-favoured conditions in a source like $b_{so}-c_{so}\geq 0$ ($b_{so}/c_{so}\geq 1$) or in a sink like $b_{si}-c_{si}\leq 0$ ($b_{si}/c_{si}\leq 1$). This may be compared to genetic programming or taxes combined with forced subsidy.

The reaction velocity (v) of the benefit production is a saturating function of the substrate concentration [S] according to Michaelis-Menten (7).

In an inactive ensemble both parties produce benefit separately:

$$b_{so}\sim v_{so}; v_{so}=\frac{[S_{so}]}{(K_{m_{so}}+[S_{so}])}\cdot V_{max_{so}}$$

$$b_{si}\sim v_{si}; v_{si}=\frac{[S_{si}]}{(K_{m_{si}}+[S_{si}])}\cdot V_{max_{si}}$$

or the parties transfer a small amount of substrate ΔS and are active:

$$b_{so}\sim v_{so}; v_{so}=\frac{[S_{so}-\Delta S]}{(K_{m_{so}}+[S_{so}-\Delta S])}\cdot V_{max_{so}};$$

$$b_{si}\sim v_{si}; v_{si}=\frac{[S_{si}+\Delta S]}{(K_{m_{si}}+[S_{si}+\Delta S])}\cdot V_{max_{si}}$$

The cost is a linear function of the substrate concentration:

$$\text{inactive: } c_{s0}=[S_{s0}] * k_{s0}; \quad c_{si}=[S_{si}] * k_{si} \quad (k=\text{constant})$$

$$\text{active: } c_{s0}=[S_{s0}-\Delta S] * k_{s0}; \quad c_{si}=[S_{si}+\Delta S] * k_{si} \quad (k=\text{constant})$$

The net profit of the ensemble is: $(b_e - c_e) = (b_{s0} - c_{s0}) + (b_{si} - c_{si})$. Although the parties are called “source” and “sink” they do not always act as source or sink in case the ensemble is inactive. The wording “symmetric ensemble” in the following paper will indicate that K_m (substrate concentration at $V_{max}/2$), V_{max} (maximal reaction velocity) and cost factor k are identical in source and sink. Other factors may be asymmetric.

Two additional factors have to be considered: entanglement and success. The entanglement factor is called “ef”: Two parties can be entangled in four different ways: $(ef_{s0})_{s0}$, $(ef_{si})_{si}$, $(ef_{si})_{s0}$ and $(ef_{s0})_{si}$.

The entanglement factor of a source with the source $((ef_{s0})_{s0})$ or a sink with the sink $((ef_{si})_{si})$ will in organisms usually equal 1 as the organism is genetically completely self-related. The entanglement factor with another organism (entanglement of the source with the sink $(ef_{si})_{s0}$ and entanglement of the sink with the source $(ef_{s0})_{si}$ will vary from ef1 (identical clones) to ef0.75 (sisters in bees and ants) to ef0.5 (parents and children, full siblings) to ef0.25 (grandparent and grandchild, half siblings) and ef0 (strangers) (8). The quantitative fate of one party will appear in the quality balance of the other party. In organisms this will be a symmetric entanglement. In the following considerations only a single entanglement factor is therefore given. A parent and his offspring for example are both 50% genetically identical and therefore the entanglement for both is ef0.5. In economy this is more flexible.

Entanglements here can be asymmetric. To buy a share buys entanglement. The share owner is now to a certain degree entangled with the company. The company is not entangled with him. However, this depends on law, common practice and the organisation structure of the shareholders including genetic entanglement within the shareholders and company members or the size of the entanglement.

The definitions of “success factor” are countless. A success factor (sf) here is a result of numerous interdependent and independent considerations. It is a number with the ability to compensate for low entanglement. The success factor is a composite value of many factors and components. Two of these components in Biology are survival probability and number. It is known from birds that artificially increasing the number of eggs will reduce the survival probability of the fledglings. The capacity of parental care and the appropriate offspring number seems to be optimized by evolution. The equations determining how an increase or decrease in one of the components of the success factor will influence the change of the other components of the success factor and whether the success factor will grow or shrink belong to the core questions and knowledge of Biology and Economics; including the mutual influence of Biology and Economy (e.g. fertility decline).

The following abbreviations are used:

sf_{so}^{noT} ; the success factor of a source with no transfer of substrate

sf_{si}^{noT} ; the success factor of a sink with no transfer of substrate

sf_{so}^T ; the success factor of a source with transfer of substrate

sf_{si}^T ; the success factor of a sink with transfer of substrate

In the calculations it will be generally assumed that transfer will decrease the success of source and increase the success of sink:

$$sf_{so}^{noT} \geq sf_{so}^T \text{ and } sf_{si}^T \geq sf_{si}^{noT}.$$

Source and sink form an ensemble. The ensemble redistributes substrate from source to sink. In the real world there will be a species specific coupling between the size of decrease in source and the size of increase in sink. In extension of this idea the success factor could be interpreted as a saturating benefit with a linear cost, too (5). A decrease in source therefore may also result in: $sf_{so}^{noT} \leq sf_{so}^T$ and $sf_{si}^T \leq sf_{si}^{noT}$ (only one example of the transfer of a burden will be presented).

In addition, the entanglement factor is a fixed long term component and the success factor a fixed short term component. The short term component could be time dependent and increase or decrease with time ($sf_t = sf_0 * e^{\pm \lambda t}$). In a first period of competition between two ensembles the success factor of ensemble A may over-compensate a small entanglement factor of A. Within this time period the ensemble B with a low success factor but a high entanglement factor may decrease or vanish. Vanishing would eliminate the ensemble B with the long term strategy. In a second period of the competition the success factor of ensemble A may have decreased very much so that now ensemble B will win due to the combination of success and entanglement factor. The long term strategy will prevail. Although we have to assume that in a long lasting evolutionary process this has happened repeatedly there will be a mixture of short and long term strategies. For example investment in reproduction is a long term strategy and investment in muscles, claws and teeth is a short term strategy. Both strategies are successfully used. The following considerations include no time dependence of the size of sf. Within the considered time period sf has a constant value and the

result of the comparison of two ensembles with different sf is ultimate – for this time period.

Net profit of an inactive ensemble (transfer space):

$$((b_{so}-c_{so}) * ef_{so} + (b_{si}-c_{si}) * ef_{si})_{so} * sf_{so}^{noT} + ((b_{so}-c_{so}) * ef_{so} + (b_{si}-c_{si}) * ef_{si})_{si} * sf_{si}^{noT}$$

Benefit/cost ratio of an inactive ensemble (ensemble space):

$$(b_{so}/c_{so} * ef_{so} + b_{si}/c_{si} * ef_{si})_{so} * sf_{so}^{noT} + (b_{so}/c_{so} * ef_{so} + b_{si}/c_{si} * ef_{si})_{si} * sf_{si}^{noT}$$

In an active ensemble the source transfers a small amount of substrate ΔS to the sink. The result is a nonlinear increase or decrease in benefit and a linear increase or decrease in cost.

Net profit of an active ensemble (transfer space):

$$((b_{so}-c_{so}) * ef_{so} + (b_{si}-c_{si}) * ef_{si})_{so} * sf_{so}^T + ((b_{so}-c_{so}) * ef_{so} + (b_{si}-c_{si}) * ef_{si})_{si} * sf_{si}^T$$

Benefit/cost ratio of an active ensemble (ensemble space):

$$(b_{so}/c_{so} * ef_{so} + b_{si}/c_{si} * ef_{si})_{so} * sf_{so}^T + (b_{so}/c_{so} * ef_{so} + b_{si}/c_{si} * ef_{si})_{si} * sf_{si}^T$$

Results

In this section I avoid to look at special cases. I will observe in general active and inactive dependent ensembles under different degrees of entanglement (ef_0 , $ef_{0.25}$, $ef_{0.5}$, $ef_{0.75}$ and ef_1) and different success factors ($sf_{0.001}$ to $sf_{2.5}$). Later, in the discussion section I will assign the observations here to mainly biological cases. Asymmetric or independent (autonomous) ensembles with brute force or deception will follow in an additional work.

The starting point of my considerations is the inactive ensemble of not entangled parties. It will serve as reference although it may be difficult to view this as an ensemble. Two parties are isolated productive and do not transfer substrate. They invest only in themselves. They are neither source nor sink although they appear as such in figure 1. This self-investment results in saturating benefit and is accompanied by linear increase in cost for both parties. As the increase of cost is linear while the increase of productivity is saturating the inactive, symmetric (dependent) and not entangled ensemble has a maximal net profit (b-c) indicated by a yellow plain (fig. 1). The red dot within this plain (0.5mM source, 0.5mM sink) is the peak of the red surface and the maximal net profit (both parties combined). This maximum serves now as reference. The net profit of an active or entangled ensemble at a distinct pair of substrate concentrations in source and sink may be larger (superadditivity) than the net profit of the inactive not-entangled ensemble at the identical substrate concentrations. However, below the yellow surface there will be always the possibility that a different pair of substrate concentrations of an inactive ensemble will have a better net profit or will be at least as good as an active ensemble. Above the yellow surface any ensemble has always a better net profit and will always prevail against the ensemble of figure 1.

Figure 1

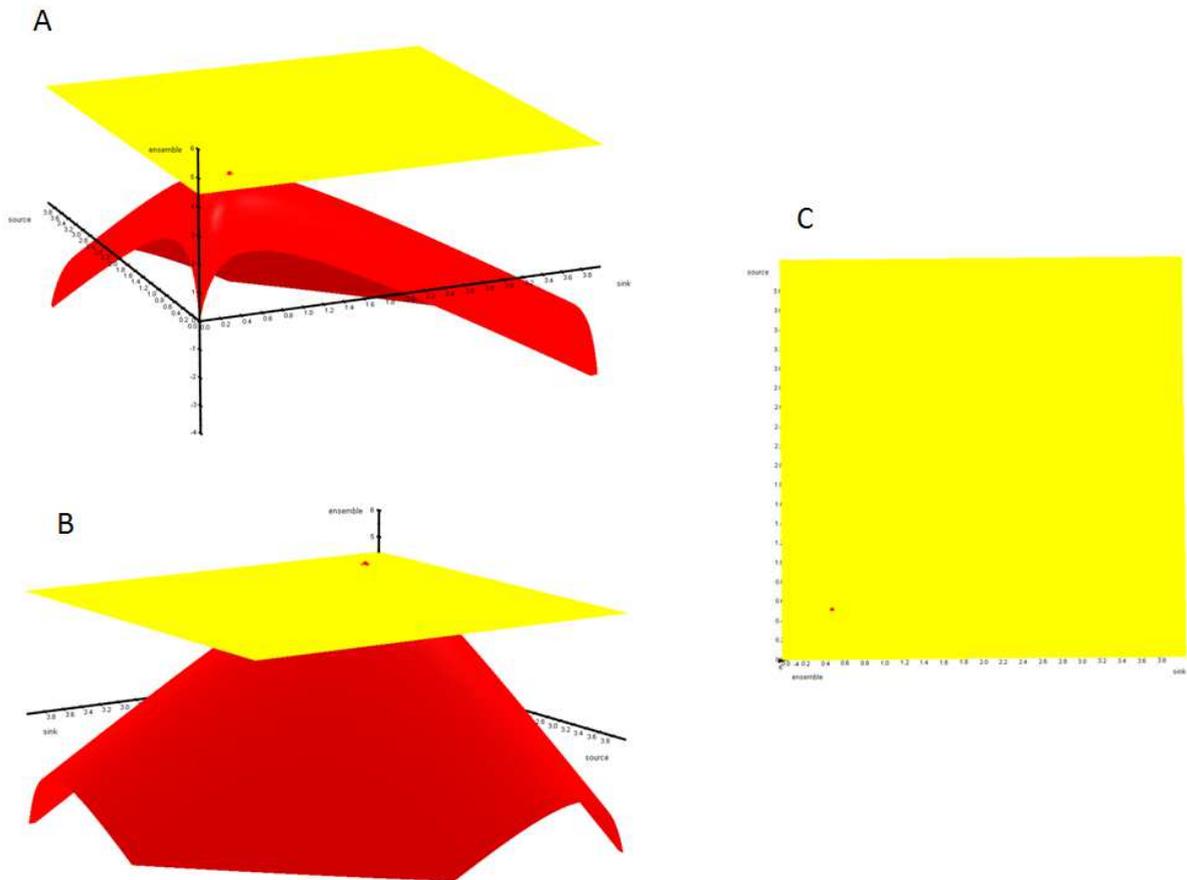


Figure 1: The inactive, (dependent), symmetric, not entangled ensemble is depicted in red. We view the ensemble from the front (A) and back (B) and in a top-down perspective (C). In A the substrate concentration in source is to the left, sink to the right and net profit (b-c) of the ensemble is on the z-axis. The success factor is $sf1$ for both parties and the entanglement is $ef0$. The yellow surface touches the maximum of the net profit. This maximum is the reference in the following pictures. The red dot in C indicates the location of this maximum within the reference surface. The K_m value of this symmetric ensemble is 0.25mM , the V_{max} value is 5mM in source and in sink and the linear cost $c=8 \cdot K_m$ for source and sink. No substrate is transferred.

In figure 2 we look at an entangled (symmetric, inactive, dependent) ensemble with an entanglement factor of $ef0.5$. Here, 50% of the sinks quantity (see discussion of the methodology) in net profit will appear in the balance of the source as quality and *vice versa*. The red surface will pierce the yellow reference surface although no transfer of substrate with

an improved net profit of quantity has occurred. The increase is solely owed to the fact that both parties are entangled now and share quality.

Figure 2

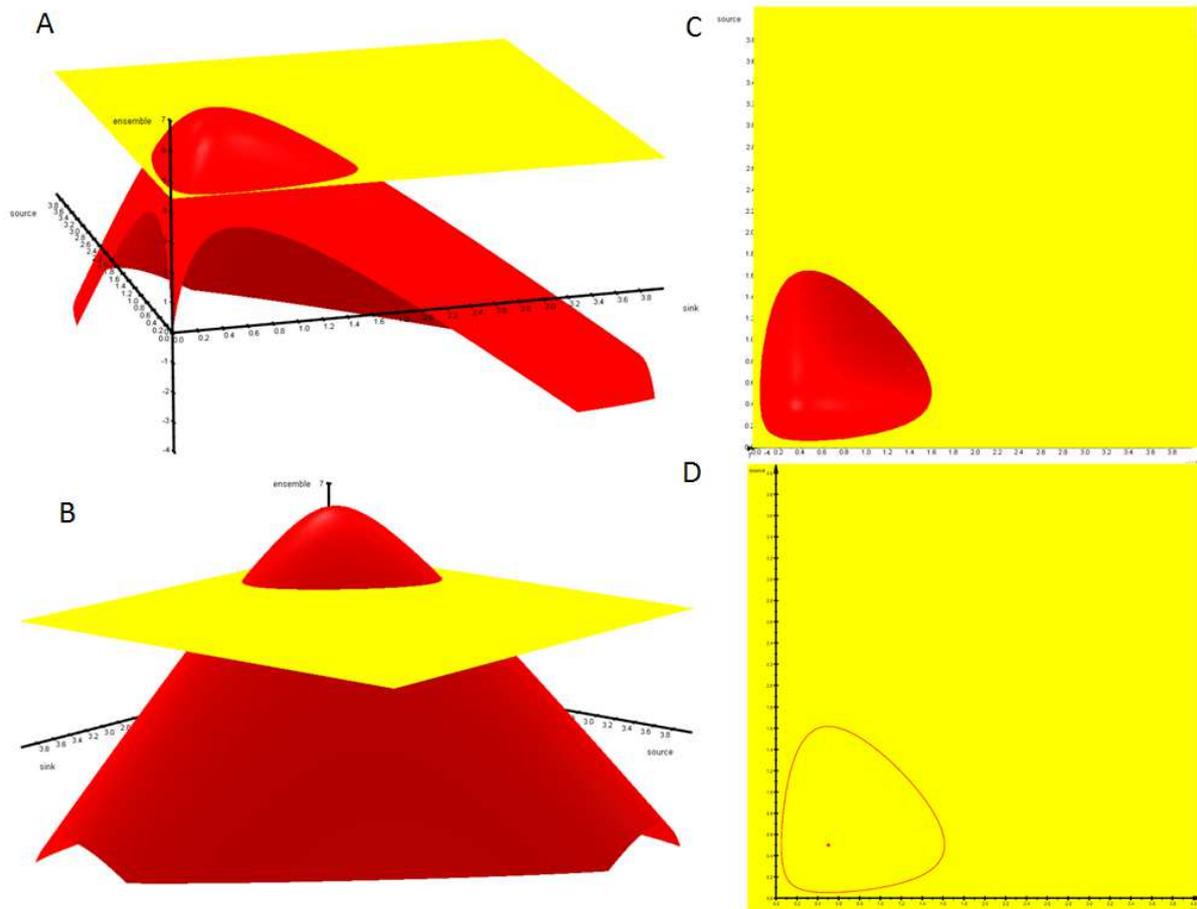


Figure 2: The inactive, (dependent), symmetric, entangled ensemble is depicted in red. We view the ensemble from the front (A) and back (B) and in a top-down perspective (C). In D we look top down at a cross section within the yellow reference surface. In A the concentration in source is to the left, sink to the right and net profit (b-c) of the ensemble is on the z-axis. The success factor is sf_1 for both parties and the entanglement is $ef_{0.5}$. The red surface penetrates the yellow plain over a wide range of concentrations. The K_m value of this symmetric ensemble is 0.25mM , the V_{max} value is 5mM in source and in sink and the linear cost $c=8*K_m$ for source and sink. No substrate is transferred.

Now let us look at an inactive, (dependent), symmetric, entangled ensemble with a low success factor ($sf_{s_i}0.1$) in sink (fig. 3). The red

surface no longer touches the yellow surface although there is still entanglement.

Figure 3

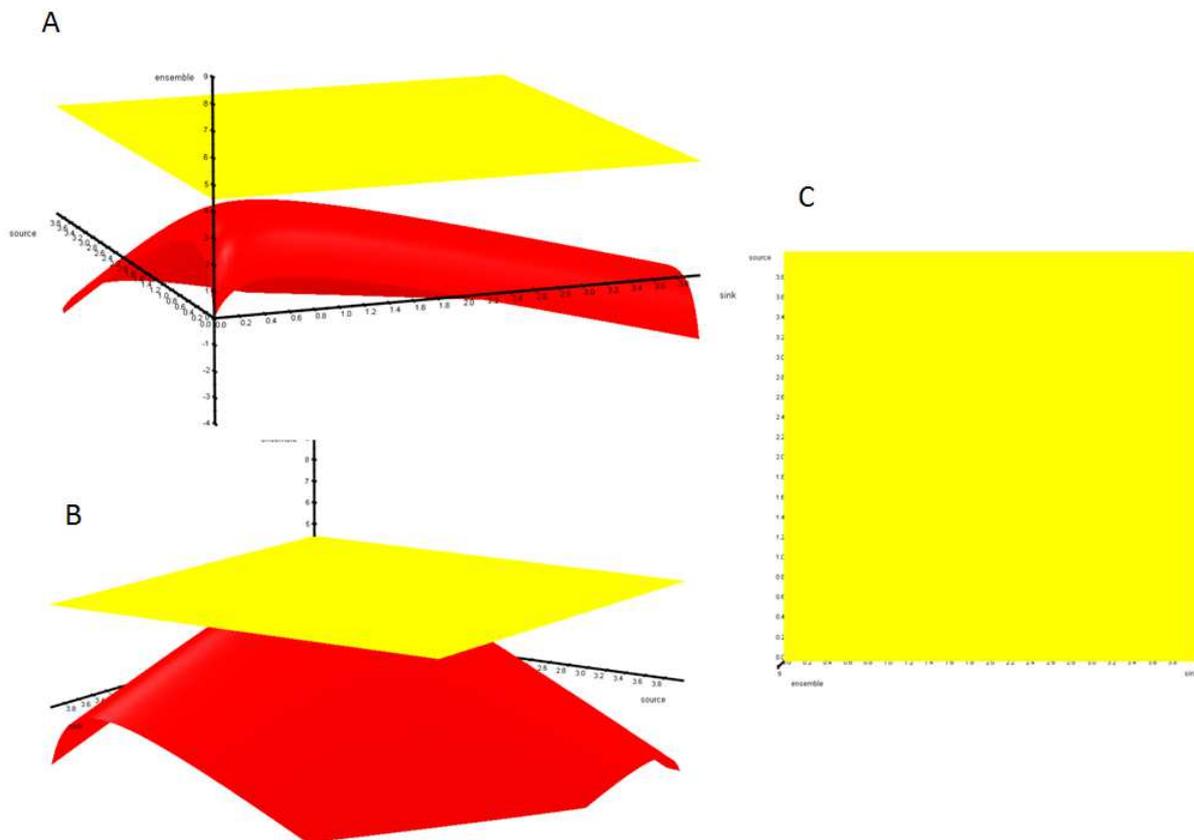


Figure 3: The inactive, (dependent), symmetric, entangled ensemble with a weak party is depicted in red. Again we view the ensemble from the front (A) and back (B) and in a top-down perspective (C). In A the concentration in source is to the left, sink to the right and net profit of the ensemble is on the z-axis. The success factor is $sf_{so}^{noT}1$ for source and $sf_{si}^{noT}0.1$ for sink and the entanglement is $ef0.5$ for both sides. The red ensemble surface no longer reaches the yellow reference surface. The Km value is still 0.25mM in source and sink, the Vmax value is 5mM in source and in sink and the linear cost $c=8*Km$ for source and sink. Again, no substrate is transferred.

As both parties are symmetrically entangled ($ef0.5$) the low success factor ($sf_{si}^{noT}0.1$) will also affect the source although there is no transfer of substrate decreasing the productivity in source. In figure 4 we observe the changes taking place when the symmetric, entangled ensemble of

figure 3 becomes active by an externally induced (dependent) transfer of substrate from source to sink. The success factor of source decreases after transfer of substrate a little ($sf_{so}^{noT}1$ to $sf_{so}^T 0.9$).

Figure 4

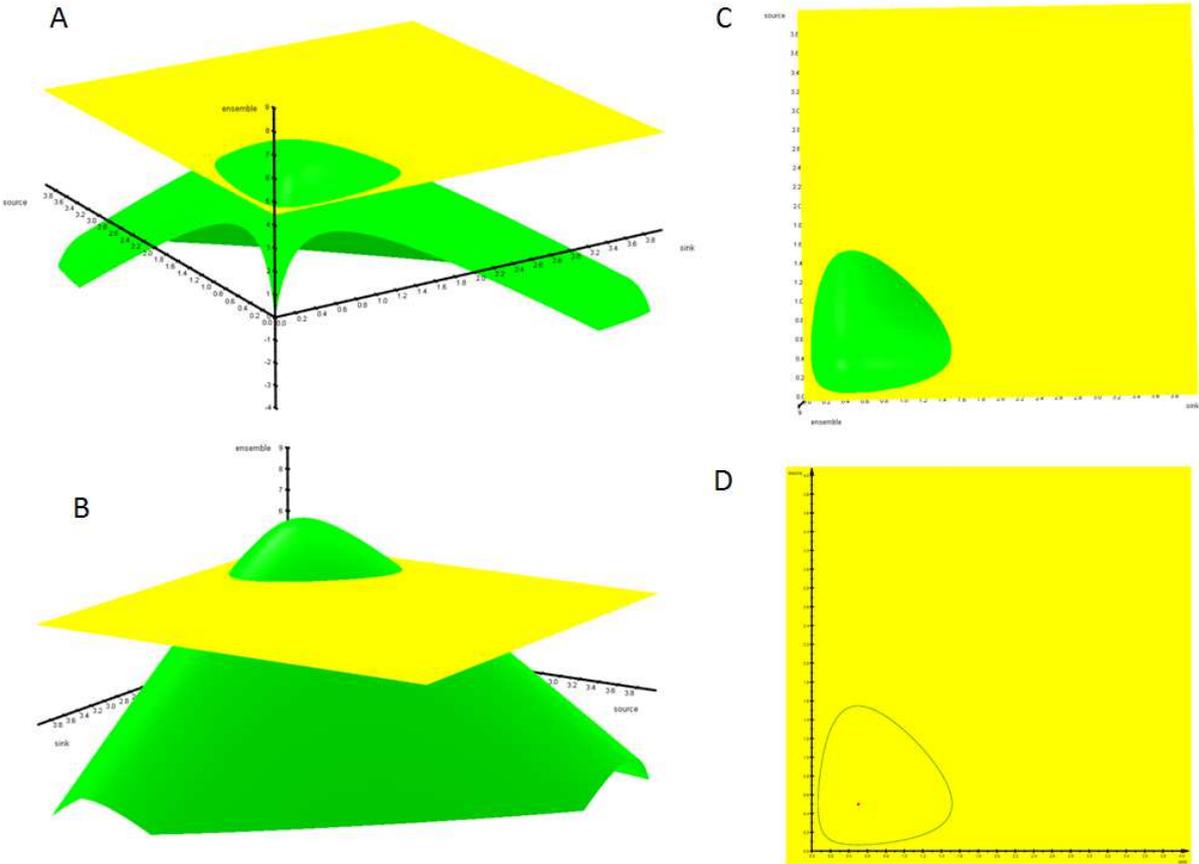


Figure 4: Now we look at an active, dependent, symmetric, entangled ensemble with a weak party. Again, this ensemble is depicted from the front (A) and back (B) and in a top-down perspective (C). The yellow reference surface is penetrated by the green surface in a wide concentration range. In D we look top down at a cross section within the reference surface. The red dot is the maximal value of figure 1 at a single concentration in source and in sink. This maximum is surrounded by a green curve indicating the concentrations combinations equal or better in the active ensemble. The shape of the closed curve in 4D looks similar to a bean curve and will be called simply “curve”. In A the concentration in source is to the left, sink to the right and net profit of the ensemble is on the z-axis. The success factor after transfer is $sf_{so}^T 0.9$ for source and $sf_{si}^T 1$ for sink and the entanglement is $ef 0.5$ for both sides. $1\mu\text{mol/l}$ is transferred.

This small transfer however increases the success factor of the sink dramatically ($sf_{si}^{noT} 0.1$ to $sf_{si}^T 1$). Through the entanglement and the general setting the small loss in source is overcompensated over a large concentration range by the drastic increase in success in sink. This type of ensemble will be active and successful in many low concentration ranges in comparison to even the best value achievable by an inactive, not entangled ensemble (0.5mM; $b-c=0$ or $b/c=1$). In this region the source will successfully give although $b-c>0$ ($b/c>1$). This ensemble will prevail against an ensemble of “self-investing” parties (red dot, figure 4 D) although they have both a success factor of 1.

Ensembles have internal variables like K_m , V_{max} and cost. I have introduced two further variables; entanglement “ef” and success “sf”. In the following pictures we are going to compare ensembles only varying “ef” and “sf” at different concentrations in source and sink (fig. 5). The biochemical part of the ensemble (K_m , V_{max} , cost) stays unchanged symmetric. The relationship of the success factors in source and sink however are strongly asymmetric. In my examples a transfer reduces usually the success factor in source only from sf_1 to $sf_{0.9}$ while the success factor in sink will rise from $sf_{0.1}$ to sf_1 . This will be discussed later in more detail. Here I want to argue in brief that this is not unusual e.g. in parents feeding offspring. The lost food portion (including a reduction in parental success) to the even hungry but mature parent will have a much higher contribution to the success of the still growing offspring.

Let us at first compare the effect of different success and entanglement factors with and without transfer of substrate in figure 5. There the effect of different factors is observed by a cross section within the reference surface.

Figure 5

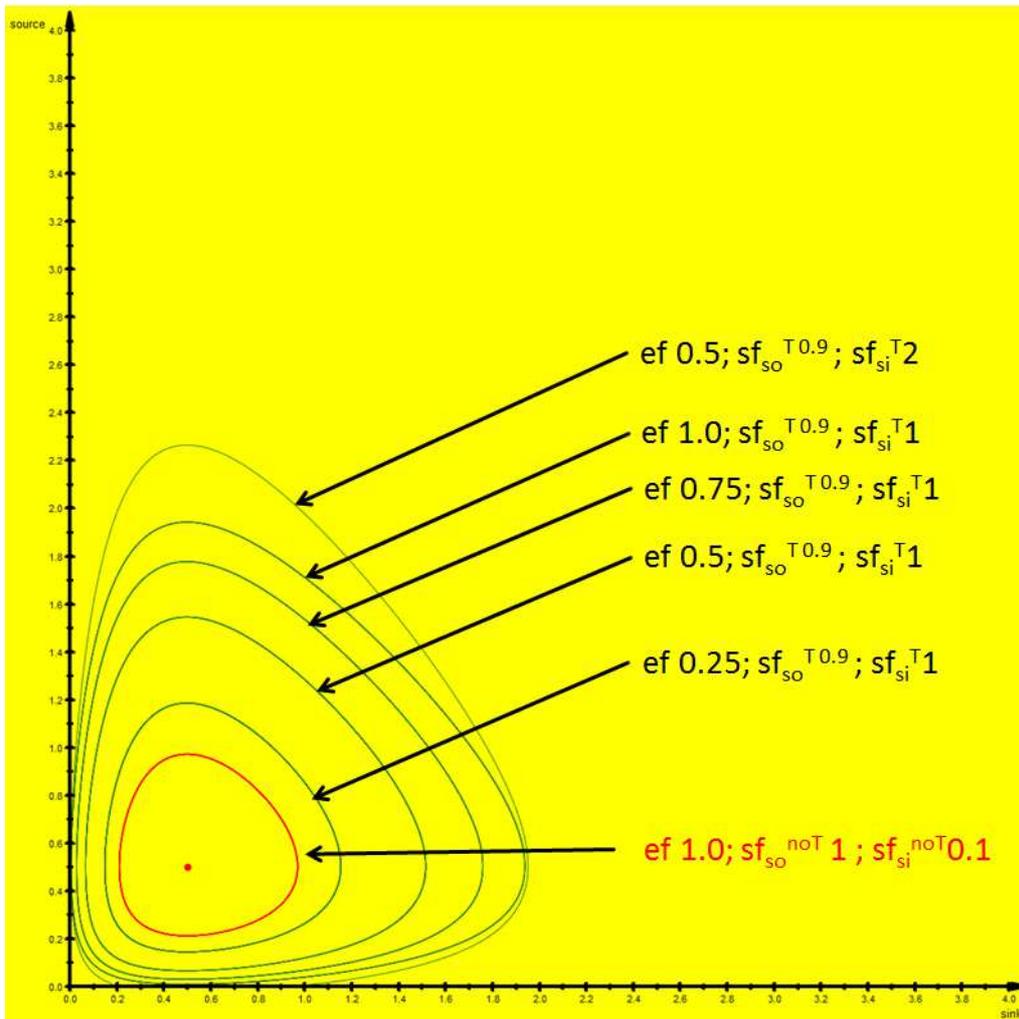


Figure 5: We look at a cross section (top down) within the reference surface similar to figure 3D and 4D. The red dot is the maximal value of figure 1 at a single concentration in source and in sink (0.5mM). This maximum is surrounded by one red and several green curves. The different ef and sf are indicated within the picture. All other variables are identical.

We observe a series of concentric curves in the plane of the reference surface. “No transfer” with $ef_{1.0}$ and $sf_{si}^{noT} 0.1$ results in the smallest curve (red). The curve with $ef_{1.0}$ is the largest of all curves with sf_{si}^{T1} . However, rising to sf_{si}^{T2} will be better even if the entanglement drops to $ef_{0.5}$. The surface areas above the reference surface can also be calculated: $ef_{0.25}; sf_{si}^{T1}=2.52(\text{mol/l})^2$. $ef_{0.5}; sf_{si}^{T1}=9.74(\text{mol/l})^2$. $ef_{0.75}; sf_{si}^{T1}=21.26(\text{mol/l})^2$. $ef_{1.0}; sf_{si}^{T1}=37.06(\text{mol/l})^2$. $ef_{0.5}; sf_{si}^{T2}=59.83(\text{mol/l})^2$.

In figure 6 we look at cross-sections of figure 5. 6A is parallel to the source axis and 6B is parallel to the sink axis; both cross-sections through the red dot.

Figure 6

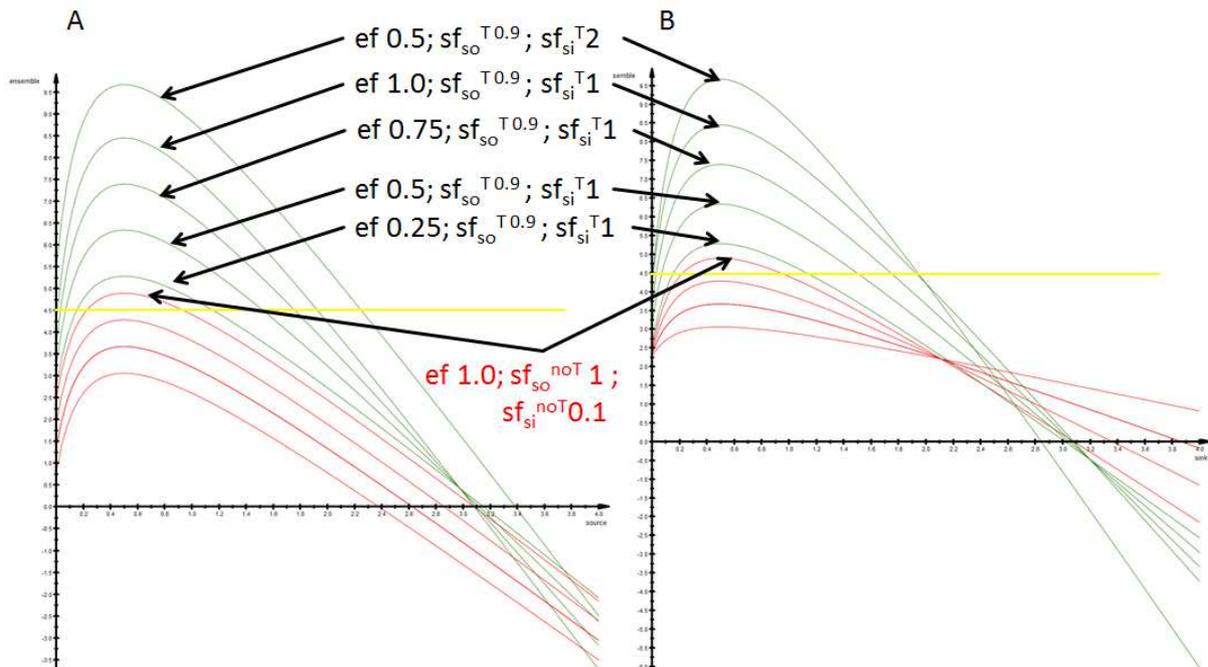


Figure 6: We look at a cross section parallel to source (A) and sink (B) axis through the red dot (0,5mM, figure 5). The different graphs are identified within the picture. All active ensembles cross the yellow reference line (reference surface in figure 5). In active ensembles the success factor of source drops from $sf^{noT}1.0$ to $sf^T0.9$ while sf in sink rises from $sf^{noT}0.1$ to sf^T1 . Here the graphs under the yellow reference surface are visible, too. They are the inactive ensembles of ef0.25, ef0.5 and ef0.75 (bottom to top). The success factor within the inactive ensemble is $sf_{so}^{noT}1$ for source and $sf_{si}^{noT}0.1$ for sink. The yellow line is the side view of the reference surface.

From figure 6 A and B it is understandable why in figure 5 only ef1.0, $sf^{noT}1$ of the inactive ensemble was visible. The other inactive ensembles are hiding below the reference surface.

In figure 7 we compare 2 groups of two ensembles with an entanglement of $ef=0.5$. Group A: $sf_{so}^{noT}=1$, $sf_{so}^T=0.9$, $sf_{si}^{noT}=0.1$, $sf_{si}^T=2$ with group B: $sf_{so}^{noT}=1$, $sf_{so}^T=0.9$, $sf_{si}^{noT}=2$, $sf_{si}^T=2$. The source pays always a cost in case of transfer but in B the success of sink is independent from transfer or no transfer.

Figure 7

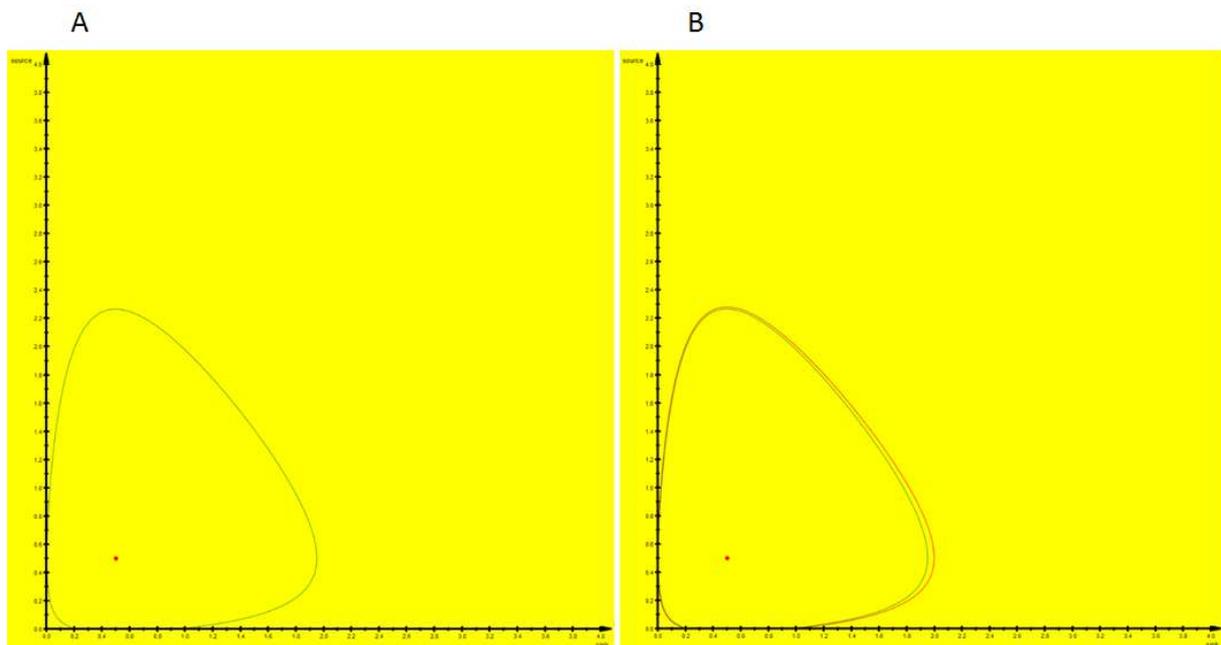


Figure 7: A top down view on reference plane with green and red graphs of active and inactive, dependent, symmetric, entangled ensembles. We compare 2 groups of with entanglement $ef=0.5$. Group A: $sf_{so}^{noT}=1$ drops to $sf_{so}^T=0.9$; $sf_{si}^{noT}=0.1$ increases to $sf_{si}^T=2$; here the success of sink depends on transfer. Group B: $sf_{so}^{noT}=1$ drops again to $sf_{so}^T=0.9$ and $sf_{si}^{noT}=2$ is equal to $sf_{si}^T=2$; now success is independent of transfer.

In figure 7A the net profit of sink is dependent on transfer of substrate within the ensemble. We only observe a green curve enclosing all concentration pairs of source and sink equal to or better than the reference surface. Without transfer the red surface of the dependent, entangled, symmetric and inactive ensemble is not able to even touch the reference surface, we can't see the red surface hiding under the yellow surface. In figure 6B, the net profit of sink is independent of

transfer within the ensemble. We observe that now the dependent, symmetric, inactive ensemble (red curve) is slightly better than the active ensemble (green curve). We already know from our initial observations that transfer is reasonable in entangled parties when the increased success factor in sink compensates the decreased success factor in source even at low substrate concentrations in source. However, in case the success factor of sink is independent of substrate transfer the ensemble with no transfer will have a better net profit.

Now I compare entangled parties with non-entangled parties. Entanglement is a double edged sword. It is a powerful feature when two parties share high quality. It will be a problem if low quality is shared within two parties. But not sharing any quality should be always inferior. The question is whether an increased success factor is able to compensate for a lack in entanglement.

In figure 8 we observe the complex behaviour of the ensembles. The compensation of entanglement $ef_{0.5}$ with sf_{si}^T1 (fig. 8; arrow 4) by a not entangled ensemble (ef_0) is only possible at sf_{si}^T2 (fig. 8; arrow 3). This compensation however is not valid for all concentrations in source and sink. An entanglement of $ef_{0.5}$ with sf_{si}^T2 can be compensated in ef_0 by $sf_{si}^T2.5$ (fig. 8, arrow 1 and arrow 2). The blue curve is deformed and only at a few concentrations pairs (high and very low concentrations) the not entangled ensemble is superior. The compensation in the absence of entanglement is only a local phenomenon. In all other areas the entangled ensemble is still superior. At the same degree of entanglement ($ef_{0.5}$) a higher success factor ($sf_{si}^T2 > sf_{si}^T1$) will compensate at all concentrations (fig. 8 arrow 2 and 4). At sf_{si}^T2 ef_0 is always inferior to $ef_{0.5}$ (arrow 2 and 3).

Figure 8

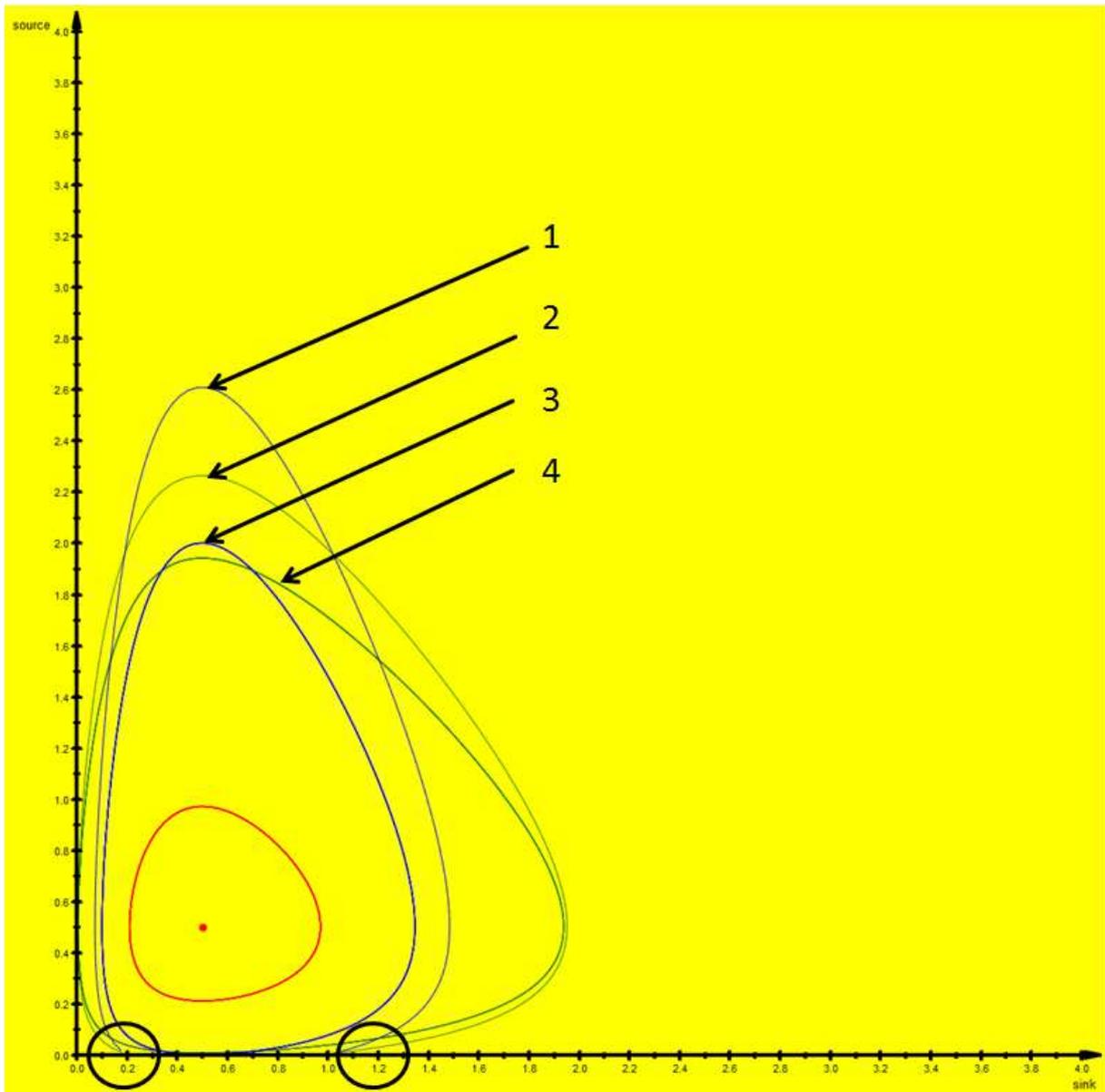


Figure 7: We look (top down) at a cross section within the reference surface similar to figure 5. The red dot is the maximal value of figure 1 at a single concentration in source and in sink (0.5mM). This maximum is surrounded by one red and several green and blue curves. They differ in ef and sf . All other variables are identical. The red is the inactive ensemble with ef_1 and $sf_{si}^{noT}1$. The other curves (green and blue) belong to active ensembles. All blue curves belong to ef_0 and all green curves belong to $ef_{0.5}$. Arrow 4 points to an entangled ensemble with $ef_{0.5}$, $sf_{so}^T0.9$ and sf_{si}^T1 , arrow 3 points to a not entangled ensemble (ef_0 , $sf_{so}^T0.9$ and sf_{si}^T2). Arrow 2 points to an entangled ensemble with $ef_{0.5}$, $sf_{so}^T0.9$ and sf_{si}^T2 and arrow 1 points to an ensemble with no entanglement ef_0 , $sf_{so}^T0.9$ but $sf_{si}^T2.5$. The two black circles highlight the areas of better net profit in not entangled parties with better success factor at low substrate concentration in source.

In direction of source (fig. 9A) we observe local superiority of the not entangled ensemble but in direction of sink the not entangled ensemble is never superior (fig. 9B) above the reference surface. Below the reference surface self-investing ensembles are always a competitor.

Figure 9

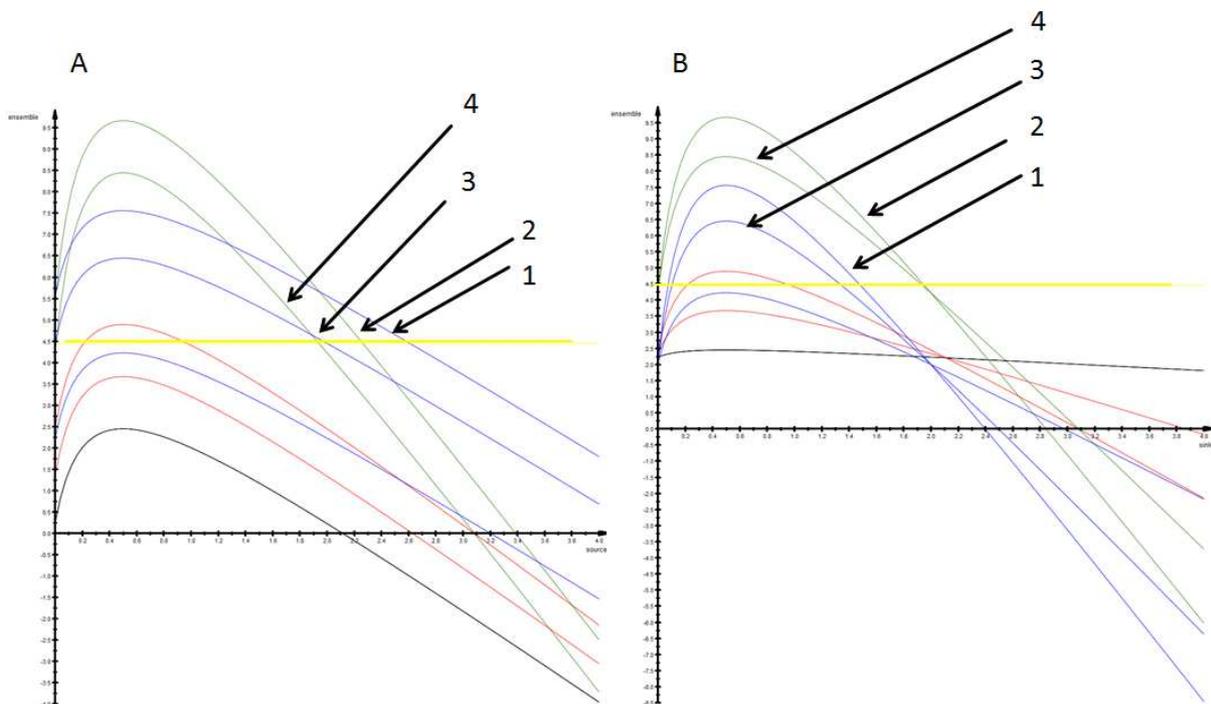


Figure 9: Again we look at a cross section parallel to source (A) and sink (B) axis. Active ensembles are all above the yellow reference line (reference surface in figure 8) including one inactive clone (red). The numbering of arrows complies with figure 8.

Below the yellow line we observe hitherto unseen ensembles. The blue graph is an active not entangled ensemble (ef_0) with $sf_{so}^T 0.9$, $sf_{si}^T 1$. The red graph is an inactive ensemble with $ef_0 0.5$; $sf_{so}^{noT} 1$, $sf_{si}^{noT} 0.1$. The black graph is an inactive, not entangled ensemble (ef_0 ; $sf_{so}^{noT} 1$, $sf_{si}^{noT} 0.1$). In active ensembles the success factor of source drops from $sf_{so}^{noT} 1.0$ to $sf_{so}^T 0.9$ while the success factor in sink rises from $sf_{si}^{noT} 0.1$ to $sf_{si}^T 1$.

In non-entangled ensembles the success factor is able to compensate for missing entanglement, however only to a small extent in a certain region of the transfer space. The source invests at high or low substrate

concentrations and the ensemble of strangers will be locally superior to an entangled ensemble with lower success factor (fig. 9A, 1 vs. 2 and 3 vs. 4). This is a local phenomenon because the entangled ensembles are superior in all other concentrations. In the absence of entanglement the source will not get back its investments in terms of quality. It pays only for the sink and therefore also for the ensemble. The reason is that substrate is moved to a place not of better productivity but of higher success. The source loses substrate and net profit in terms of quantity without participating in a high quality increase. The sink gets quantity and in addition does not participate in the quality loss in source. This all is a heavy load for the source. As the substrate decreases in source the ensemble of strangers will lose the local superiority in the next period. In case both success factors of source and sink are identical the decreasing substrate in source will not be compensated by an increase in sink (non-linear relationships). Over several periods the ensemble will lose the source. The local improvement of the ensemble means for the source an improvement of general quantity but not of personal quality. At the same success factor it is even better not to invest in ef_1 than to investment into ef_0 .

Success factor and entanglement factor are able to compensate each other also in entangled parties. This is demonstrated in figure 10 and 11. The difference in entanglement has been adjusted to $ef_{0.25}$ and $ef_{0.5}$ within the two compared ensembles. The success factors in both ensembles have been chosen so that at low entanglement the success factor will be larger than at higher entanglement. In figure 10 we have a top down view of a cross section within the reference surface,

Figure 10

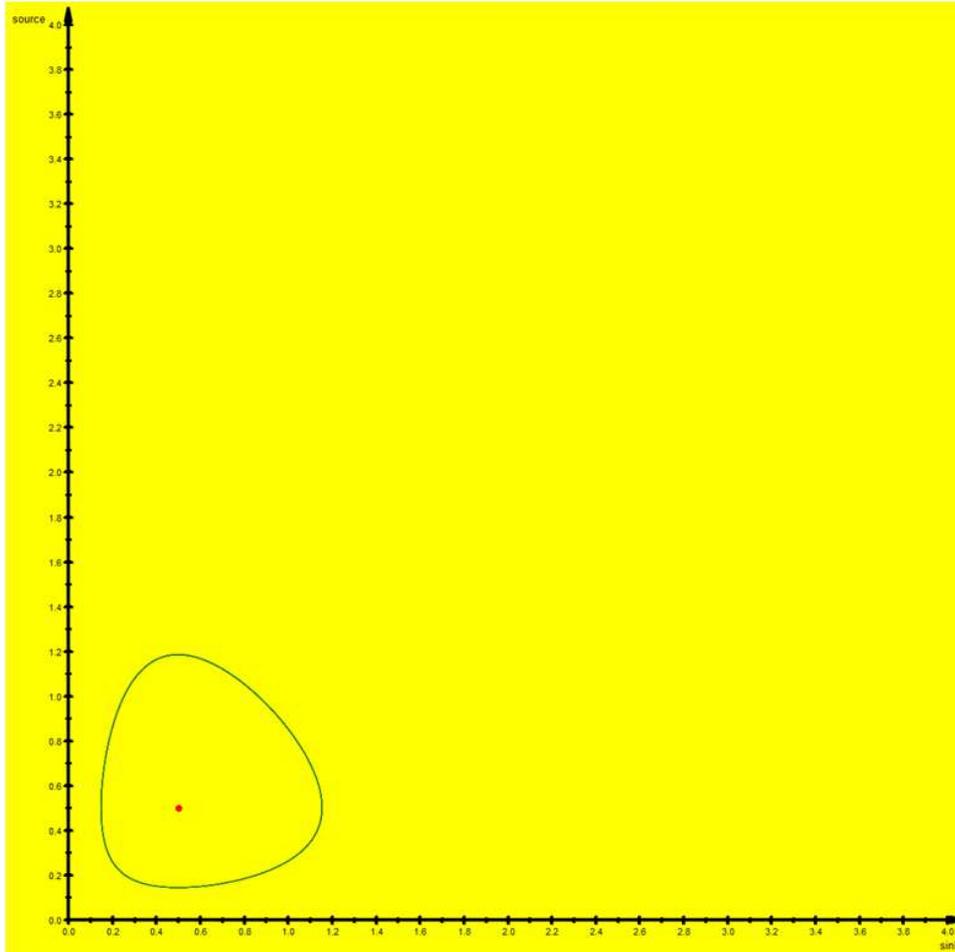


Figure 10: We look at a cross section within the reference surface. The red dot is surrounded by a single green curve of an ensemble with a source ($ef_{so} 0.25; sf_{so}^T 0.9$) investing in a sink ($ef_{si} 0.25; sf_{si}^T 1$). No curve of $ef_{so} 0.5$ is visible.

Only a single curve of the ensemble with low entanglement but high success factor is observable. The other curves hide under the reference surface (fig. 11).

Figure 11

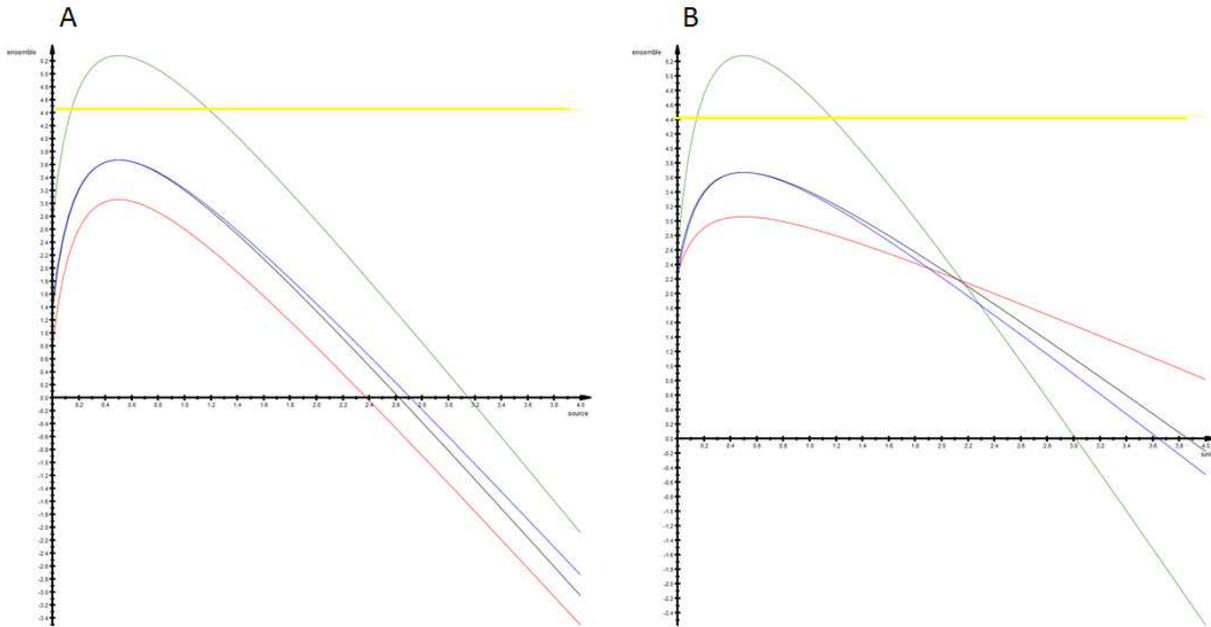


Figure 11: The cross section parallel to source (A) and sink (B) axis of figure 9 shows much more details. Only one active ensemble (green, source $ef_{0.25}$; $sf_{so}^T 0.9$ and sink $ef_{0.25}$; $sf_{si}^T 1$) is above the yellow reference line (reference surface in figure 10). The same ensemble but inactive (source $ef_{0.25}$; $sf_{so}^{noT} 1$ and sink $ef_{0.25}$; $sf_{si}^T 0.1$) is represented by the red graph. A transfer of substrate increases the success factor of sink by a factor of 10.

The blue graph is an active ensemble with $ef_{0.5}$ (source $ef_{0.5}$; $sf_{so}^T 0.9$ and sink $ef_{0.5}$; $sf_{si}^T 0.2$). The black graph is the inactive ensemble with the same entanglement factor ($ef_{0.5}$) but “no transfer” (source $ef_{0.5}$; $sf_{so}^{noT} 1$ and sink $ef_{0.5}$; $sf_{si}^{noT} 0.1$). Here a transfer of substrate increases the success factor of sink only by a factor of 2.

The difference in entanglement ($ef_{0.25}$ and $ef_{0.5}$) is considerable. However, this difference is easily compensated by an increase in success factor after transfer from $sf_{si}^{noT} 0.1$ to $sf_{si}^T 1$ (red and green) in comparison to $sf_{si}^{noT} 0.1$ to $sf_{si}^T 0.2$ (black and blue). In the edge region at low net profit values (b-c, ensemble axis) the sequence is reversed in direction of sink (fig. 11B). As control the four surface areas above zero net profit ($b-c > 0$) have been calculated. (green: $ef_{0.25}$; $sf_{so}^T 0.9$, $sf_{si}^T 1 = 52,02(\text{mol/l})^2$. red: $ef_{0.25}$; $sf_{so}^{noT} 1$, $sf_{si}^{noT} 0.1 = 26,15(\text{mol/l})^2$. blue: $ef_{0.5}$;

$sf_{so}^T 0.9$, $sf_{si}^T 0.2 = 29,96(\text{mol/l})^2$. black: $ef 0.5$; $sf_{so}^{noT} 1$, $sf_{si}^{noT} 0.1 = 30,23(\text{mol/l})^2$. The lower entanglement ($ef 0.25 < ef 0.5$) is still compensated by the higher success factor ($sf_{si}^T 1 > sf_{si}^T 0.2$). It is not a local phenomenon.

The system is set up in a way that transfer always lowers the success factor of the source and will increase the success factor of the sink. What happens if a transfer lowers the success factor of a source to zero? Let us look at figure 12.

Figure 12

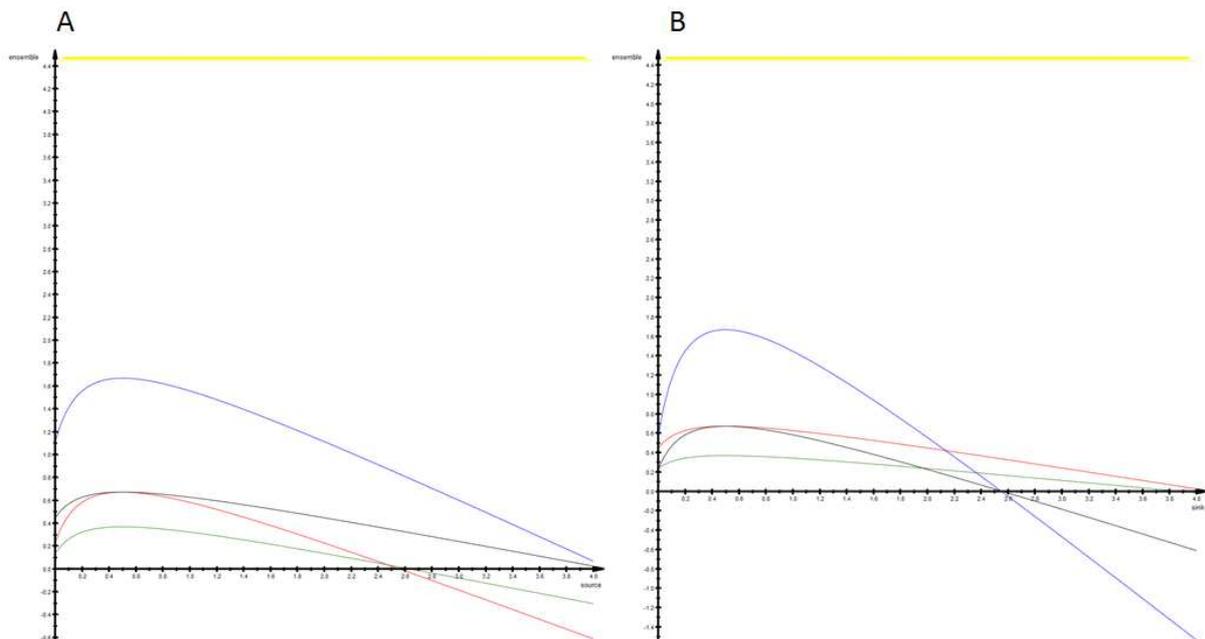


Figure 11: Again I compare two ensembles in an active (green, blue) and an inactive (red, black) state with cross sections parallel to source (A) and sink (B) axis at 0.5mM (red dot). Both ensembles share the same entanglement factor ($ef 0.5$) and different but very low success factors. All ensembles exist far below the yellow reference line. The green (active) and red (inactive) graph stand for an ensemble which will go on. Here $sf_{so}^{noT} 0.2$ drops to $sf_{so}^T 0.1$ in source while the sink will increase $sf_{si}^{noT} 0.001$ to $sf_{si}^T 0.01$. The blue (active) and black (inactive) graphs stand for an ensemble which will in case of activity end. Here $sf_{so}^{noT} 0.001$ drops to $sf_{so}^T 0$ in source while the sink will increase $sf_{si}^{noT} 0.2$ to $sf_{si}^T 0.5$ (complete consumption of source).

A top down view on the yellow reference surface is not given as all ensembles are far below this plane. The blue, active ensemble has the highest net profit. Here the complete source is consumed by the sink. However, although the source is lost, the ensemble has the best net profit. The surface areas of the positive net profit ($b-c>0$) is giving the same result as figure 12 (green: $ef0.5$; $sf_{si}^T0.01$, $sf_{so}^T0.1 =7.59(\text{mol/l})^2$; red: $ef0.5$; $sf_{si}^{noT}0.001$, $sf_{so}^{noT}0.2 =8.65(\text{mol/l})^2$; blue: $ef0.5$; $sf_{si}^T0.5$, $sf_{so}^T0 =13.27(\text{mol/l})^2$; black: $ef0.5$; $sf_{si}^{noT}0.2$, $sf_{so}^{noT}0.001 =8.65(\text{mol/l})^2$) and recalls the same message: neither feed nor beat nor ride a dead horse, take the saddle and leave.

In all considerations up to now there was a single source and a single sink. In consequence of this simple arrangement there was no alternative where the substrate would come from or where it would go to. Now I am going to look at one source investing in two entangled sinks and two (not entangled) sources investing in one entangled sink.

At first I test the effect of the same amount of substrate in two alternative sinks with different success factors but the same degree of entanglement ($ef0.5$). In the first alternative sink the transferred substrate will raise the success factor considerably from $sf_{si}^{noT}0.1$ to $sf_{si}^T0.6$ (blue curve, fig. 13) however to only a smaller final value than in the other alternative sink $sf_{si}^{noT}0.7$ to $sf_{si}^T0.8$ (green curve, figure 13). The increase of the success factor in the second alternative sink with the same amount of substrate would be much smaller but the final success factor would have a larger value than in the first alternative.

Figure 13

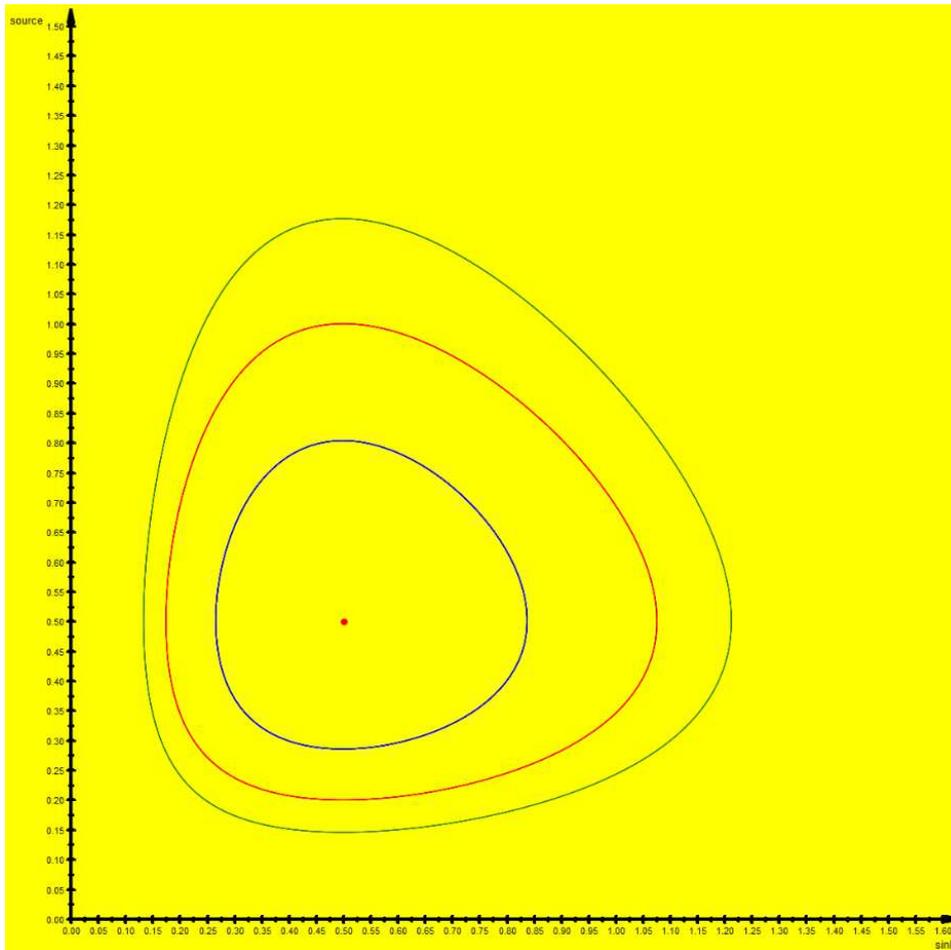


Figure 13: Again we look (top down) at a cross section within the reference surface. The red dot indicates the maximum of a not entangled and inactive ensemble (0.5mM). Three curves are visible. The green curve is an active ensemble: $ef_{0.5}$; $sf_{si}^T 0.8$, $sf_{so}^T 0.9$, the red is the same but inactive ensemble: $ef_{0.5}$; $sf_{si}^{noT} 0.7$, $sf_{so}^{noT} 1$ and a blue curve of an active ensemble: $ef_{0.5}$; $sf_{si}^T 0.6$, $sf_{so}^T 0.9$. The inactive ensemble belonging to the blue curve is under the yellow plane and therefore not visible (see figure 14).

The increase can be extracted from the surface areas above $b-c=0$:
 green: $ef_{0.5}$; $sf_{si}^T 0.8$, $sf_{so}^T 0.9 = 52.81(\text{mol/l})^2$; red: $ef_{0.5}$; $sf_{si}^{noT} 0.7$, $sf_{so}^{noT} 1 = 47.54(\text{mol/l})^2$; blue: $ef_{0.5}$; $sf_{si}^T 0.6$, $sf_{so}^T 0.9 = 42.66(\text{mol/l})^2$; black: $ef_{0.5}$; $sf_{si}^{noT} 0.1$, $sf_{so}^{noT} 1 = 30.23(\text{mol/l})^2$

Green surface minus red surface $= 5.27(\text{mol/l})^2$, 11% increase in surface area; final success factor $sf_{si}^T 0.8$

Blue surface minus black surface = $12.43(\text{mol/l})^2$, 41% increase in surface area; final success factor $\text{sf}_{\text{si}}^T 0.6$

A low increase in $(\text{mol/l})^2$ in one ensemble is connected to a high final success factor. A high increase in $(\text{mol/l})^2$ in the other ensemble is connected to a low final success factor.

Figure 14

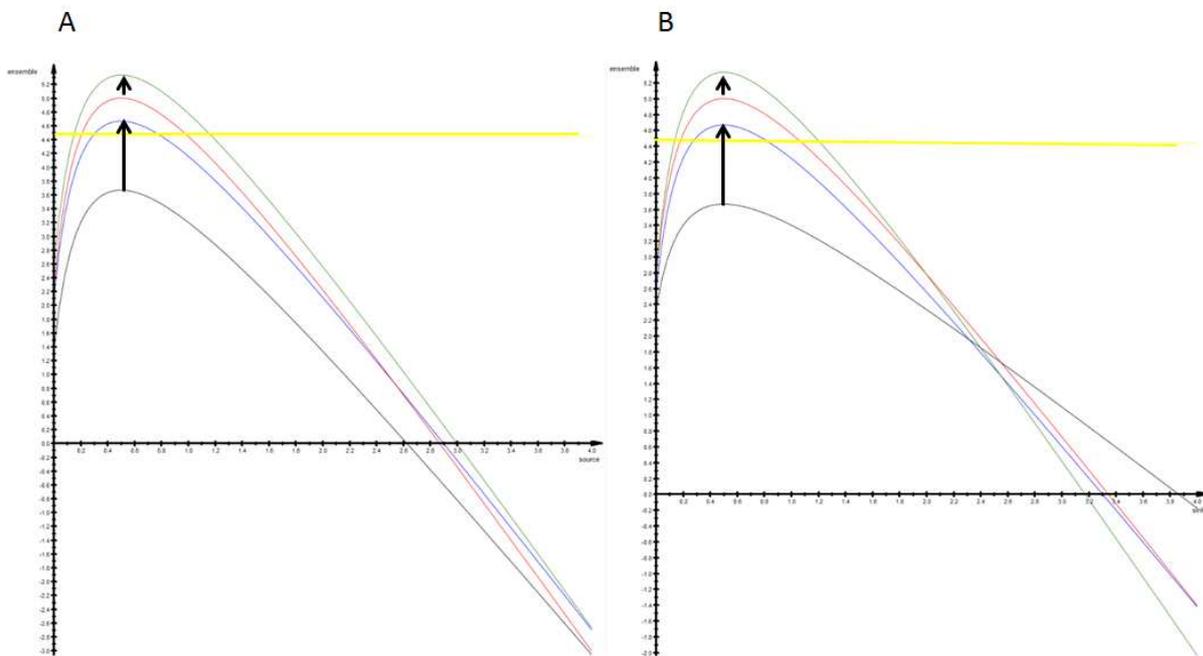


Figure 14: We see four graphs: The red graph is an inactive ensemble: $\text{ef} 0.5$; $\text{sf}_{\text{si}}^{\text{noT}} 0.7$, $\text{sf}_{\text{so}}^{\text{noT}} 1$. The green graph is an active ensemble: $\text{ef} 0.5$; $\text{sf}_{\text{si}}^T 0.8$, $\text{sf}_{\text{so}}^T 0.9$. The black graph is an inactive ensemble $\text{ef} 0.5$; $\text{sf}_{\text{si}}^{\text{noT}} 0.1$, $\text{sf}_{\text{so}}^{\text{noT}} 1$. The blue graph is an active ensemble: $\text{ef} 0.5$; $\text{sf}_{\text{si}}^T 0.6$, $\text{sf}_{\text{so}}^T 0.9$. The black arrows indicate the increase from the inactive to the active ensemble.

The second combinatorial possibility to “one source invests in two sinks” is “two sources invest in the same sink”. Many different combinations of entanglement and success factors are imaginable. As example I will concentrate on a performing and two underperforming ensembles with $\text{ef} 0.5$ between sources and sink. The two sources are determined to

make the final success factor of sink sf_{si}^T . Therefore, in an underperforming group of sources one source has to compensate for the lack of giving in the second source. As the production of benefit is a saturating function there will be nonlinear more to give for the performing source. In an underperforming sink both sources have to give in a nonlinear way more to compensate the underperforming sink. As there are now three parties the net profit of the ensemble is calculated according to:

$$\begin{aligned} & ((b_{so1}-c_{so1}) * ef_{so1} + (b_{si}-c_{si}) * ef_{si})_{so1} * sf_{so1}^{noT} + \\ & ((b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{so2} * sf_{so2}^{noT} + \\ & ((b_{so1}-c_{so1}) * ef_{so1} + (b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{si} * sf_{si}^{noT} \end{aligned}$$

$$\begin{aligned} & ((b_{so1}-c_{so1}) * ef_{so1} + (b_{si}-c_{si}) * ef_{si})_{so1} * sf_{so1}^T + \\ & ((b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{so2} * sf_{so2}^T + \\ & ((b_{so1}-c_{so1}) * ef_{so1} + (b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{si} * sf_{si}^T \end{aligned}$$

As there are now two sources the yellow reference surface is the maximal net profit of three self-investing parties. The red point is omitted.

Figure 15

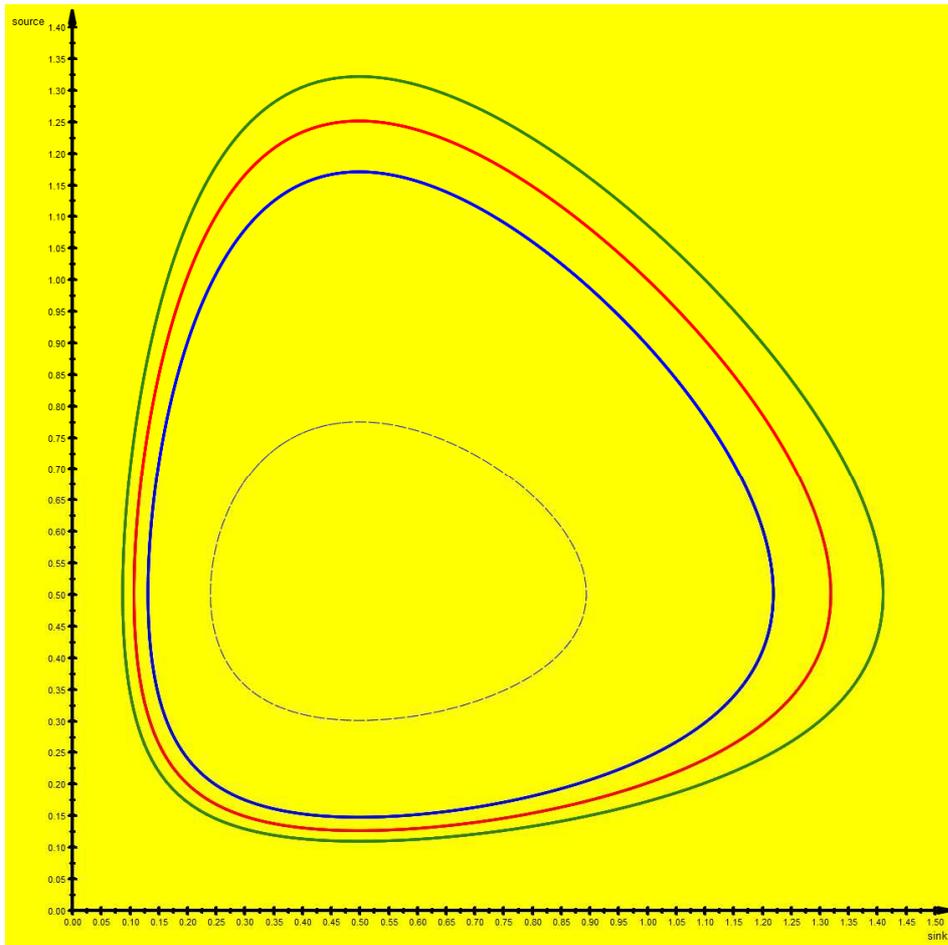


Figure 15: We see four curves on the reference surface (top down view) of three parties. The inner dashed curve is an inactive ensemble of three parties: $ef_{0.5}$; $sf_{si}^{noT}0.1$, $sf_{so1}^{noT}1$, $sf_{so2}^{noT}1$. The yellow surface indicates the maximum of three self-investing parties. The sources are entangled with the sink but not with each other.

The green curve is an active ensemble with three performing parties: $ef_{0.5}$; sf_{si}^T1 , $sf_{so1}^T0.8$, $sf_{so2}^T0.8$.

The red curve is an active ensemble with an underperforming source: $ef_{0.5}$; sf_{si}^T1 , $sf_{so1}^T0.6$, $sf_{so2}^{noT}0.9$. The second source gives less. This must be compensated by the first source to make sink reach sf_{si}^T1 .

The blue curve is an active ensemble with an underperforming sink: $ef_{0.5}$; sf_{si}^T1 , $sf_{so1}^T0.7$, $sf_{so1}^{noT}0.7$. Both sources have to give more to make sink reach sf_{si}^T1 .

In all curves the two sources are entangled with the sink by the same factor; $ef_{0.5}$. Without transfer the sink has a low success factor; $sf_{si}^{noT}0.1$. The two sources are not transferring; $sf_{so1}^{noT}1$, $sf_{so2}^{noT}1$. With transfer and three fully performing parties the sink will increase to sf_{si}^T1 while

both sources drop to $sf_{so1}^T 0.8$, $sf_{so2}^T 0.8$. However in case one of the sources will not give it's share ($sf_{so2}^T 0.9$) the other party has to compensate ($sf_{so1}^T 0.6$) so that the sink will still reach $sf_{si}^T 1$. As we deal with saturating functions one source has to give more in compensation than the other sources saves. In case the sink is underperforming both sources have to give more substrate ($sf_{so1}^T 0.7$, $sf_{so2}^T 0.7$) so that sink will still reach $sf_{si}^T 1$. Underperformance within an ensemble can't be compensated in a non-linear mathematical environment. An underperforming sink does more harm than one underperforming source.

Up to now I have assumed that transfer of substrate will decrease the success of source and increase the success of sink: $sf_{so}^{noT} \geq sf_{so}^T$ and $sf_{si}^T \geq sf_{si}^{noT}$. This is true for a substrate that will confer a positive net profit ($b > c$) to source and sink. It could be called simply an ease or advantage. The transfer of an advantage will be felt as a loss in source and as a gain in sink. In case we understand the success factor as a saturating benefit with a linear cost the transfer of a substrate could also confer a negative net profit ($b < c$) in source and sink and would have the meaning of a burden: $sf_{so}^{noT} \leq sf_{so}^T$ and $sf_{si}^T \leq sf_{si}^{noT}$. The transfer of a burden will be felt as a gain in source and as a loss in sink. Figure 16 contains an example for such a case.

Fig 16

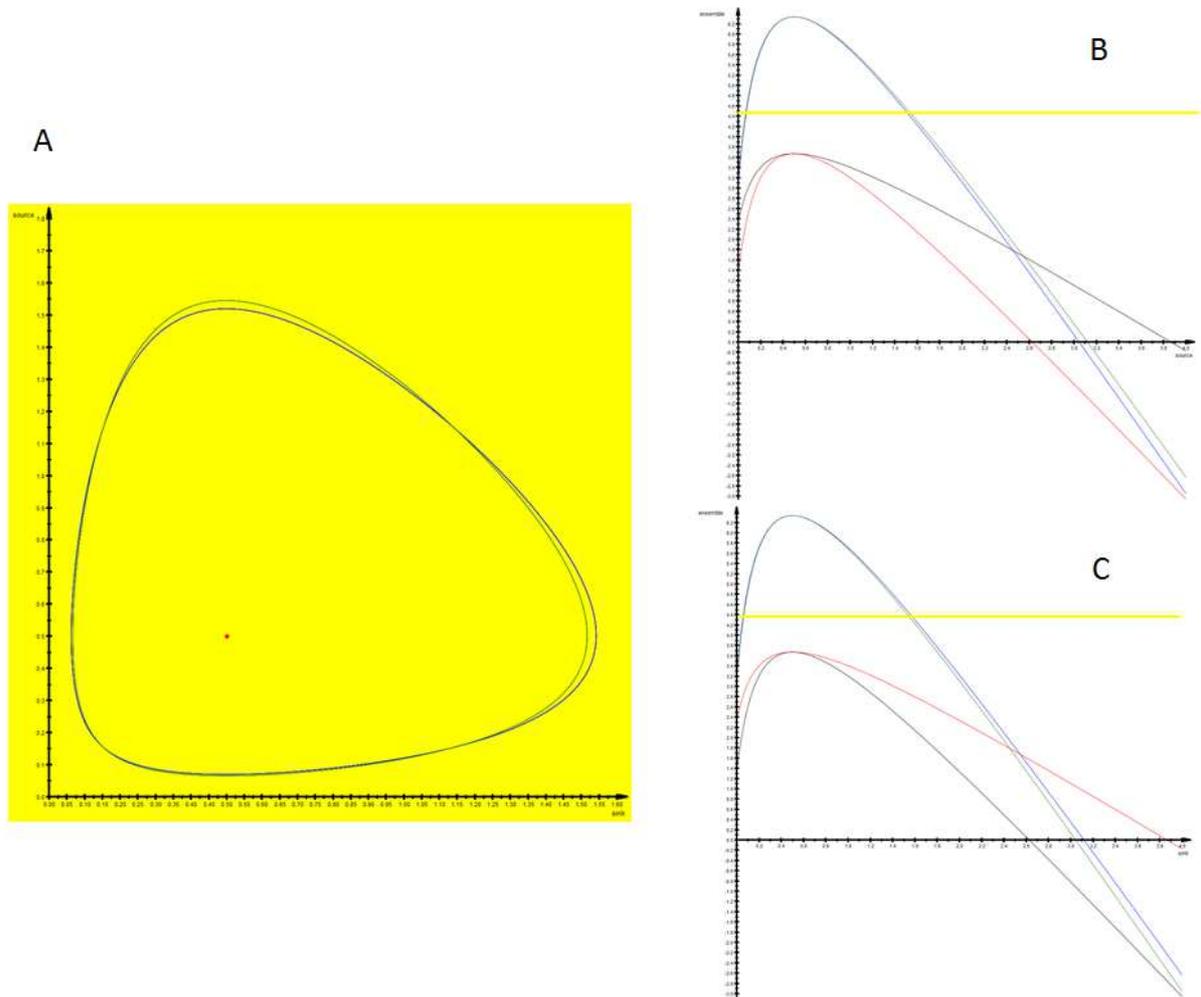


Figure 16: In picture A we look at a cross section within the reference surface. The green and blue curves belong to an active ensemble. The green circle stands for an ensemble transferring an advantage, the blue curve is an ensemble transferring a burden.

At 0.5mM we cut parallel to source (B) and sink (C) axis. The green (transfer) and red (no transfer) curves belong to the transfer of an advantage ($sf_{so}^{noT} \geq sf_{so}^T$ and $sf_{si}^T \geq sf_{si}^{noT}$). The success factors are set to: $sf_{so}^{noT}=1$; $sf_{so}^T=0.9$; $sf_{si}^T=0.1$; $sf_{si}^{noT}=1$. The blue (transfer) and the black (no transfer) curves belong to the transfer of a burden ($sf_{so}^{noT} \leq sf_{so}^T$ and $sf_{si}^T \leq sf_{si}^{noT}$). The success factors are set to: $sf_{so}^{noT}=0.1$; $sf_{so}^T=1$; $sf_{si}^T=0.9$; $sf_{si}^{noT}=1$.

The surprising observation is that transfer of a burden or transfer of an advantage is difficult to distinguish on the level of an ensemble.

Discussion

Discussion of the methodology

There are biophysical and biochemical reasons why cells do not grow endlessly. The most important reason is diffusion limitation (surface to volume ratio). Economic reasons are tightly linked to this reason. The productivity saturates (Michaelis-Menten-kinetics saturates like m^2/m^3) while the cost increases in a linear fashion. Division into smaller units is a way out of the biophysical problem. As the size is cut in half, the genetic information is doubled. The doubling of information is a key event in organisms. Two identical cells regain biophysical advantages but also gain new statistical advantages. The possibility to lose the complete genetic information by random accidents drops from a specific value to the square of this value in single celled life. The probability to acquire any mutation will double for the doubled genome.

So it is advantageous for cells to double.

Double counting is considered a severe mistake in all sciences. Exactly this seems to have occurred within this paper in consequence of the introduction of an entanglement factor to entangle source and sink.

Philosophic examinations on the relation of quantity and quality are colourful, complex and divers. In every-day life quality will be preferred over quantity and a lot of quality is preferred over a little quality. Quality is sometimes thought to arise from quantity including a phase transition. Quantity itself is interpreted as a type of quality by others. Counting is a measure to determine quantity. Quantity is basically a pure number (1, 2, 3, etc). "One meter" as example combines a quantity and a quality.

Quality is defined as: "The standard of something as measured against other things of a similar kind; the degree of excellence of something; a

distinctive attribute or characteristic possessed by someone or something.” Often a quality is described by words like “good or bad” and “high or low”. Although quality seems to be different in nature compared to quantity, quality can also be ranked by number (one or two smiley’s, 3 or 5 stars).

Quantity and quality seem to form the coordinate system of a two dimensional surface and each point on the surface is defined by an independent pair of both coordinates. Only in that surface we can discriminate between things of the same quantity but of different quality or *vice versa*. Quality is a dimension orthogonal to the dimension of quantity. If we observe only quantity quality will be a hidden variable.

Within the transfer space a substrate is transferred from source to sink; after transfer source and sink act independently. The source is orthogonal to the sink. The net profit will increase or decrease in source and will increase or decrease in sink. A high net profit in a sink with the transferred substrate is an indicator of high quantity and high quality of sink. In case both parties are by genetic information or otherwise informational entangled the aspect of high quality is also true to a certain degree for the entangled source – the quantitative aspect of the transferred substrate is missing as the source is orthogonal to the sink. The additional, quantifiable productivity takes place only in sink. The same is true for the consideration of lost productivity and lost or gained net profit in source. There is no double counting of quantity. Quality appears as potential quantity. Quality is a hidden feature. Shares increase in price when “good news” promises future net profit. This net profit has not yet been realized. When the dividend will be paid the shares will drop again. The price of a young racing horse will be determined according to the family tree. This is making use of genetic entanglement with real success of other, older horses.

Quantity and quality as well as source and sink are orthogonal dimensions. When we look at the ensemble we calculate the complete balance of the system of two parties. We look at a balance of genes or shares independent of their location in a top down manner (net profit of the ensemble) with a bottom up concept (separated results in source and sink). Genes and shares have always two aspects – quantity and quality. The net profit axis is now a combined axis summing up quantitative and qualitative aspects of the ensemble consisting of source and sink.

Cell division is a new type of quantity in comparison to a single cell of the double size. It is a transformation of quantity into quality – a new independent dimension appears. The cells have become physically and quantitatively independent. The (genetic) information is still identical in both new cells; they are qualitatively entangled. Entanglement starts with the appearance of similar or identical information in a new, independent organism (location). This is very similar to the viewpoint in Quantum-Physics: *“An example of entanglement occurs when a subatomic particle decays into a pair of other particles. These decay events obey the various conservation laws, and as a result, the measurement outcomes of one daughter particle must be highly correlated with the measurement outcomes of the other daughter particle.”* (Quantum entanglement - Wikipedia)

The term “correlation factor, cf” could have also been used instead of “entanglement factor, ef”. Correlation indicates a statistical relationship of two data sets or random variables. In a positive correlation the probability of one observation will increase with another observation. Both observations have lost statistical independence but a causal relationship is not necessarily indicated. In my biological examples the parties are connected by identical (ef1, clone) or similar (e.g. ef0.5, parent-offspring) genetic information. There is a causal reason for identical or similar

biologic and biochemical observations; the genes and DNA are identical or similar. Entanglement is like correlation an indicator of deviation from random observations but we know the reason.

After transfer we observe a real net profit change in sink; a quantity. I conclude from this observation a qualitative net profit change in source. In reverse I observe a net profit change of quantity in source and extrapolate a net profit change of quality in sink. I use direct proportionality and a linear relationship. This may be different in other areas. In Economy and Biology also trade-offs are observed; more quantity will mean less quality. Negative entanglement is imaginable and would be caused by any information increasing the probability of an observation not to be made $(1-p)$. The size of entanglement of source and sink could be a function of and depend on other (changing) factors or change with time. Entanglement could also be a result of a saturating and a linear component, again. However, entanglement then is no longer a fixed long term component like in kinship.

The self-entanglement of source $(ef_{so}1)_{so}$ and sink $(ef_{si}1)_{si}$ is not changing the system. The appearance of a second, informational entangled but physically independent party is the important step. My model is completely different to all game theoretical models. I do not observe a single party interacting with other parties and strategies. It is necessary to understand what it means to explore an ensemble. Although an ensemble consists of two parties, the ensemble surface (in transfer space and ensemble space) is no indicator for the fate of the single party. As long as we examine source and sink we do not see the ensemble but when we look at the ensemble, source and sink are no longer separately tangible. The reason is that source and sink are two

dimensional, orthogonal entities while the ensemble is a three dimensional entity. The entangled ensemble unites quantities and qualities as well as source and sink.

Discussion of results

Observation is the key to understand reality – not wishful thinking. Parents feed offspring – in some species, in others not. Sometimes the parents are consumed by offspring (parental cannibalism). In some species offspring feeds parents, sometimes to an extent that the offspring is consumed (filial cannibalism). Why do parents feed offspring although they are hungry? Why do wolves feed littermates while some sharks cannibalize their littermates in the womb; but isn't that basically the same? We observe sterile young females (worker cast in e.g. bees or ants) and sterile old females (menopause). All these observations are the result of economic decisions. The economic decision process of all organisms has been shaped and optimized by evolution. What is the underlying common mechanism of the different and partly opposing decisions on the level of individual organisms?

In figure 1 we look at a symmetric ensemble of two not entangled, no substrate transferring parties. They only invest in themselves. The saturating benefit and the linear cost in both sides lead to an optimum of single (two dimensional) and combined (three dimensional) net profit. Further increase in benefit will be exceeded by the increase in cost. This achievable maximum serves now as reference. The yellow surface has the same value as the red dot, the peak of the combined net profit.

In figure 2 both sides are entangled by $ef=0.5$. They share 50% quality as 50% of the (genetic) information is identical. The net profit axis is now a combined axis of quantity and quality. All other properties of the two parties remain unchanged. This inactive ensemble is in many combinations of substrate concentrations superior to the best value of the inactive and not entangled ensemble of figure 1 not sharing quality.

Although the ensemble in figure 3 is biochemically (K_m , V_{max} ; cost) still symmetrically the ensemble has become asymmetric due to the fact that the success factor of one side (here called sink) is now much smaller ($sf_{si}^{noT}=0.1$). It is an ensemble with a weak party. This low value and an entanglement factor of $ef=0.5$ indicate that this party is an offspring - a young, small and unexperienced entity. This inactive ensemble has a low net profit below the reference surface.

Offspring is in many species protected and nourished by at least one parent. The ensemble becomes active and substrate is transferred to the offspring (fig. 4). The transfer of substrate with higher efficiency of productivity in offspring ($sf_{si}^{noT}=0.1$ increases to $sf_{si}^T=1$) and the symmetric entanglement of parent and offspring ($ef=0.5$) increase the net profit of quantity and quality within this ensemble considerable over the reference surface. The small loss of productivity in the parent ($sf_{so}^{noT}=1$ decreases to $sf_{so}^T=0.9$) results in a small loss of net profit; over-compensated by far in the offspring. The green surface appears in a concentration range in the parent where we also observe $b_{so} > c_{so}$. Such a condition has the biological meaning that even hungry parents feed offspring.

From previous papers (5, 6) it was already clear that a source gives deliberately when the source is in $b_{so}-c_{so} < 0$ or $b_{so}/c_{so} < 1$, a condition where the additional benefit is smaller than the additional cost of a substrate. Only completely (over)saturated parents would feed offspring.

In addition, they would under those conditions also feed non-relatives. One assumption was that the parent-offspring ensemble would be highly asymmetric. This is an option, but as parent and offspring share a lot of genes the biochemical asymmetry will be limited.

Now, after I introduced entanglement also a hungry parent will feed (only) offspring under the set conditions. The relationship of decrease and increase in success factor is a reasonable assumption. The loss of the same food portion for the mature parent ($sf_{so}^{noT}1$ to $sf_{so}^T0.9$) has a different meaning for success in comparison to the gain in success for the small and still growing offspring ($sf_{si}^{noT}0.1$ to sf_{si}^T1). As mentioned in my basic assumptions the success factor could be interpreted as a saturating benefit with a linear cost. It is reasonable to think of the grown parent as in a much more saturated overall condition than the still growing offspring.

In figure 5 we compare different degrees of entanglement. We could also say different degrees of relatedness. At a $sf_{so}^T0.9$ and sf_{si}^T1 the clone (ef1) ensemble is doing better than an ensemble of bee sisters (ef0.75) and they do better than an ensemble of parents and offspring (ef0.5) and they are better than an ensemble of grandparents and grandchildren (ef0.25). If I raise the success factor to $sf2$ only in parent and offspring they now do best although they are less related than a clone or bee sisters (still at $sf1$).

The nutritional state of a parent is an important factor for the success of both parent and offspring. Worker bees do not have own offspring; they are sterile, they never will be a parent. Some of their sisters (ef0.75) of a later generation (the future queens) are better nourished and probably therefore have a higher success factor than the workers. The workers do not have offspring to whom they would be entangled only by ef0.5 and

invest into their fertile sisters ($ef_{0.75}$). The flow of substrate is from a low success source to a high success sink and into higher entanglement. Bees and ants also feed the present queen, their mother. They are entangled by $ef_{0.5}$. The live span of workers during summer is only a few weeks in comparison to several years of their mother. The success factor (sf_{si}^T) of the mother is in consequence much higher. So the offspring as source feeds the parent as sink here. This is a reversal of the usual pattern where the older parent with shorter residual lives span and therefore lower success factor is the source for the much younger sink with a longer residual lifespan and therefore a better success factor. Also at equal entanglement the flow of substrate is from low success (source) to high success (sink). This is the usual pattern of economy where investors prefer the better success factor in their investment decisions.

Not all parents and offspring transfer substrate. Many species produce offspring and make no further investment. The investment of an ensemble has to consider several basic economic facts:

- Each portion of substrate can only be invested once. Either the old offspring is fed (better performance) or new offspring is produced (larger number).
- An increased investment in number will reduce the investment into performance or vice versa as the amount of substrate is limited.
- Transfer or no transfer of substrate may have opposite effects on the ensemble and single parties.
- The best ensemble will prevail.

Two different species with different investment strategies should not be compared to understand the underlying economic decision process. We have to compare within the same species two competing investment

strategies. Usually one of them will have already prevailed in the course of evolution and so the other is no longer observable. For an average genome the product of entanglement ($ef_{0.5}$) and success factor (sf_2) is one. This means that the genome is maintained within the population although it is diluted. It will neither increase nor decrease. The success factor is composed of many different to success contributing features. One of them is offspring number and the other is survival probability of parent or offspring. The ensemble making the best in parent and offspring out of the same food portion will prevail. Two opposing strategies are easily recognized with many shades of grey between them. The two strategies are a pure number (statistical) strategy with thousands or millions of offspring or a performance strategy with only a few offspring but additional investment later into the offspring. In figure 7 we observe such two different ensembles. In 7A we observe offspring who needs help. Only after transfer of substrate (feeding, protection) we observe a successful ensemble (green). In 7B offspring needs no help. Now the non-transferring ensemble (red) is more successful than the transferring ensemble.

Care within genetically entangled ensembles (genetic reciprocity) is successful in case the care recipient is responding with a strong increase in success factor. In human societies help to genetically unrelated persons is observed – usually under conditions of surplus or severe hardship. Is the model able to reveal this, too? Therefore, the entanglement between source and sink is reduced to zero (ef_0 , strangers, not genetically entangled). Two messages can be extracted from figure 8. At an identical success factor “no help” to a clone (red curve, fig. 8) is still much better than help to a stranger (fig. 9A, 9B; blue graph below the yellow reference line; red graph above the yellow reference line).

However, the model is able to demonstrate local superiority of an ensemble with transfer between strangers at high and very low substrate concentrations in combination with a higher success factor (figures 8, and 9A and 9B) than in a comparable entangled party. The success factor is able to compensate for absent entanglement locally. Surprisingly there is room for charity in this completely selfish and rational model. The invested substrate is lost to the source. But the ensemble of strangers is doing locally better at a higher success factor than the biologically entangled ensemble at a lower success factor. In man a success factor is an argument *per se*. Therefore, in non-entangled human ensembles the size of success factors will be a central aspect of discussions and manipulations. A second ingredient will be the fabrication of apocalyptic stories with a scenario of hardship and menace as evolution has taught our species that giving to non-entangled parties is only useful then. The ensemble will end when in repeated cycles the source is constantly giving without the ability to regenerate in an open system.

An increased success factor is able to completely compensate lower entanglement ($ef > 0$). The case examined here (fig. 10, 11) has a biological meaning. Old females in the family of the four great apes (*Hominidae*) still bear offspring with the exception of humans. Menopause in human females renders old females sterile – why? Figures 10 and 11 suggest an answer. At a certain relationship of success factor to entanglement the investment of a grandmother into her grandchild ($ef > 0.25$, $sf_{so} > 0.9$, $sf_{si} > 1$) is better than an investment into her own child ($ef > 0.5$, $sf_{so} > 0.9$, $sf_{si} > 0.5$) at lower success factor. The reason is that the death of an old mother before the child becomes independent is a probable event, due to the long childhood phase in humans. In that

case all investments into her child are lost. The same investment into her grandchild ($\epsilon f_{0.25}$) will not be lost as there is still the younger mother, her daughter ($\epsilon f_{0.5}$). This observation is supported by data from human populations (9).

Besides setting the entanglement factor to zero (ensembles with strangers) the success factor can also be set to zero. Such an ensemble will end. For all the other ensembles there may be a next round. There are a lot of ensembles where we observe the last round in Biology. Below the yellow reference surface self-investment would be better. However this decision may be no longer an option. The question may now be: What is the smallest evil? The smallest evil could be to completely give up the sink, convert it to a source (fig. 12 blue) and make the most of it in this time period, which will definitively be the last time period for this ensemble. The green, red and black ensemble chooses unending terror by transfer or by inactivity while the blue ensemble chooses a terrible end. The end of an ensemble could have the meaning that one party will be lost completely. The other party will go on and be part of a new ensemble. The example in figure 12 could be interpreted as a model for cannibalism between parent and offspring ($\epsilon f_{0.5}$). Two forms of cannibalism are observed. Offspring feeds on parent and parent feeds on offspring. In such extreme cases the success factors of source and sink are assumed to be very low. In case the source transfers everything to the sink the success factor of the source becomes zero ($sf_{so} \rightarrow 0$). The example in figure 12 could be read as follows: The parent feeds the offspring but the success factor stays very small. In addition, transfer is a severe mistake as the loss in the adult is not overcompensated by the offspring (green). In case of the blue graph the offspring now acts as source (back)-transferring everything to the parent.

The parent survives with a much better success factor ($sf_{si}^{noT}0.2$ increases to $sf_{si}^T0.5$). Such a parent may start in the next round with new offspring much better than the parent with a surviving but low quantity offspring.

On the other side of rational charity to strangers (fig. 8) we find rational self-abandonment (fig. 12). Biologic entanglement in parents is $ef0.5$. Biologic success factors are difficult to determine but tend to be in average genes of $sf2$ ($ef0.5*sf2=1$). Entanglement is a matter of information. Besides genetic information there is cultural information. In human societies success factors as well as entanglement seems to be modifiable by deception and force. The ability to modify the perception of these factors opens a wide field for irrational outcome of rational decisions. Brotherhood ($ef0.5$) may be claimed where entanglement is near zero ($ef0$), success factors may be artificially increased with the promise of eternal life and endless material or immaterial rewards in a next live. In such a scenario of manipulated entanglement and success the own life and well-being may become rationally expendable. In this concept it is no longer necessary to manipulate the perception of hard facts like cost or benefit. Maybe it is much easier to manipulate the perception of soft factors or hard to check factors like success factor or entanglement.

The next example (fig. 13, 14) is an example of a target conflict in Biology and Economy. Both aims – maximal increase of success factor per investment and largest success factor per same sized investment – can't be reached simultaneously as the underlying functions are saturating. A just or equal distribution of the substrate between the two

parties will not help and would not be reasonable. In Biology this is called parent-offspring conflict (10, 11). The parent tries to maximize the success factor within the younger offspring making the most out of the transferred substrate while the older offspring fights for more food to realize the better success factor. The ensemble has a conflict that can't be resolved and has not been resolved by evolution. The distance between the blue and green curve is a direct measure for the intensity of the conflict. And yet, there is a solution when the success factors become similar over time so that the distance between blue and green curve will vanish. In addition, the model could be modified taking the relatedness of both sinks into account. Both sinks are either entangled by a factor of $e^{0.5}$ (siblings) or $e^{0.25}$ (half-siblings). Including the entanglement of the two sinks, the conflict would be resolved even sooner.

$$((b_{so}-c_{so}) * ef_{so} + (b_{si1}-c_{si1}) * ef_{si1} + (b_{si2}-c_{si2}) * ef_{si2})_{so} * sf_{so}^{noT} +$$

$$((b_{so}-c_{so}) * ef_{so} + (b_{si1}-c_{si1}) * ef_{si1} + (b_{si2}-c_{si2}) * ef_{si2})_{si1} * sf_{si1}^{noT} +$$

$$((b_{so}-c_{so}) * ef_{so} + (b_{si1}-c_{si1}) * ef_{si1} + (b_{si2}-c_{si2}) * ef_{si2})_{si2} * sf_{si2}^{noT}$$

and

$$((b_{so}-c_{so}) * ef_{so} + (b_{si1}-c_{si1}) * ef_{si1} + (b_{si2}-c_{si2}) * ef_{si2})_{so} * sf_{so}^T +$$

$$((b_{so}-c_{so}) * ef_{so} + (b_{si1}-c_{si1}) * ef_{si1} + (b_{si2}-c_{si2}) * ef_{si2})_{si1} * sf_{si1}^T \text{ (or } *sf_{si1}^{noT} \text{)} +$$

$$((b_{so}-c_{so}) * ef_{so} + (b_{si1}-c_{si1}) * ef_{si1} + (b_{si2}-c_{si2}) * ef_{si2})_{si2} * sf_{si2}^{noT} \text{ (or } *sf_{si2}^T \text{)}$$

In economy we observe the same target conflict. The classical investor's dilemma is either to invest at a low success factor with a high yield or invest with a lower yield at a higher success factor. The size of the short term success factor seems to be essential to completely or partially

compensate long term entanglement. In economic decisions the estimation of success factors can be influenced by true or deceptive information as already mentioned – e.g. like the starting of a Ponzi-scenario. In the greylag goose larger eggs are preferred over smaller eggs in rolling them back into the nest (12). The reason is that the success factor of a larger egg is better than of a smaller egg. Eggs are discriminated according to the size of the already made investment and the size of the resulting success factor. In consequence the goose will prefer large artificial eggs over their own eggs. In evolution of the economic decision process an upper limit neither in man nor in goose seems to have developed for success factors too large to be true.

Besides one source investing in two different sinks there is also the possibility that two sources invest in one sink (fig. 15). The biological equivalent here is the couple of male and female taking care for offspring and the importance of mate choice. Due to the non-linearity of benefit and net profit there will be no compensation for lack of performance in any party of an ensemble. Neither one of the parents nor the offspring should display a lack of performance. Mate choice has two aims: select a partner with good feeder attributes and good genes for successful offspring. We could here also introduce an additional entanglement between the two sources which would make them relatives.

$$((b_{so1}-c_{so1}) * ef_{so1} + (b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{so1} * sf_{so1}^{noT} +$$

$$((b_{so1}-c_{so1}) * ef_{so1} + (b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{so2} * sf_{so2}^{noT} +$$

$$((b_{so1}-c_{so1}) * ef_{so1} + (b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{si} * sf_{si}^{noT}$$

and

$$((b_{so1}-c_{so1}) * ef_{so1} + (b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{so1} * sf_{so1}^T +$$

$$((b_{so1}-c_{so1}) * ef_{so1} + (b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{so2} * sf_{so2}^T +$$

$$((b_{so1}-c_{so1}) * ef_{so1} + (b_{so2}-c_{so2}) * ef_{so2} + (b_{si}-c_{si}) * ef_{si})_{si} * sf_{si}^T$$

The entanglement of the two sources will increase the net profit with respect to shared quality but that would be inbreeding. The success factor of such offspring from genetically related sources will usually be smaller. The ensemble would have a bad performance finally. Not only the success factors in source and sink seem to be correlated but also the degree of entanglement between two sources will correlate to the success factor of the sink. In viscous populations inbreeding is observed regularly and could be taken into account in my model. The result obtained may also explain the formation of mating aggregations (lek) in birds. At low cost to wander around the females obtain an assessment of a quality type (attractiveness) and quantity (number of males) within a complete male genotype (all genetically related males within the lek) at the same place. The females obtain a top down view on a parental ensemble (the mother and father of the males).

In figure 16 we observe the transfer of a burden: $sf_{so}^{noT} \leq sf_{so}^T$ and $sf_{si}^T \leq sf_{si}^{noT}$. The biology behind this example is the observation that in many species with parental care offspring is carried. To move is an energy consuming behaviour. A single food portion can only be spent once – either for growth or for locomotion. It is important for offspring to grow as fast as possible to reduce certain risks associated with small body size. The offspring is now the source where weight is a relative big burden. The parent is the sink where the additional weight is only a small fraction of the total parental weight. When the offspring grows to a size comparable to the parent the smaller saving in the offspring is

outweighed by the larger cost in the parent. The ensemble stops to transfer the burden and the offspring has to move on its own.

In my calculations I have always assumed that both parents have the same entanglement with the offspring ($e=0.5$). This may be too simple. The mother confers much more genetic information (e.g. the genome of the mitochondria) to the joint offspring than the father. Maybe this was a starting point in evolution for the usual larger maternal investment into offspring. An entanglement of $e=0$ is also a matter of point of view. DNA sequencing and other biochemical facts prove that all life on earth has the same origin. This is the biological equivalent of a singularity. Therefore, it may be difficult to find $e=0$ in organisms on earth.

In many of my examples I have compared two different ensembles either transferring or not transferring substrate. This could also be understood as the same ensemble with behavioural alternatives depending on the actual success factor and the better outcome.

My paper could be falsely interpreted as a group-selection variant. Group selection is defined as: “a selection for traits that are beneficial to a population at the expense of the individual possessing the trait.” An ensemble consists of two biologic parties (source and sink) as diverse as male and female, parent and offspring, prey and predator, trees and root-fungi or bees and flowers. A large flock of migratory birds saving energy by formation flight is an ensemble as well as populations of a tolerant host and a virulent parasite outcompeting an ensemble of a less tolerant host and a less aggressive parasite (or *vice versa* when both ensembles are separated physically and the arms race is at a distance). In all examples the parties act selfishly. There is no negative trait in my model; only substrate with a better or worse net profit here or there. Such a

negative trait in group selection is altruism. Altruism is absent in my model. The ensemble concept is based on completely selfish acting entities. What counts is the outcome of an ensemble transferring substrate in competition with another ensemble not transferring substrate. Transfer under force may lead to suffering in one or both parties and yet the ensemble may have a better productivity. This has been called “wise exploitation” earlier. I would agree that “biological reciprocity” looks similar to “entanglement”. The use of quality within quantitative considerations reminds of the introduction of $\sqrt{-1}$ (i) and complex numbers. My interpretation is: entanglement is a bidirectional matter of quantity based quality shared by joint (genetic) information. Possibly other pairs of attributes - one visible, one hidden in two parties each - could be used in the context of entanglement. The complex ensemble of source (a) and sink (b) is: $Z_{e(so,si)}=(a+bi)+(ai+b)$. Net profit is only a complex vector of quantitative net-profit (a, b) and qualitative net profit (ai, bi).

Summary

The basis of all my calculations is a net profit analysis within each party of an ensemble separately followed by the calculation of the combined net profit with regard to quality and quantity before and after transfer of substrate. Economic rationality guides source and sink and yet irrationality may develop. The transfer space in combination with entanglement by genetic information and success factors in source and sink is basically a very simple model. Besides the beauty of the graphs and surfaces they appear to be meaningful for a large and diverse set of biological phenomena. This model roots completely in biochemistry and

is able to explain and unite a lot of different and contradicting observations in Biology and maybe in economy on the substrate money.

Final remarks

The aversion of selfishness and individual profit together with the idea to compare the benefit of one organism with the cost of another organism - genetically related or not - is basically a religious concept and roots in the parable of the "Good Samaritan" (13). To found biologic concepts on this ground may help to raise funds from wealthy religious foundations but is not science. There is no progress in getting the "Good Samaritan" out of equations (14) when you put him in first. Proceedings like this weaken the foundations of Biology and open a door to religious influence on scientific matters. The strategy behind is aimed at the justification of "*institutional designers moving away from the assumption of universal self-interest*" (15) and could be interpreted as attempt to lay foundation for dominant influence of external authorities with aura of moral superiority, infallibility and the final say. However, only the next experiment might have the final say.

Literature

1. Gordon, S. (1989) "Darwin and Political Economy: The connection Reconsidered"; Journal of the History of Biology 22(3): 437-459.
2. Bloom, A.J., Chapin III, F.S., Mooney, H.A. (1985) "Resource limitation in plants - an economic analogy"; Annual Review of Ecology and Systematics, Vol. 16: 363-392
3. Hamilton, W.D. (1964) "The genetical evolution of social behaviour. I"; Journal of Theoretical Biology 7 (1): 1-16.

4. Hamilton, W.D. (1964) "The genetical evolution of social behaviour. II". *Journal of Theoretical Biology* 7 (1): 17–52.
5. Friedrich, T. and Köpper, W. (2013) "Schumpeter's Gale: Mixing and compartmentalization in Economics and Biology"; University Library of Munich, Germany MPRA Paper 45405
6. Friedrich, T. (2014) "Work cycles of independent ensembles"; University Library of Munich, Germany MPRA Paper 55090
7. Segel, I.H. (1976) "Enzymes"; *Biochemical Calculations*, 2nd ed., Wiley, New York, Chapter 4
8. Wright, S.G. (1922) "Coefficients of inbreeding and relationship"; *American Naturalist* 56: 330–338.
9. Lahdenperä, M., Lummaa, V., Helle, S., Tremblay, M., Russell, A.F. (2004) "Fitness benefits of prolonged post-reproductive lifespan in women"; *Nature* 428: 178-181
10. Trivers, R.L. (1974). "Parent-Offspring Conflict"; *American Zoologist* 14 (1): 249–264
11. Godfray H.C.J. (1995) "Evolutionary theory of parent-offspring conflict"; *Nature* 376: 133-138
12. Lorenz, K. und Tinbergen, N., (1938) „Taxis und Instinkthandlung in der Eirollbewegung der Graugans“; *Zeitschrift für Tierpsychologie* 2 (1): 1-29
13. Bible "The Parable of the Good Samaritan"; New Testament, Gospel of Luke (10:29–37)
14. Nowak, M.A. and Highfield, R. (2011) "SuperCooperators: Altruism, Evolution, and Why We Need Each Other to Succeed"; Free Press, New York.
15. Hauser, O.P., Rand, D.G., Peysakhovich, A., Nowak, M.A. (2014) "Cooperating with the future"; *Nature* 511: 220–223