CHAPTER **E**

Economics and Business

"Invisible hand" comes into Henri's mind on Tuesday morning. His intent is to put together a brief business plan for the Flourishator product. He is confident of the potential benefits of the product, or at least, he is sure that the fundamental idea is credible enough. But what he is less sure is the how the benefits could be translated into a flow of money.

As an engineer, Henri is inclined to think about any system as a combination of forces and flows. Is the force behind economic actions the invisible hand? Sounds strange, Henri thinks. Surely, he had tried to understand the strange concepts of quantum physics, with limited success, he has to admit, and the invisible hand appears as strange a concept. Is it so that human pleasure is the driving force for something that we call economy? So, the more pleasure is pursued, the more active the economy will be.

Does that automatically mean that any economic activity increases pleasure or happiness? Maybe an invisible hand is needed to change the direction. He imagines a chain of logic: (pleasure $\Rightarrow$ money) & invisible hand $\Rightarrow$ (money $\Rightarrow$ pleasure). Henri decides to use a brisk walk to clarify his foggy mind before beginning to write the business plan.

If human delight is the main driving force for an ecosystem, an intermediate force must be able to carry the energy through the whole ecosystem. Money, of course, is used for that purpose in the economic part of the ecosystem. That fact reminds him about his somewhat poor fiscal state; he really needs to make some money during summer vacation. On the other hand, Irene wants them to spend some time in Italy together. He is not sure whether he is able to handle all those urgent needs properly.

Shall he be selfish? Perhaps, if everyone just pursues his own interest, everyone would benefit. Is that really true? Henri wonders while walking through the campus area hardly noticing that it has started snowing. If I have a need to delight my friend, and someone had invented a novel product that might be able to serve that need, will something automatically happen in a way that everyone gains? Obviously numerous actors are needed to pursue the goal, including me, my friend, an inventor, a product vendor, a service provider, and many other people as well. It seems that a huge amount of coordinated activities are required to realize the whole network of actions. Does that really emerge by the aid of the invisible hand?

With these reflections, Henri reaches his apartment, and since he's hungry, he checks the refrigerator he shares with his fellow students. Unfortunately, it was almost empty. Henri muses, once again, whether some of the students had forgotten who had bought which groceries—a small tragedy of commons. Delight might be nice, but there indeed are other more fundamental needs, such as food, Henri ponders and decides to go to a local supermarket that fulfills the basic needs of students.

While walking through the white and silent campus, Henri tries to summon up what he has learnt during a couple courses that dealt with management and organizations. An economy is just an abstract system, with or without the "invisible hand." There must something more concrete and more organized, for instance, some knowledge that tells how the production shall be organized to obtain an efficient outcome.

He needs a plan, indeed, a business plan for Flourishator—based on what? Something like Google's subtle marketing could be a starting point. Henri devises an approach based on a separation of "open source", "random", and "commercial" proposals. For instance, the default proposal would always be open source, developed by the hopefully flourishing community. Then if a user wants, she would be able to check commercial advices somehow related to the wish she had expressed. Even the commercial advices might be beneficial, because sensible or funny advices given by an established brand may strengthen the brand's reputation—or that is the postulation Henri writes in his business plan. He knows pretty well how strongly most of us hate interruptive marketing through mobile devices.

Henri continues his speculation by assuming that a relatively small number of distinct advices, funny and serious at the same time, may serve the purpose of spreading awareness of the product in the early phase of dissemination.

He needs to make up some numbers as well, numbers that would convince venture capital investors. Let us see, innovators represent 2 percent of a population, early adopters 12 percent, early majority 20 percent, and so on. Is the penetration of the application important from the viewpoint of individual user? He is not sure, because advice is typically a personal matter, and does not need any other person to use Flourishator. In a way, there might be a negative network effect, because when advice becomes too well known it loses its original value.

As far as Henri can assess, the critical parameter describes the balance between two processes: the creation of novel advices and the consumption of old advices. Consumption must be converted somehow to a creative process. But how, Henri wonders. Money could be used as an incentive, but he is sure that direct monetary rewards for creative individuals are useless, if not harmful.

After some frustrating effort to develop convincing numbers for his business plan, he almost gives up. Then he decides to write something: if the critical process parameter can be kept above one for a period of two years, it is possible to reach a stage in which 100 000 new users per month adopt the application. The users are most active during their first month of usage applying Flourishator twice a day. After that initial state, an average user may use the product twice a week. That results is a usage of 10 million advices per month. If 20 percent of these advices are provided by companies paying for the opportunity of directed marketing, revenue stream of 100 000 Euros per month. Henri hopes that his business evaluation makes enough sense. Maybe it is somewhat optimistic.

Now he needs good advice because there has been almost total silence from Milano, what does it mean? Was there something wrong with the messages he had sent on Saturday evening? Or did he say something that annoyed Irene on Sunday? Henri has no clue. And there is not yet any good advice available in Flourishator.

Economics in communications ecosystems

What is the difference between business and economics? In the context of this book, economics is more about models, even theoretical, whereas business is about the practical matters needed to realize the production and provision of goods and services. In principle, we may assume that there is first an economic idea that is then realized by means of best business practices. Alternatively, we may assume that all kinds of business activities emerge in an appropriate environment and then economics is used to explain what has happened in reality. I tend to believe the latter idea.

My own experience about business development is limited to an internal venture project at Nokia. The venture project was relevant from the perspective of this book because the aim was to develop a tool that could be used by service providers to optimize their business by means of networking technology, particularly by using QoS mechanisms. At that phase of career, I had limited knowledge of those economic models that are described later in this chapter. Still, I do not believe that my rather poor economic skills had any significant effect on the fate of the venture project. Instead, one of the main lessons I learned was the strong influence of social aspects on the nature of business processes. Above all, in big organizations, different departments (marketing, research, product development, top management) are also social systems with their own logic. Those issues are discussed more in Chapter S.

Nevertheless, one particular issue came into view when we tried to analyze why QoS mechanisms were not used in a way engineers had planned. First, it was obvious that offering communication services with high quality requires cooperation between different players. At the same time, services providers are fiercely competing against each other. Even when some agreements between service providers can be crafted, it is difficult for one partner to observe what others are doing inside their networks. This dilemma makes any high quality service over multiple domains almost impossible to realize even when all necessary technical tools are available. Game theoretical models might be useful to assess the fundamental nature of the situation even though they seldom are able to solve the problem per se.

Terms

Pareto-optimality, Nash equilibrium, prisoner's dilemma, and assurance game are concepts that are useful in understanding the logic in those kinds of situations. Moreover, they can be used to make a business analysis, for instance by a CEE, more convincing. There are many other economic terms and concepts that a CEE has to master, including the following basic ones:

> **brand:** a unique combination of design, signs, and symbols, employed in creating an image that identifies a product and differentiates it from its competitors,
>
> **business:** the activity of providing goods and services involving financial, commercial, and industrial aspects,
>
> **capital:** a resource or resources that can be used to generate economic wealth,
>
> **competition:** an activity existing among two or more elements of a system when each is striving to maximize its use of a finite and/or non-renewable resource,
>
> **demand:** willingness and ability to purchase a good or service,
>
> **economics:** the study of the production, distribution, and consumption of goods and services,
>
> **economy:** the production and consumption of goods and services of a community regarded as a whole,
>
> **entrepreneur:** a person with the capacity and willingness to undertake conception, organization, and management of a productive venture with attendant risks, while seeking profit as a reward,
>
> **firm:** the basic unit of decision-taking in a decentralized economy,
>
> **investment:** money committed or property acquired for future income,
>
> **market:** an observation horizon where consumers can efficiently observe other consumers and suppliers can efficiently observe many other suppliers using prices,
>
> **Pareto-optimality:** a situation in which it is not possible to improve the economic outcome of some people without making others worse off,
>
> **profit:** the revenue obtained from goods or services subtracted by the cost of producing and marketing goods or services, and
>
> **risk**: a possibility of incurring loss or misfortune.

In addition, economists have been productive in inventing specific terms that they expect everyone to know, such as the following:

allocation	endowment effect	NPV
ARPU	expense	OPEX
bargaining power	free market	penetration
bubble	GDP	prisoner's dilemma
bundling	homo economicus	revenue
business model	horizontal integration	ROI
business plan	indifference curve	tit-for-tat strategy
CAPEX	integration	value chain
cash flow	invisible hand	value proposition
churn	KPI	vertical integration
competitive advantage	market share	winner's curse
cost	microeconomics	zero-sum game
dominant strategy	mixed strategy	
elasticity of demand	Nash equilibrium	

Business

For some readers business might represent the core of communications ecosystems. Maybe the reason for you to open this book was to gather some insight that can be used to earn money. That is, of course, fine. Still, for those readers I can identify three risks:

1. If you will not accept the main lessons of this book concerning the importance of genuine human benefit, you may even consider the whole book detrimental for your pursuit towards successful business. Consequently, the risk is that you become disappointed because you cannot find any advice that is immediately useful for your business.
2. You will change your mind, at least to some extent, and start to believe that human benefit is the fundamental issue while business is just one tool to pursue a good life. The risk is that this new attitude may have a negative effect on your business performance, at least in the short term.
3. You persist in believing that money brings happiness, but you will still be able to utilize the insight provided by this book to gain a relative advantage compared to your competitors. The risk is that your gain is smaller than the cost paid by others, including the society as a whole.

As an example of the last risk, we may consider the success of quick loans taken by means of text messages. That business has been really successful in Finland during the last few years: according to Wikipedia the total amount of quick loans in 2011 was 330 million Euros. The average cost was about 25 percent of the principal amount although the average repayment period was only 33 days. We may image a situation in which a similar business idea was invented based on a deep understanding of human needs. Still the fulfillment of immediate needs, for instance, one more drink on Saturday night or a pizza on Sunday morning is not necessarily beneficial for the person, if the regular small decisions lead to a downward spiral.

Certainly, there are numerous business ideas that are beneficial for all parties. For instance, it seems that the text message service has been profitable for service providers, useful for individual users, and beneficial for the society. However, text message service was not really invented and implemented because of a careful business or benefit analysis.

It seems that business is difficult to comprehend in general. One obvious reason for the difficulty is that business (as we now understand it) is a recent innovation in terms of human evolution. The realm of business has created a large amount of artificial and abstract terms, like Net Present Value (NPV), vertical integration, competitive advantage, cash flow, and value chain. These business terms make sense only in an extensive conceptual framework that consists of hundreds of terms and their relationships. Unfortunately, the conceptual framework when evoked also seems to convey a specific mindset, that of

> **homo economicus:** the concept in many economic theories of humans as rational and narrowly self-interested actors who have the ability to make judgments toward their subjectively defined ends.

It is hard to consider a single business term without the economic framework and without the idea of homo economicus. From the perspective of net present value, the only relevant human actions are those that affect the consumption of goods and services. The *advantage* in competitive advantage means economic advantage. It is measured by an economic metric, for instance, by Return on Investment (ROI). There is even a term that aims to be a generic measure of success: Key Performance Indicator (KPI). Note also that performance is something that is assessed from the perspective of a selected entity and in which all other entities are primarily seen as parts of an environment, as means to achieve something, or as rivals. KPI is a useful concept in many areas but more often than not, it promotes selfish actions. KPI is, thus, hardly a recommendable approach in the human or social domain.

Thus in order to respect the first rule for CEE, the rule of human benefit, also in the context of business analysis, we need something that can be used to maintain the equilibrium between economic and human aspects. The purpose of the discussion about emotions, sense of coping, and sense of significance in Chapter H is to serve that objective. It is useful to remember that emotions (e.g., those shown in Figure H.3) are closer to the core of our life than anything that occurs in the economic domain. Particularly, the concept of sense of significance cannot be conveyed to the realm of economics without destroying its meaning. In contrast, the purpose of sense of coping is to build a connection between economic and human domains as illustrated in Figures H.9 and H.10. The story about Henri and Irene going through this book acts as another method. A third method is to create physical analogies for the abstract idea of business as illustrated in Figure E.1.

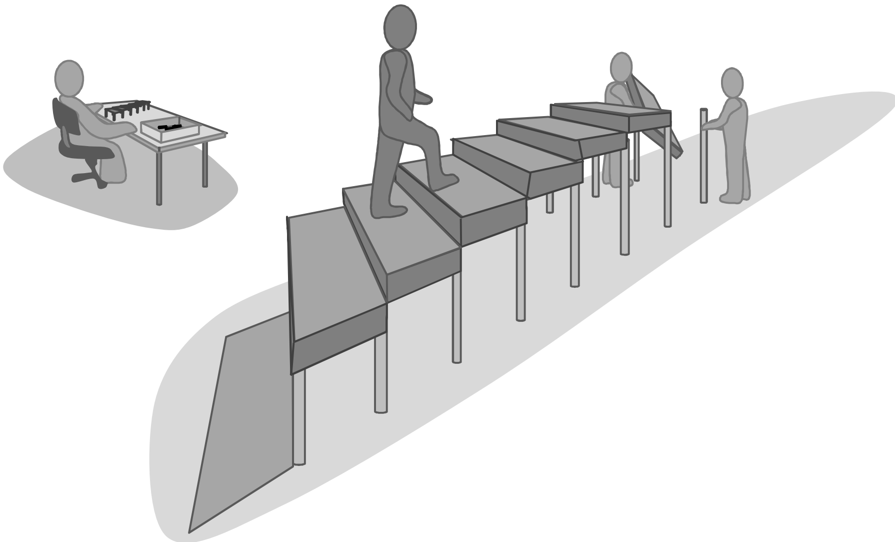

Figure E.1: A portrait of building a business.

We can make various interpretations about the meaning of the portrait shown in Figure E.1. The steps may represent the actions needed to develop a successful business while the climber represents the top management of the enterprise or an entrepreneur with a dream of becoming rich. The construction seems unstable which makes task of the climber risky and demanding. In addition, the reward at the end is vague. The builders represent other people required to construct the business in reality. When the manager is ready to make the next step, it might be easy for him to ignore all those people that have built the construction. He may consider himself as the only person having the capability, courage and vision to proceed towards the goal. On the background, numerous people have influenced the design of the business, for instance, by building more or less realistic models.

Two fundamental questions are hard to answer in the realm of business without any additional tools. First, how should the profits of a successful business be divided between different contributors? Secondly, who is responsible for a failure? The hard-core economists seem to believe that the free market is able to answer these questions: whatever division between the contributors emerges in a free market is the correct division, particularly as to the allocation of profits. In contrast, when something undesirable happens, for instance, after a

> **bubble:** an economic cycle characterized by a rapid expansion followed by a rapid contraction,

a fierce debate about the culprits of the collapse and economical will typically emerge. Andrew Odlyzko (2010) provides a fascinating historical perspective to this dilemma. The underlying psychology of economic bubbles seems to remain the same independent of the subject of the bubble. New bubbles will most likely emerge every ten or twenty years.

The advantage of illustrations similar to Figure E.1 is that they provide a way to utilize our innate capability to assess what is fair and what is unfair. Although the cultural background of a person most probably affects the assessment, we may still presume that the capability works best in the case of conflicts in small groups or communities concerning the allocation of tangible matters. For instance, the decision whether to hunt stags or hares in a case where stag hunting requires cooperation evokes clearer feelings than an abstract game determined by numbers (see, for instance, p. 49 in Bowles 2004).

Thus, we may make a tangible question: who should be blamed if the stairs in Figure E.1 collapse? The climber has taken a conscious risk probably in order to obtain a larger part of the catch than others have, and should accept, therefore, the possibility of failure. Still, it might turn out that the design of the construction was poor in the first place, or the builders were incompetent or careless. What about the rights and responsibilities of the owner of the piece of land? Remember that any business heavily depends on the environment; a solid piece of land is much better place to build than a swamp. Similarly, a society with clear and fair rules and institutions is better place for business than a society without proper institutions.

Although the risk taker is entitled to a larger share of the yield because of the risk he is taking, the share must remain sensible. The main difference between small hunter groups and current business ventures is that the top managers are not anymore dependant on the support of a fixed group of people working as their subordinates as the leader of a hunting group was dependant on the other hunters in his group. Instead, the long-term success of top managers depends more on other top managers that serve in boards of directors. Consequently, a top manager assesses the fairness of the allocation of profits not between him and the employers of the firm but between him and other top managers. One of the lessons of game theory (discussed later in this chapter) is that co-ordination is more beneficial when the likelihood of meeting the same player is larger. A top manager can leave a company and the employers but usually cannot avoid meeting the same top managers. There are also other reasons for the fast increase in the benefits of top managers as discussed by Coff (1999).

There are two main lessons of this brief discussion. First, economic calculations or the outcomes of the free market cannot define what is fair and what is unfair, because those concepts belong to the area of humans. Secondly, in order to incite feelings about fairness we need to convert the economic affair to a more tangible situation. Unfortunately, these conversions are always prone to numerous interpretations and often lead to conflicting inferences. Besides, excessive application of an analogy can lead to unreasonable inferences. We must consider, hence, an economic issue from various perspectives without relying on too simplistic assumptions.

Business development

This introductory book cannot provide any deep insight in the development of business. Still I feel necessary to write something about business development. This brief section is based on a book written by Osterwalder and Pigneur (2010) about Business Model Generation. One reason to select this book is that the book's philosophy is similar to the CEE rule of human benefit. On page 5 Osterwalder and Pigneur state:

> "Ultimately, business model innovation is about creating value, for companies, customers, and society."

The architecture of the book is based on a canvas consisting of nine building blocks (Osterwalder and Pigneur 2010, p. 19): customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnership, and cost structure.

What I appreciate in the book, in addition to its basic philosophy and clear structure, is the way of illustrating the fundamental idea: the canvas is cleverly divided into the blocks providing clear additional value for the reader, both for understanding the big picture and for memorizing the blocks. For instance, customer segments are connected to value proposition through customer relationship and channels (I will not present the canvas here but encourage you to first sketch your own canvas consisting of the above-mentioned building blocks). A large canvas can also be used to arrange events to innovate, develop, and analyze business ideas.

Most of the building blocks are discussed in other parts of this book. We can identify at least the following connections:

- Revenue stream ⇒ pricing and advertising as a part of the benefit model.
- Key resources ⇒ management.
- Key activities ⇒ engineering and technology.

Here we discuss briefly about value proposition, channels, customer relationship, and key partnerships. The most important building block from the viewpoint of this book is *value proposition*. Osterwalder and Pigneur (2010, p. 23 - 25) lists eleven elements that can be used to define the value proposition. The following list is based on those elements but they are organized in the spirit of the benefit model presented in Chapter H (see also Figures H.12 and H.13). Consequently, value proposition can be based on three main categories:

1. Fulfillment of a need by offering a novel product, an old product for new customer segments, or customization of an old product.
2. Increase of gross benefit by improving capabilities or performance, design, usability, or conceptual clarity, or brand (producing emotional benefit).
3. Reduction of sacrifices by decreasing price, risks, or other cost factors.

All of these have a positive effect on the net benefit perceived by customers. However, we shall remember that when improving an element, e.g., performance, negative network effects may deteriorate other elements of the value proposition, e.g., usability or price.

In addition to the creation of the value proposition, the potential customers have to be convinced about the merits of the product. Osterwalder and Pigneur discuss this issue under the title of channels. They divide channels into five phases that correspond the five phases of adopting an innovation (see the discussion about diffusion in Chapter C):

1. Awareness ≈ knowledge.
2. Evaluation ≈ persuasion.
3. Purchase ≈ decision.
4. Delivery ≈ implementation.
5. After sales ≈ confirmation.

A topic closely related to channels is customer relationship. Actually, I would call the above list "phases of customer relationship" and the topics addressed by Osterwalder and Pigneur under the title "customer relationship" (personal assistance, self-service, automated services, communities, and co-creation) as channels. The most interesting channel from the viewpoint of communications ecosystems is user communities, because they may create many kinds of positive network effects.

Integration and value networks

This topic about vertical and horizontal integration is the last one in the long process of writing this book. This fact may reveal something. Vertical and horizontal primarily belong to the area of geometry while it is hard to say where the abstract term of

> **integration:** process of attaining close and seamless coordination between several groups, organizations, or systems

belongs to. The combined terms, horizontal and vertical integration, are so abstract that they elicit hardly any feelings. It is difficult to write anything without feelings. Certainly *key partnership* is an easier concept in that sense. Partner is usually something desirable at least compared to a competitor. However, for those economists that promote the free market, partnership should be problematic. In order to make this topic more comprehensible, horizontal and vertical integration and value networks are illustrated in Figure E.2.

One of the extreme cases of vertical integration took place in United States in the field of telephone services. In addition to providing the customer service as a monopoly in local areas, they operated all parts of networks and made their own telephones, telephone cables, telephone exchange equipment and other supplies. In many other countries, telephone service was offered by public organizations that had close relationship with one or few, often local manufacturers. For instance, Televerket was responsible for telecommunications in Sweden from 1853 to 1993. Televerket had a de facto national monopoly for telephone services. At the same time, they cooperated closely with their equipment vendor, LM Ericsson.

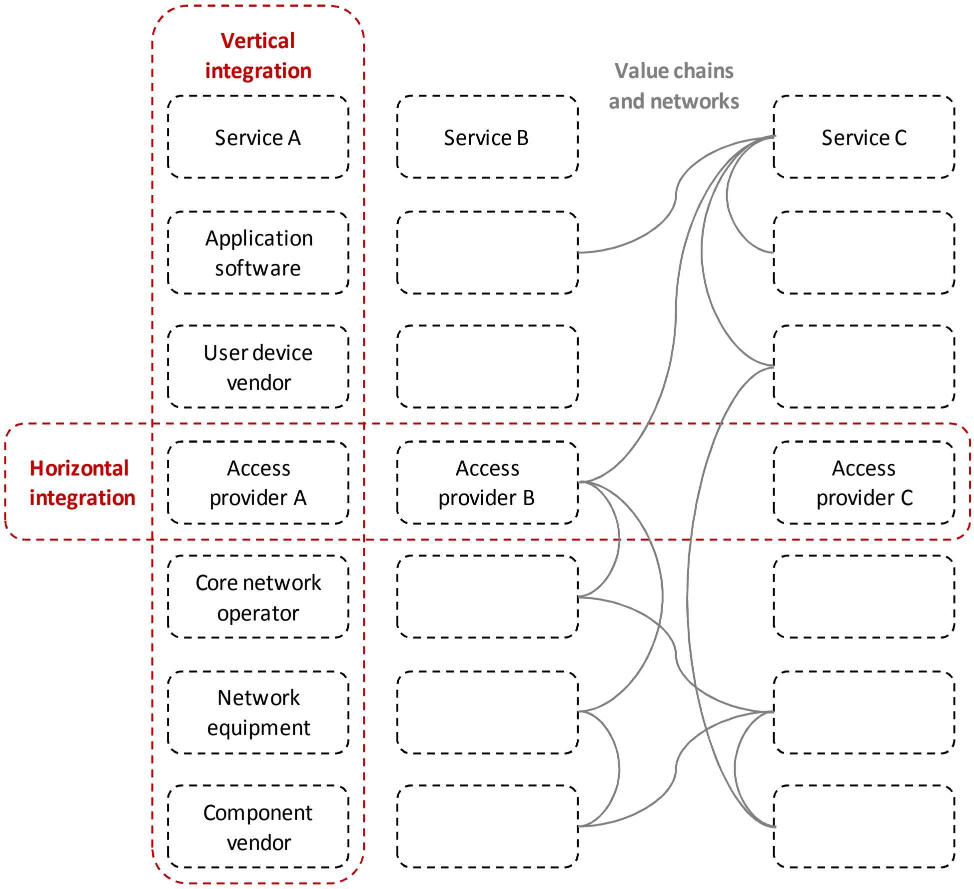

Figure E.2: Vertical and horizontal integration and value networks in case of communications services.

In Finland, the situation was more complicated because in some parts of the country access networks were owned and services provided by local associations. Post and Telegraph Office (later Telecom Finland, now part of TeliaSonera) had a de facto monopoly for long-distance and international calls since 1935. Because prices were determined by the government, telephone calls were effectively used as a way to collect tax. When long-distance telephone service was liberalized in 1992, the prices dropped rapidly during the first months. Whether the monopoly was beneficial for the society at any point of time is hard to assess. At least it seems that extensive use of monopolies led to slow diffusion of innovations.

In general, vertical integration can be justified because of lower transaction costs, synchronization of supply and demand, lower uncertainty, and strategic independence. On the other hand, integration also increases coordination costs, reduces the motivation to improve performance and service quality, and provides abundant room for autopoiesis (that is, to build and maintain organization for its own sake). In the case of monopoly, the outcome can become very inefficient.

Although Figure E.2 is presented as a two-dimensional system, current communications ecosystems are more complex with relatively independent dimensions of service, software, and hardware. Thus, the relationships between actors can be described better by value networks. The complexity of the ecosystem makes it almost impossible to obtain a truly monopolistic position. Every player has to build all kinds of business relationships with numerous other players.

Prospect theory

The prospect theory proposed by Kahneman and Tversky (1979) describes human behavior in uncertain situations. Everyday life offers multitudinous situations in which we need to make a decision without certainty about all the consequences of each available choice. In principle, the uncertainty may concern two aspects:

1. The immediate result of a choice or *outcome*. For instance, if you decide to put a coin into a slot machine, you may either lose the coin or win something. Even if you knew exactly the probabilities of each prize, you cannot be sure whether you will win on any particularly round.
2. The long-term consequences of each possible outcome, or value. Although it seems obvious what it means to win, say, 100 Euros, it is almost impossible to assess what would be the real difference in the life of person between winning 100 Euros and not winning 100 Euros. Will it have any effect after an hour, a day, or a year?

There probably will emerge a fleeting burst of positive (or negative) feeling after a win (or loss), while the long-term consequences remain usually ambiguous. The assumption made here is that evolution has given us a capability that is able to take into account the likely long-term consequences of different outcomes. In particular, evolution might have been able to prepare us to assess the real difference between losing a stone ax and obtaining a stone ax, or between obtaining one ax and obtaining five axes. Another stone ax might be useful while losing the only stone ax would be a life-threatening event. Additional stones axes would be useless for a person unable to carry them with him. What seems to be sure is that evolution has not been able to make a difference between, say, obtaining 1234 axes and obtaining 1243 axes—those abstract numbers do not activate any emotions.

Our brains may to contain specific parts that are used to assess the probabilities of various events. Note, however, that *probability* is an extremely recent concept compared to the time scales of evolutionary processes. Thus, our mind is hardly prepared for exploiting formal information about probabilities, like 2 percent or even smaller probabilities below fractions of percents. Even after using probabilities and statistical models most of my professional career, it is difficult for me to get any useful intuitive feeling about probabilities below 1 percent. It is almost impossible to make a clear distinction between probabilities of 0.1 percent and 0.01 percent in my mind without using any mathematical framework.

If we apply the idea that humans are not able to distinguish more than seven levels, we may infer that we are internally able to distinguish only seven classes of probabilities, something like the following:

- certain: $p^* = 100\%$,
- very likely: $p^* = 96\%$,
- likely: $p^* = 83\%$,
- equally likely: $p^* = 50\%$,
- unlikely: $p^* = 17\%$,
- very unlikely: $p^* = 4\%$, and
- impossible: $p^* = 0\%$.

The prime purpose of these rough classes of probabilities is to direct immediate actions instead of any optimization of outcome (as is typically the case when mathematical models are derived and used). For instance, *certain* just means that a person will not consume any mental resources to assess the consequences of any other outcome. *Half* means that the consequences of two outcomes are given equal weights, which is mentally the easiest estimation. *Very likely* and *likely* correspond to weight ratios of 24:1 and 5:1, respectively. In a way, these weights are more fundamental than the probabilities shown above. Note also that the numbers presented are guesses without any formal validation. The main reason to present the probabilities at all is to stress the fact that our intuition cannot really make calculations with very small probabilities. Even if we assume that someone is able to add one or two classes of probabilities (e.g., 0.1 percent), that is not enough to cope with all challenges in the modern world.

This may result in a situation in which any event that has been demonstrated as possible (e.g., winning 10 million Euros in a lottery) is *felt* to be as likely as a significantly more probable event (e.g., winning 1000 Euros in a lottery). Correspondingly, if a bad event is considered sufficiently improbable (e.g., a car accident) it is classified as impossible and ignored totally even when it should be carefully considered.

In consequence, our mind seems to make assessments in uncertain situations as illustrated in Figure E.3. The immediate outcome is shown on the horizontal axis and the psychological value is shown on the vertical axis. According to prospect theory by Kahneman and Tversky (1979), there are three fundamental properties in the relationship between outcome and value:

1. We tend to always select a reference level (zero both on the horizontal and vertical axes),
2. The function is convex for positive outcomes and concave for negative outcomes, and
3. The slope is steeper below zero than above zero.

Figure E.3 is drawn based on the following function:

$$Value = \begin{cases} Outcome^{\delta} & if\ Outcome \geq 0 \\ -\lambda \cdot (-Outcome)^{\delta} & if\ Outcome < 0 \end{cases}$$

where $\lambda = 2.25$ and $\delta = 0.88$ based on the results in Tversky and Kahneman (1992). This also means that bad is 2.25 times stronger than good (see discussion in Chapter H). Now the vertical (value) dimension should be linear in the sense that a change from, say, from 1 to 2 is equally important as a change from 10 to 11. One may state that this model demonstrates the irrationality of human behavior because it obviously leads to a non-optimal result in many economic settings: in economic terms a change from -10 to 0 is equal to a change from 90 to 100 whereas on the value dimension the change from -10 to 0 (on the outcome dimension) is 3.3 times larger than the change from 90 to 100. However, we must remember that this kind of valuation—even if strange from the economic viewpoint—can still be rational in situations where choices are made in complex social settings.

The modeling effort becomes more complex if we take into account our limited ability to assess probabilities. An approach is presented in Kahneman and Tversky (1992). That extended version of the original version of prospect theory takes into account the fact that people are assessing very small and very high probabilities in a different way than relatively likely outcomes. However, it seems that the behavior of a majority of people is difficult to model in cases with very small probabilities, for instance, when there is a miniscule probability to win 500 000 000 dollars.

It seems that formal reasoning combined with strict probabilistic models results in a much better outcome in great majority of cases. Those that are able to make money by exploiting the poor abilities of others may still disagree with this statement.

Prospect theory is closely connected to the concept of

> **endowment effect:** the hypothesis that people value a good or service more once their property right to it has been established.

This is essentially the same as a shift of the reference level in prospect theory: before the purchase, the reference level is "not owning the product," but after the purchase, the reference level is "to own the product." This means also that the value difference between owning and not owning is changed. This is why many advertisements try to present the situation in a way that the customer is losing something if he or she is not purchasing the product.

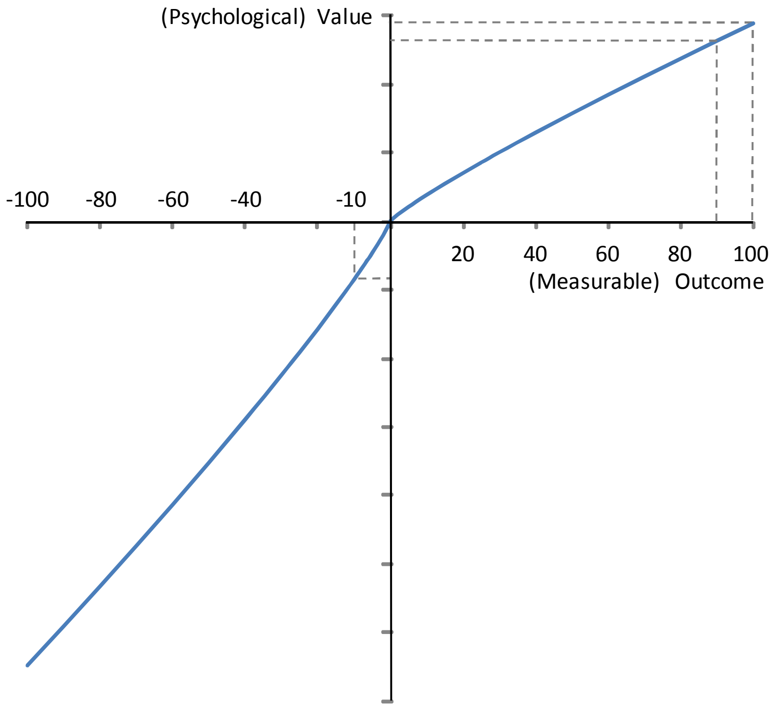

Figure E.3: Value as a function of outcome according to prospect theory (λ = 2.25 and δ = 0.88).

One important concept that is related to this topic is

> `indifference curve:` a graph showing different bundles of goods or properties, each measured to a quantity, between which a consumer is indifferent.

Typically, an indifference curve is used to illustrate the preferences of consumers between different bundles of goods. Now let us use an indifference curve to illustrate the effect of prospect theory on consumer preferences. Figure E.4 shows the willingness to pay as a function of access bit rate. The figure includes two turning points. Point A in the figure defines user expectations about the available bit rate (1 Mbit/s in Figure E.4): Below that limit, the effect of bit rate is more pronounced than above the limit. Point B in the figure defines the customer expectation about the appropriate price of the service: Above that limit, the bit rate requirement increases more rapidly than below the limit. A similar function can be used to describe the willingness to pay for improved availability of service. For instance, the expectation about availability can be 99 percent, which means that the willingness to pay drops faster below that limit than above the limit.

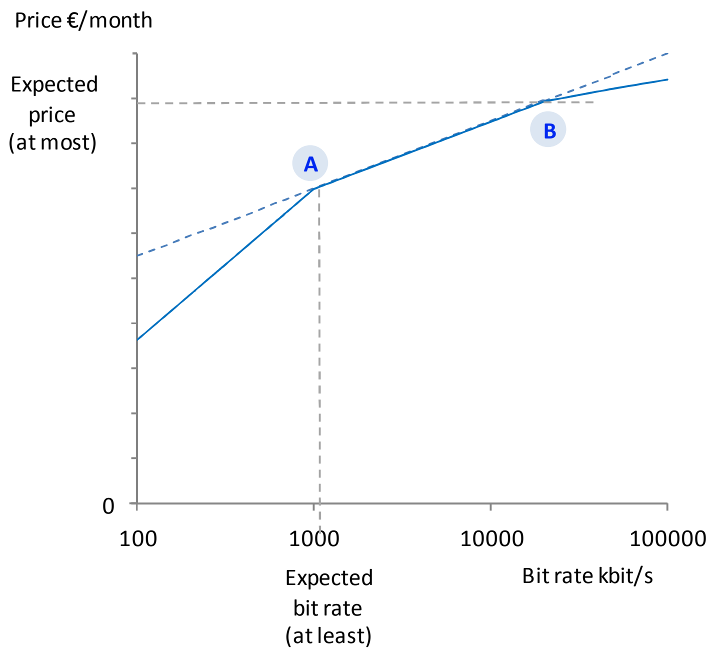

Figure E.4: Willingness to pay for different access bit rates.

Now we can combine the willingness to pay for bit rate and willingness to pay for availability by means of an indifference curve. The result is presented in Figure E.5 for a relatively low quality in which both access bit rate and availability can be below expectations. The indifference curve is smooth when the prediction of prospect theory is not taken into account (or $\lambda = 1$). Then if prospect theory is applied with $\lambda = 2.25$, the indifference curve turns more abruptly. Finally, we can define that strict quality requirement means that λ approaches infinity as depicted in Figure E.5. This extreme case seems to represent an on/off mindset in which a requirement is either met or unmet. That kind of mindset can be found both in technical and economic domains, while ordinary consumers seldom think in that way.

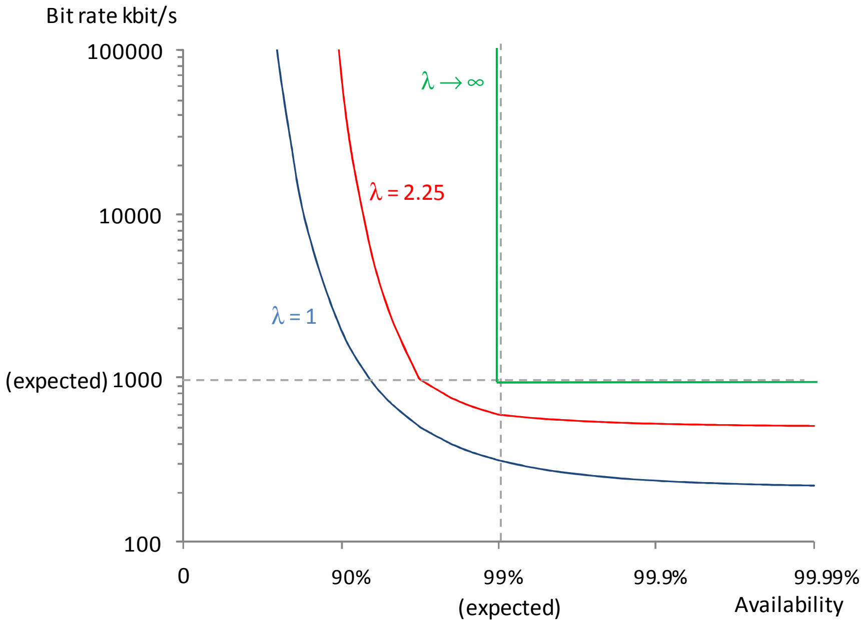

Figure E.5: Indifference curve between availability and access bit rate, for three cases: without expectations ($\lambda = 1$), expectation effect according to Prospect theory ($\lambda = 2.25$), and strict quality requirements ($\lambda = \infty$)-

Games in economics

Game theory is an established branch of science. It has been used to explain human behavior in economic contexts, and sometimes even to justify all kinds of economic rules and conventions; tragedy of commons and invisible hand are famous examples. Simple models can be very powerful in directing our thoughts also in cases where the models are not valid. Thus, I strongly recommend anyone that aims to become a communications ecosystem expert (CEE) to study at least the basics of game theoretical models. Certain concepts are so central that a CEE has to master them. The following discussion introduces some of the concepts and models, but, naturally, in order to master game theoretical models much more shall be read. Models can become useful only through playing with them and by using them to understand real dilemmas.

The objective of this brief discussion about game theoretical models is to provide some additional insight in the applicability of the models in the framework of this book. In particular, the difference between an (objective and measurable) outcome and a psychologically experienced value is essential. This distinction also is closely related to the concept of metric and questions: "What do we really try to optimize in everyday life?" and "What is the underlying assumptions made in formal models about the target of optimization?" As an example, we may also consider whether cooperation between prisoners represents social optimum if that leads to the shortest combined sentences in prison. Correspondingly, it is not at all obvious that a result in which the profits of firms in total are maximized is the best result for the society as a whole.

Pareto efficiency or Pareto-optimality is one of those concepts that you need to know in order to be able to read microeconomic articles, to discuss about economics, and to model economic behavior. To express it simply: An allocation is Pareto-optimal if there is no other feasible allocation that is preferred by at least one and not less preferred by any. This definition appears unambiguous, and in the realm of mathematics, it is. On the contrary, if we consider real situations, the word "preferred" is less clear.

What do we really aim at maximizing? For some people, the target might indeed be wealth measured strictly in economic terms. The prospect theory discussed above indicates that in practice we are not interested in a direct outcome but something else, here called the (expected) value of the outcome. In addition, people are inclined to consider not only their own outcome but also the difference between their own outcome and the outcome of other people (envy has sometimes a strong effect on human behavior).

In order to assess this question we may use utility functions. In this book, a utility function is assumed independent of the possessions of other people. Another seemingly reasonable assumption is that the total desirability of possessing various goods can be described by the sum of individual utilities. Thus, the utility of owning an amount of goods (1…j…) for a person (i) can be described in the following form:

$$U_i = \sum_j f(X_{i,j}).$$

This kind of model seems to be the first one that comes into mind when we start to build a model to describe human behavior. This model also seems to indicate that a rational person would maximize her or his own utility. This simple model based on additive utilities might be a good starting point, but we must still be aware of the limitations of the model.

What an *idealized* free market is able to achieve is that the members of the society are able to reach Pareto-optimum by means of voluntary exchange of goods. This is called the first welfare theorem (see, e.g., Bowles 2004, p. 213). The theorem is based on the following assumptions (according to Wikipedia):

- market exists for all possible goods,
- markets are in full equilibrium and perfectly competitive,
- transaction costs are negligible,
- there is no externalities, and
- participants have perfect information.

In short, the theorem roughly says that if a market is perfect, then the outcome of market transactions is also perfect in some sense. Some of the assumptions are actually implausible, particularly that markets are in full equilibrium. That means that buyers and sellers do not set prices by means of any process, but the prices are given. How the prices emerge is not explained. Even though the "invisible hand" argument is often used to promote the superiority of a free market, we need to be aware of the fact that reality never fully conforms to the underlying assumptions of the first welfare theorem. Realistic markets include transaction costs, external effects, and participants have only limited information.

Although the communications ecosystem we aim to analyze is essentially based on relatively free market, we must not assume that a free market will automatically result in the best possible outcome (whatsoever metric is used to define the meaning of best). I will not go deeper in this question of the relevance of the theorem. I encourage every prospective communications ecosystem expert to read the insightful discussion about this topic written by Bowles (2004) and Smith (2008).

From the viewpoint of economics as a social system of professionals, it seems that for a period there was a strong incentive to conform to strict scientific rules in order to gain recognition within the discipline (see Smith 2008). There was a particular tendency to build sophisticated mathematical frameworks that provided a solid basis for proving theorems. One of the most famous examples is the above-mentioned first welfare theorem. Without doubt, that was a major scientific achievement per se. However, the proved theorem does not provide much insight in those processes that lie behind the real market behavior. Thus, we may also ask: what has been the metrics that has guided the research conducted by micro-economists? It might be that in some cases the metric has been the success of individual scientists instead of the usefulness of the results.

Now let us return to the Pareto-optimality. Although the concept is extensively used in economics, it is also problematic when applied in realistic situations. In particular, when the number of people involved in the allocation is large, it might be almost impossible to find any allocation that does not incur any cost to anyone. However, in games with a few actors Pareto-optimality is a practical concept.

Furthermore, Pareto optimality can be deemed as an inadequate concept to assess the desirability of the outcome, because it does not take fairness into account. This drawback might be avoided if we make a clear division between outcome and value measured by eudemony. Let us assume that the wealth of 2 million Euros is distributed within a small community. At the starting phase, the wealth is divided between one rich person and 100 poor persons (Allocation 1 in Table E.1).

Now the community has the opportunity to increase its total wealth by 1 million Euros owing to the abilities and effort of the rich person. Because of the limited motivation of the rich person, that amount will be achieved only if the rich person gets all the money. If we just consider the monetary outcome, the new allocation (Allocation 2 in Table E.1) provides a Pareto improvement because no one is losing while one is gaining. Pareto improvement is obtained if we assume that utility is an increasing function of wealth and does not depend on the wealth of others. Regardless of this reasoning, in reality it is very unlikely that the poor people would prefer Allocation 2 to Allocation 1. Thus, it is questionable to claim that Allocation 2 provides Pareto improvement compared to Allocation 1. Thus, we must change some of the assumptions we have made.

Table E.1: Outcome and eudemony for different allocations of wealth.

	Outcome for a person (€)			*Eudemony for a person*		
Allocation	*1*	*2*	*3*	*1*	*2*	*3*
1 rich	1 000 000	2 000 000	1 140 000	87.2	89.3	87.2
100 poor	10 000	10 000	13 600	67.2	66.3	68.0
Total	2 000 000	3 000 000	2 500 000			
Average	19 802	29 703	24 752	67.4	66.5	68.2

The analysis based on a direct outcome does not take into account two facts: first, the satisfaction experienced by an individual depends also on the wealth of other persons, and secondly, satisfaction depends non-linearly on wealth. In this analysis we assume that outcome means wealth and value is defined by eudemony. Because eudemony is defined as the preference of certain state of affairs on a linear scale, we may state that it is an appropriate measure to describe Pareto optimality.

Now we may assume that the eudemony for a person, Ψ_i, is a function of an individual's outcome, X_i, and the average outcome over the community, $E(X)$, in the following way:

$$\Psi_i = 50 + 10\, log_{10}(X_i) - 6\, log_{10}\big(E(X)\big) + 0.5\, log_{10}(X_{max}).$$

The third term is the (negative) external effect that is caused by two phenomena. First, we tend to compare our own wealth with the average wealth of the society. Thus, an increase of average wealth (without any change in our own wealth) decreases our satisfaction with current wealth. Secondly, an increase of the average wealth has a concrete, measurable effect on the availability of resources. The last term is added to the formula due to the possible advantages created by the richest members of the community. In particular, less wealthy people may also obtain positive feelings when they observe rich people, like increased hope to become rich if work hard enough. Rich people may also instigate negative feelings, like envy, particularly if their richness is deemed unfair. In consequence, this coefficient is probably significantly smaller than the other coefficients, and could be negative in some cases. The coefficients selected here (10, -6, and 0.5) are somewhat arbitrary, but still the result seems to be feasible. For instance, the model predicts that for a given wealth the richest person should be about 6 times wealthier than the poor people are to achieve the social optimum, if the total wealth is kept constant. In reality, we shall also take into account the motivation effect of uneven wealth distribution.

Fairness might also be considered a separate issue. As an example, an economist may state that the objective of an economy is to produce as much wealth as possible. Thus, a strategy that generates more wealth is always better than another strategy that generates less wealth. The question of what is the optimal allocation of the created wealth among the individuals is solved as a separate problem. However, this is not a feasible approach if we want describe what happens in reality. If we consider the allocations in Table E.1 as the results of different strategies to produce wealth, the outcome is what defines the desirability of the allocations for each actor, not any intermediate result. If the rich person knows that the gained wealth will be later allocated evenly among all members of the group, his incentive will be different than if he genuinely assumes that he will be able to keep all the additional wealth for himself.

Allocation 3 represents a situation in which the rich person knows that he can keep only 27 percent of the obtained wealth while 73 percent of the wealth is allocated evenly among other people. What is then the final outcome? If the "rich" is a firm instead of a person, we may indeed assume that the final outcome is the allocation of wealth after all relevant phases of the allocation process (taxes, paid salaries, etc.). Then the Pareto optimality is defined in the outcome columns. In that case, any allocation of additional wealth provides Pareto improvement compared to the original state (Allocation 1).

In contrast, if we assess the behavior and satisfaction of real people, we shall not limit our analysis to the wealth as the final outcome, because that is not what most of us are mostly concerned about. Even if we consider sense of coping and exclude sense of significance and happiness from eudemony calculations (as defined in Chapter H, see Figures H.3 and H.10), we always compare our situation with other people. Thus, an increase of income for a person has a negative external effect on the satisfaction of other people. Note that this is a fact that cannot be changed by just stating that rich people are entitled to be rich and poorer people should not envy or hate them.

In the model described above, if the rich person gets less than 27 percent of additional wealth, he becomes less satisfied than in the original situation, even though he gains some wealth, because of the comparison effect. Correspondingly, if poor people combined get less than 25 percent they become less satisfied. Thus, a Pareto improvement is achieved, in the sense of eudemony, only if the allocation of additional wealth lies somewhere between these limits.

In this case, the social optimum depends on the incentive function of the rich person. However, it is clear that Allocation 2 does not result in a social optimal, because the average value of individuals is smaller than in the case of Allocation 1 although the total wealth is much higher. The statement of this book is that the social optimum can be effectively measured by the total eudemony of the society.

These considerations about the difference between outcome and eudemony shall be kept in mind when we introduce some fundamental game-theoretic models. Because this chapter is about economics, the primary assumption is that outcome is something concrete and clearly additive, like money, wealth, or capital. However, when we want to interpret the results of experiments and real economic behavior, we cannot avoid taking into account the value or benefit aspect. Actual behavior depends on the expected benefits not on the outcome itself.

Game theoretic models

This section provides some notes on game theory. The evident objective is to introduce basic concepts and models, but an even more important objective is to arouse your interest in game theoretical models. It would be necessary to gain some insight in the characteristics of elemental game settings, including Prisoner's dilemma, Assurance game, and Mixed strategy games, because they can be used to understand important, more complex phenomena in economics.

Table E.2 presents the pay-off matrix for a game played by two persons (A and B). Both players have two options (1 and 2). The outcome for a player depends on both player's own decision and the decision made by the other player. For instance, if Player A selects Option 1 and Player B selects Option 2 then the outcome for Player A will be a_{12} and the outcome for Player B will be b_{12}. Further, it is assumed that both players know the whole pay-off matrix, but they do their selections independently without the possibility to make common agreements with each other. The pay-off matrix is typically presented on a measurable linear scale, such as money or time. Finally, it is assumed that each player makes their decision based on their own outcome without considering the outcome of the other player. In brief, players are assumed to behave selfishly in a way that maximizes their own expected outcome.

Table E.2: The pay-off matrix of a generic two-player game with two options.

		Player B	
		Option 1	*Option 2*
Player A	*Option 1*	a_{11}, b_{11}	a_{12}, b_{12}
	Option 2	a_{21}, b_{21}	a_{22}, b_{22}

Even this simplistic game gives rise to several different results. The selfish behavior may lead to the best or to the worst joint outcome (I call $a_{ij} + b_{ij}$ *the joint outcome* because in many realistic games the selections of the players have many other external effects than the direct outcomes for the players). Furthermore, the outcome does not necessarily have a linear transformation to the value experienced by the player. Thus, it is somewhat questionable to state anything about the optimality of the result from social or society viewpoint based on the simple pay-off matrix.

Prisoner's dilemma

Table E.3 shows the most famous example of game theory: Prisoner's dilemma. In the basic form, the game is played by two players, or in this case, by two suspects of a crime. Each suspect may either cooperate with the other player and deny everything, or betray the other suspect. Both suspects make their decisions without knowing the decision of the other suspect and without the possibility to make any binding agreement. If both suspects cooperate in the sense that they will not betray the other player, each of them will get one year in prison. This is the best joint outcome. Thus, it is reasonable to assume that if the players could make a binding agreement, they both would cooperate.

In contrast, if one suspect betrays and the other suspect still cooperates, the suspect who betrayed will be freed while the other suspect will get ten years in prison. Each suspect has, hence, a strong incentive to betray if he assumes that the other suspect will cooperate. Furthermore, if the first suspect assumes that the other suspect will betray, the first suspect also has a strong incentive to betray, because when both suspects betray the first suspect will get six years in prison instead of ten years. Because the game is symmetric, the other suspect sees exactly the same dilemma.

Table E.3: Prisoner's dilemma where the numbers refer to the number of years in prison (a sentence means a loss of years).

		Player B strategy	
		Cooperate	*Betray*
Player A strategy	*Cooperate*	-1, -1	-10, 0
	Betray	0, -10	-6, -6

In consequence, whatsoever a suspect assumes about the behavior of the other suspect, the suspect has an incentive to betray. Thus the

> **dominant strategy:** a strategy for one party in a game which gives it results at least as good as any other, whatsoever strategy the opponent adopts

for both players is to always betray. Surprisingly, this rational behavior—in the sense of individual optimization—gives rise to the worst joint outcome, because the sum of sentences is larger than in any combination of individual options. This is the main lesson of this theoretical game: totally rational behavior may result in the worst joint outcome. In other words, the only

> **Nash equilibrium:** a situation in which two or more agents have selected strategies where no agent can gain by any change in their strategy given the strategies currently being pursued by the others

in this game is the situation in which both betray. In this type of simple game with two players, it is easy to identify whether there is any Nash equilibrium. In complex games with several players and several options, the identification of Nash equilibrium is much more difficult. Furthermore, there are cases in which the theoretical equilibrium is easy to identify but still in reality people behave differently.

Symmetric games

Prisoner's dilemma is a special case of symmetric game. Symmetric game means that the situation for both players is identical. Table E.4 presents a setting in which the number of free parameters is minimized. Note that one is allowed to make a linear conversion for the parameters without sacrificing the generality of the results: we can either add the same constant to each parameter or multiply all of them by another, positive constant. For instance, Prisoner's dilemma presented in Table E.3 can be converted to the form in Table E.4 by first adding 10 to all choices and by then by dividing the result by 9. As a result we get a symmetric game with c = 10/9 and d = 4/9. Still, remember that this kind of linear conversion that is feasible on the level of measurable outcome is not necessarily acceptable on the level of expected value.

Table E.4: A symmetric game in which c > 1 > d > 0.

		Player B	
		Option 1	*Option 2*
Player A	*Option 1*	1, 1	0, c
	Option 2	c, 0	d, d

In the basic setting of the game, only one round is played. If the game will be repeated several times, the optimal strategy (for instance, to always betray in the case of Prisoner's dilemma) might be changed. The famous strategy that often gives the best result in repeated games is called tit-for-tat. Tit-for-tat means that in the first round a player always cooperates (Option 1 in Table E.4), whereas on every other round the player adopts the same strategy as the other player during the previous round. Robert Axelrod (2006) has provided a detailed discussion about the fundamental nature of tit-for-tat strategy.

Hence, reputation is valuable, which means that cooperation might be a reasonable option even if it is detrimental in the short term. There is, however, a caveat in this reasoning of series of rounds, because if the players know that a round is the last one then there is not anymore any motivation to cooperate during that round. Correspondingly, if the players know that the next round (after the round they are now playing) will be the last one, they do not either have a reason to cooperate, because they know that the other player is defecting during the last round regardless of the behavior during this round. In principle, it is possible to continue this reasoning ad infinitum. However, it is not at all obvious that a typical person is ever able and willing to make a long series of reasonings. Thus, it might still be reasonable to cooperate if you know that there are exactly 10 rounds to be played and the other player is a human being instead of an artificial decision maker (or a harsh economist).

The situation is different if the player knows that there will be several rounds, but do not exactly know how many rounds there will be. The simplest model is a repeated game in which the probability that the current round is the last one is constant (ρ). This means that the expected number of remaining rounds is always $1/\rho$. Now if a tit-for-tat player (T) encounters an always-defect player (D), the average outcome over a large number of rounds for the tit-for-tat player is:

$$\pi_{T,D} = 0 \cdot 1 + d(1/\rho - 1) = d\,(1-\rho)/\rho\,.$$

The first term is the result during the first round and second term covers the subsequent rounds. Correspondingly, if a tit-for-tat player encounters another tit-for-tat player, the average result over all rounds is on average:

$$\pi_{T,T} = 1/\rho\ .$$

The other option is to defect always with similar types of results:

$$\pi_{D,T} = c + d\,(1-\rho)/\rho,$$

$$\pi_{D,D} = d/\rho.$$

Which one of these strategies a player shall select depends on parameters c, d, ρ, and the distribution of selected strategies in the population.

If there are on average too few rounds, the defect strategy always is the best choice. Thus if the expected number of rounds $1/\rho < (c-d)/(1-d)$, then a rational player defects always independent of the share of tit-for-tat players. Otherwise, there is boundary line above which a rational player selects tit-for-tat strategy. The boundary for the share of tit-for-tat is the following:

$$Share(tft) = \frac{d\rho}{1-d+(2d-c)\rho}\,.$$

If the share of tit-for-tat players is smaller than this limit, defect is a better strategy than tit-for-tat, otherwise tit-for-tat is better, as illustrated in Figure E.6 in case of Prisoner's dilemma defined in Table E.3.

If we know all parameters (c, d, and ρ), it is straightforward to determine the best strategy regions as illustrated in Figure E.6. However, to make a rational decision between the strategies, a player has to make a realistic estimation about the share of players using each strategy. This choice obviously depends on the nature of the game, that is, on the other parameters. Could we continue further the analysis? Maybe.

If we do not know anything about the probability of two choices, the most apparent guess is that both are equally probable. Thus, we may assume that the share of both strategies is 50 percent. Then we can deduce that the average number of rounds has to fulfill the following condition to make the tit-for-tat strategy a feasible choice:

$$1/\rho > c/(1-d)$$

where c and d refers to the parameters in Table E.4. For instance, in case of Prisoner's dilemma shown in Table E.3, this leads to an estimation that tit-for-tat is the most feasible choice if the expected number of games is larger than 2 because c = 10/9 and d = 4/9.

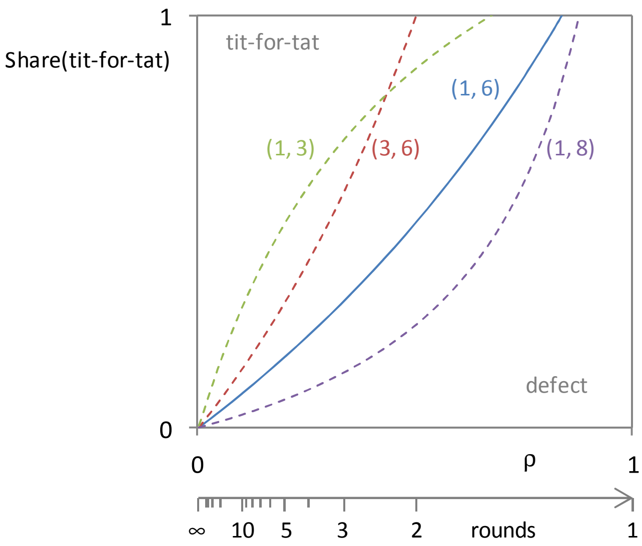

Figure E.6: Optimal selection between tit-for-tat and defect strategies in Prisoner's dilemma game. Notation (x, y) means that both players get x years in prison when they cooperate and y years when they both betray. A cooperative player gets 10 years in prison when the other one betrays.

We have to remember that this result is based on a guess of the behavior of other players. If a player has better estimates about the likely behavior of other players, he shall exploit that information. For instance, when these kinds of games are repeated several times, players may learn that cooperative behavior is beneficial for them. After this learning process, the initial share for tit-for-tat players would be higher than 50 percent. On the contrary, if the games are played by students that have just been convinced by a strict economist that people are inherently greedy and always act selfishly, the expected share of always-defect players could be larger than 50 percent.

Assurance game

A typical pay-off matrix of an assurance game is shown in Table E.5. The game can be interpreted in a way that there are two neighboring farmers with similar fields. The decision both farmers have to make is whether to sow their seed either early or late. If both are early farmers, the crop is good for both of them even though birds will eat a considerable amount of seeds. However, if one farmer sows early while the other farmer sows late, then the early farmer will lose his crop because of the birds and the late farmer obtains a good crop. Finally, if both are late farmers the crop will be relatively poor for both of them.

Table E.5: An assurance game.

		Player B	
		Option 1	*Option 2*
Player A	*Option 1*	4, 4	0, 3
	Option 2	3, 0	2, 2

Assurance game is similar to Prisoners' dilemma except that now there are two Nash equilibriums: both cases in which both select the same option. Obviously, the case in which both select Option 1 provides a better joint outcome. Still the other, worse equilibrium can be more stable. Why? Now if a player is not sure what the other will do, the first assumption might well be that the other player selects randomly between the two options. Now the evaluation is simple: the average outcome of Option 1 = 4/2 + 0 = 2, while the average outcome of Option 2 = 3/2 + 2/2 = 2.5. Therefore, Option 2 appears better than Option 1. In short, the risk of guessing wrongly is smaller when the player selects Option 2. After this reasoning, the player may even conclude that the probability that the other player selects Option 2 is larger than 50 percent. Only if both players can assure the other one that he will cooperate, the joint optimum will be more likely than the other equilibrium.

In general, a symmetric game can classified as an assurance game if

$$(1 > c > d) \ and \ (c + d > 1)$$

where the parameters c and d refer to Table E.4. In Table E.5 c = 3/4 and d = 1/2 which makes it a typical assurance game.

It would be quite easy to make a binding agreement between two farmers, whereas it is much more difficult to make binding agreements between tens or hundreds of farmers. What would happen if there is no way of making agreements, but the situation just evolves according to some general rules?

Let us assume that there are 100 farmers arranged in regular way as illustrated in Figure E.7. Zero means that the piece of land is cultivated by an Early farmer, while 1 means that the land is cultivated by a Late farmer. Thus, each farmer has 8 neighbors that affect the success of the farmer. In order to maintain symmetry, farmers at the left and right sides are neighbors with each other, and farmers on the top and at the bottom are neighbors with each other.

The crop for a farmer depends on the types of his neighbors in the following way:

$$Crop(Early\ farmer) = 4 - n/2$$

$$Crop(Late\ farmer) = 3 - n/8$$

where *n* is the number of Late neighbors.

In addition, because of the rough competition the average price paid to the farmer depends on the average crop E(C) in a way that the profit for a farmer is Crop(farmer) – E(C).

Thus, farmers do not gain any wealth on average. Then if a farmer consumes all his wealth he has to cease farming, and a new farmer starts a business with initial wealth of 2. The new farmer selects randomly whether it will be an Early farmer or a Late farmer. Finally, a tax of 1 percent limits the accumulation of wealth. No farmer changes his behavior. As a result there is no learning process on the level of individual farmers, the only changes in the farming behavior occur through the replacing of unsuccessful farmers by new farmers.

It is easy to deduce that the best crop is achieved when all farmers are Early farmers. The other stable situation is when all famers are Late farmers. The worst situation is when a small number of Early farmers are scattered among Late farmers.

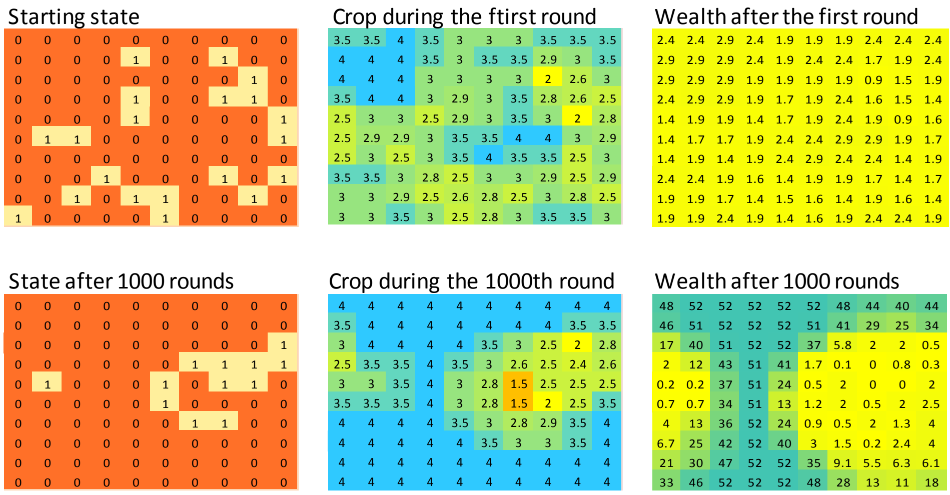

Figure E.7: Illustration of emerging phenomenon in a system with simple interactions.

Note the following facts:

- There were not any differences between the skills of the farmers.
- There was not any kind of learning.
- Player did not make any observations of other players.
- There was not any significant correlation between the original strategy of the farmer (Early or Late) and the wealth after 1000 rounds.
- The areas of Early farmers and Late farmers emerged spontaneously without any intentional coordination between the farmers.

The system described above can essentially evolve in three ways:

1. All farmers become Early farmers, typically after a couple of rounds.

2. There will be a relatively stable situation in which Early and Late farmers occupy their own regions (as illustrated in Figure E.7).
3. All farmers become Late farmers.

If the number of Late farmers exceeds 20 at the start and they are randomly distributed over the whole region, all farmers tend to become Late farmers eventually. Only if there is only one Late farmer among the 100 farmers, the system will likely reach a stable state of Early farmers. Note that even one Late farmer can deteriorate the profitability of eight Early farmers in a way that may lead to bankrupts and new farmers starting from scratch.

But maybe we have assumed too much randomness in the process of system evolution. Instead, we may assume that new farmers have studied agriculture and game theory, and are able to observe the behavior of their neighbors. A farmer may end up with the (correct) conclusion that he should become a Late farmer if and only if at least three of his neighbors are Late farmers. Furthermore, we may assume that no farmer will change his strategy whatsoever happens to his or her neighbors.

Does this better education improve the situation? Not really. Now an even smaller number of Late farmers (less than 10) may lead to a situation in which either all or majority of farmers will be Late farmers. This is the main lesson of this example: seemingly, systematic differences in success (as illustrated in Figure E.7) do not necessarily indicate anything that could be called a fitness difference. All Late farmers are identical with each other and all Early farmers are identical with each other. Furthermore, the opportunities for farming are identical in every place, even though there are regional differences in the prosperity of the farmers over a period. Finally, the regions of Late farmers are relatively stable although the individual farmers in the Late-farmer region last only a couple of rounds. The fate of farmers in that region is purely due to historical accidents that have lead to the differences between regions, instead of the individual skills of farmers or the difference in the environment!

Finally, an accumulation of wealth (in this specific game) is possible only if there are regional differences. If there are no differences, an efficient market prevents any collection of excessive wealth. Thus in the case illustrated in Figure E.7 the prosperity of Early farmers is possible only because of the poorer region with incessant bankrupts. The joint optimum among all farmers seems to require wealth differences, if the criterion is the accumulated wealth. However, from the viewpoint of the society as a whole, early farming is clearly preferable because the crop is larger—you may also consider other viewpoints, for instance, that of birds. Note also that if the system allows binding agreements between farmers the overall behavior of the system may alter totally.

In the case of communications ecosystems many viewpoints are possible: in addition to the accumulated wealth for the companies under scrutiny, there are other stakeholders including customers and other members of the society. You may consider the above example also from that perspective.

Invisible hand game

It is also possible to design games in which a rational behavior leads to optimal joint outcome, as presented in Table E.6. In this case, the joint optimum is reached when Player A selects Option 1 while Player B selects Option 2. Rationality means here that both players aim at maximizing their own outcome (typically money). In this "invisible hand" game both players have an incentive to select the option leading to joint optimum independent of the choice of the other player.

Table E.6: An invisible hand game.

		Player B	
		Option 1	*Option 2*
Player A	*Option 1*	4, 2	2, 1
	Option 2	5, 6	3, 5

We may also assume that Player A applies in reality metrics that describes difference between him and the other player, while Player B remains to optimize the outcome per se. In that case, the game shall be rather described as shown in Table E.7. How should we define joint outcome in this case?

Table E.7: A modified version of game in Table E.6 in which Player A appreciates the difference between the outcomes between him and the other player. Outcome for Player A in parentheses.

		Player B	
		Option 1	*Option 2*
Player A	*Option 1*	2 (4), 2	1 (2), 1
	Option 2	-1 (5), 6	-2 (3), 5

The game shown in Table E.7 obviously results in a different result than the original invisible hand game, because now Player A would select Option 1 instead of Option 2. Both players now get a smaller reward, but we shall still assume that Player A is more satisfied with this outcome than if he had selected Option 2. However, because the sum of values (2 + 2) is smaller than (-1 + 6), it is not clear whether the game should be considered anymore an invisible hand game. In general, it is difficult to make any simple statement about the joint outcome in cases where two players adopt different metrics to make their decisions.

Finally if both players appreciate the difference as described in Table E.8 rather than the (original) outcome we get a zero-sum game in which the sum of results is always zero. In this case, if players select the best strategy in the sense of difference, the result (or Nash equilibrium) will be the worst option as to the outcomes (Player A gets 2 and Player B gets 1).

Table E.8: A modified version of game in Table E.6 in which both players appreciates the difference between the outcomes instead of own outcome.

		Player B	
		Option 1	*Option 2*
Player A	*Option 1*	2,- 2	1, -1
	Option 2	-1, 1	-2, 2

We may also generalize the analysis in the following way:

$$V(own) = O(own) + \kappa^{\pm} \cdot O(other)$$

where V is the value of the result in general for a player and O is the outcome for the player herself or for the other player. In addition, coefficient κ may have different values:

- when own outcome is better than the outcome of the other player (κ^{+}), and
- when own outcome is worse than the outcome of the other player (κ^{-}).

For instance, a player may prefer the joint outcome when she gets more than the other player ($\kappa^{+} = 1$), while the same player may try to maximize her own outcome when she gets less than the other player ($\kappa^{-} = 0$). Another player may always be purely competitive ($\kappa^{+} = \kappa^{-} = -1$). According to various studies, people are more cooperative when they get more than the other player does, that is, $\kappa^{+} \geq \kappa^{-}$ (see, e.g., Charness and Rabin 2002).

We have to be, however, careful when interpreting the results of studies indicating that people behave inherently unselfishly. It is difficult to discern different reasons for a cooperative behavior: the player might indeed appreciate the outcome of the other player, or the player might be selfish but make a longer-term calculation. For instance, Player A in Prisoner's dilemma (Table E.3) may consider both strategies (cooperate or betray) equally bad. Does this imply that he is somehow unselfish? Different interpretations are possible. If we assume that for him $\kappa^{+} = 0.5,\ and\ \kappa^{-} = 0$ and the expected probability that Player B would betray is 50 percent, then the two strategies are equally attractive (or repellent). However, we may also interpret $\kappa^{+} = 0.5$ in a way that Player A believes that he will later benefit from the more favorable outcome of Player B.

Zero-sum game

In zero - sum games, the sum of outcomes for the players or the joint outcome is always zero as in the game defined in Table E.9. The main lesson from a CEE viewpoint is that any game with a strong zero-sum nature cannot provide any significant social benefit unless there are clear positive external effects. It is easy to state that it is right and fair that the winner wins whatsoever was agreed beforehand if both players have voluntarily participated in the game. Still, it is unclear whether the game is rational from the society viewpoint, particularly if there are no additional benefits to be obtained, such as pleasure of the players or other people.

Table E.9: A zero-sum game.

		Player B	
		Option 1	*Option 2*
Player A	*Option 1*	a_{11}, $-a_{11}$	a_{12}, $-a_{12}$
	Option 2	a_{21}, $-a_{21}$	a_{22}, $-a_{22}$

Think about, for instance, the “game” between two amateur soccer teams that have a long tradition to play a match against each other every year. The “game” means here the decision how to prepare for the soccer game during the previous year. Whatsoever a team does to improve the likelihood of winning, equally increases the likelihood of the other team losing. In a way, the more the teams train the more the total cost of the undertaking as a whole increases.

Let us assume that there is a pot of 10 units to be given to the winner of the game. If both teams train equally hard, the expected outcome is 5 units for both teams. Extra training induces a cost factor (x) that improves the likelihood of winning. In the extreme case presented in Table E.10 a heavily trained team always wins a lightly trained team. If $0 < x < 5$, the game is similar to Prisoner’s dilemma. That also means that the only Nash equilibrium is the case in which both teams train heavily.

Moreover, the amount of training tends to reach a level at which the cost is 5 units. The main point stressed here is that if the training does not have any other positive effect than the increased probability of winning, the structure of the game leads to poor joint outcome. This can be called

> **winner's curse:** the danger that the winner of a game or contract will eventually lose more than gain.

This may happen as well in the economic domain as in the sports domain.

Table E.10: A game between two soccer teams where the options are either to train lightly or heavily.

		Player B	
		Train lightly	*Train heavily*
Player A	*Train lightly*	5, 5	0, 10 - x
	Train heavily	10 - x, 0	5 - x, 5 - x

One may still present several counterarguments, most notably that training is not only a cost factor but also it can be rewarding as such, and secondly that the spectators appreciate more a game between trained teams than between untrained teams.

The first argument is not significant because the cost factor x shall also include all other positive effects in addition to the increased probability of winning the game. There likely is an amount of training above which the marginal cost is positive, and we are primarily interested in that level of training. Heavy training means here, therefore, a level of training that is not justified unless it improves the probability of winning.

The other argument is more essential. Indeed, it is more pleasurable to watch a game between skillful and trained teams than between two poor teams. Thus, we may also assume that the spectators are willing to pay more for watching a skillful team. Let us assume that a heavily trained team increases the total reward by 5 units. Thus, if both teams train heavily the total reward will be 20 units. The pay-off matrix is presented in Table E.11.

Table E.11: A game between two soccer teams with "price elasticity".

		Player B	
		Train lightly	*Train heavily*
Player A	*Train lightly*	5, 5	0, 15 - x
	Train heavily	15 - x, 0	10 - x, 10 - x

Is this still a kind of Prisoner's dilemma? Yes, if the factor x remains between 5 and 10. Once again, the structure of the game tends to result in a situation in which both teams train heavily and the outcome approaches zero for both teams (that is, x remains just below 10). Consequently, this type of "price elasticity" in regards to the product quality does not alter the fundamental structure of the game. Even though the outcome appears to be inefficient (because light training still provides better outcome for the teams in total), the result may still be socially more efficient if we take into account the benefits gained by the spectators.

Remember also Rules 1 and 2 for CEE: human benefit is the real driving force, and all relevant benefits and costs must be included in the assessment. The simple game analysis provides insight in the decisions of teams. In the same way, we may justifiably argue in the case of Prisoner's dilemma that the social optimum is indeed that criminals betray each other, due to the benefits for the society as a whole.

Mixed strategy

Let us consider a game shown in Table E.12. It is definitely an unfair game as Player B always loses while Player A wins the same amount of money. This game is also described by Siegfried (2006, p. 46 - 48) as a dilemma between Alice and Bob.

Now if we consider the game first from the viewpoint of Player B, we notice that he may decide to always select Option 1 because it is on average better for him (-4 vs. -5). However, if Player A learns that Player B always selects Option 1, Player A can safely select Option 2, because that is better for her in that case. Then, of course, Player B can observe the systematic behavior of Player A, and decide to select Option 2 instead of Option 1.

Table E.12: A game leading to mixed strategy.

		Player B	
		Option 1	*Option 2*
Player A	*Option 1*	3, -3	6, -6
	Option 2	5, -5	4, -4

Consequently, it may seem that there cannot be any optimal strategy for either of the players. Yet, the optimal behavior might be more complex than just selecting the same choice every time. In a *mixed strategy*, a player makes a random selection between two (or more) choices according to pre-defined probabilities. The optimal choice for a player is to select the probabilities in a way that the other player cannot improve her expected outcome by systematically selecting any available option.

If we consider a simple game shown in Table E.2, a mixed strategy can be optimal if and only if:

$$(a_{11} - a_{21})(a_{12} - a_{22}) < 0 \; and \; (b_{11} - b_{12})(b_{21} - b_{22}) < 0.$$

Now if the above condition is valid, Player A can make both options (1 and 2) equal for Player B by selecting probabilities based on the following equation:

$$p(A,1) \cdot b_{11} + \big(1 - p(A,1)\big) \cdot b_{21} = p(A,1) \cdot b_{12} + \big(1 - p(A,1)\big) \cdot b_{22}$$

where $p(A,1)$ is the probability that Player A selects Option 1. Consequently, we obtain the following result:

$$p(A,1) = \frac{b_{22} - b_{21}}{b_{11} - b_{12} + b_{22} - b_{21}}.$$

Similarly for Player B the optimal probability of selecting Option 1 is:

$$p(B,1) = \frac{a_{22} - a_{12}}{a_{11} - a_{21} + a_{22} - a_{12}}.$$

In the game shown in Table E.12 the optimal probabilities are:

$$p(A,1) = \frac{-4+5}{-3+6-4+5} = 1/4,$$

$$p(B,1) = \frac{4-6}{3-5+4-6} = 1/2.$$

In theory, this result is unequivocal. If one player follows any other rule, the other player shall obey a pure strategy (that is, select either Option 1 or Option 2 continuously). However, that is true only on the condition that the first player does not change his strategy based on the observations about the behavior of the other player.

In practice, random choices are tricky. Human beings are not able to generate genuinely random sequences of choices. For instance, if a player has selected Option 1 four times in a row, the player may be more likely to select Option 2 in the next round. In this kind of game, whatsoever behavior that is predictable for the other player can be used by that player. Any prediction method applied by a player makes the behavior of the player more predictable than random behavior! Thus, it can be argued that a mixed strategy based on optimal probabilities is the only optimal strategy from the perspective of an individual player.

In case of pure zero-sum games, all outcomes are equal from social viewpoint (if we ignore the value aspect). In contrast, if the game is far from a zero-sum game, there is an incentive for the players to cooperate with each other, which makes it somewhat questionable to call any mixed strategy optimal. For instance, if the above formulas are applied to the assurance game (Table E.5) we obtain the following probabilities:

$$p(A,1) = p(B,1) = 2/3.$$

This hardly is an optimal strategy, because if Player A selects always Option 1 then the optimal strategy also for the Player B is to select Option 1 always.

The most important message of this game is that the best strategy is not necessarily a pure strategy in which you play in the same way on each round, but a mixed strategy where you select randomly among a set of strategies with certain (optimal) probabilities.

Rationality of playing games

Let us further consider the issue about rationality when playing simple games. Here we assume that there are two distinct types of players: an ordinary player and a casino. There are a couple of major differences between the players. We may surely assume that the casino just tries to maximize the outcome, that is, the total profit. In contrast, the human player likely feels a loss of money more strongly than a win of the same amount of money (as the prospect theory predicts). The casino can gather knowledge about the likely behavior of ordinary players, which may give it a relative advantage.

Table E.13 presents a game that seems to be favorable for the human player. Does the Casino have any incentive to offer a game that obviously generates on average a loss of 1 Euro per round for the casino? The casino may still deduce that the game, indeed, might be profitable because players are not typically able to generate a long sequence of random choices. If the casino is able to improve the accuracy of predicting the player's choice from 50 percent to 51 percent, the casino will win on average 1 Euro per played game.

Table E.13: A gambling game.

		Casino	
		Option 1	*Option 2*
Player A	*Option 1*	102, -102	-100, 100
	Option 2	-100, 100	102, -102

Now Player A may be convinced about his ability to make random choices between the two options and thus be sure to win in the long term. In that sense, playing the game seems to be a rational choice for Player A whereas it seems irrational for the Casino. However, if we believe the prospect theory in case of Player A, the pay-off matrix shall be different as shown in Table E.14. From this perspective, playing one round is not feasible for Player A.

Table E.14: A gambling game (Table E.13) from the perspective of Player A according to prospect theory (λ = 2.25 and δ = 0.88).

		Casino	
		Option 1	*Option 2*
Player A	*Option 1*	59 (102), -102	-129 (-100), 100
	Option 2	-129 (-100), 100	59 (102), -102

Still, a person would decide to play the game, because he believes that he is able to win over 50 percent of the games in the long run. In practice, the player might play a large number of rounds by using a totally random sequence of choices (that he has defined in advance by the help of a random number generator). However, even after 1000 rounds, the probability that the player has lost money is significant.

Thus, we may ask: is a person rational if he decides to play the gambling game? According to Table E.13 the answer is yes, but according to Table E.14 the answer is no, unless the player is able to play thousands of rounds. If the player wants to play thousands of rounds, he has to spend a lot of time and effort to memorize the random sequences and to play the games, which induces a considerable cost for the player. Finally, we apply the value of time model, the real question is whether the pleasure of playing exceeds the pain of memorizing long sequences of random numbers.

Lessons for CEE

All these, more or less theoretical, games might be interesting enough, but then we may ask: did we learn anything useful from the viewpoint of communications ecosystem? The success of an agent (either a person or a firm) may depend as much on the environment as on the actions taken by the agent. Hardly ever an optimal strategy, capability, or fitness guarantees permanent success for anyone. Still, it is useful to have insight into some of the basic facts that game theory have taught us during the last 60 years:

- Choices that seem to be optimal for each individual player do not necessarily result in a good outcome for anyone, as the simple Prisoner's dilemma demonstrates.
- If you want to promote cooperation with other players, behave clearly and consistently. Tit-for-tat is often the most reasonable strategy.
- In zero-sum type of games (where cooperation does not provide any significant benefit), it is better to behave in a way that is unpredictable for other players. A well-designed mixed strategy is then the most reasonable choice.
- Ordinary people do not necessarily maximize measurable outcome (e.g., money) but something vaguer that is called value in this book.

Book recommendations

S. Bowles, 2004, *Microeconomics, Behavior, Institutions, and Evolution*, Princeton: Princeton University Press.

> If you want to understand the intricate nature of human behavior in the economic domain through modeling then this is the book to be read. Five hundred pages full of models, concepts, games, and examples surely take some time to read and absorb, but the reward in the form of increased insight can be momentous.

V. L. Smith, 2008, *Rationality in Economics*, Cambridge, MA: Cambridge University Press.

> I have had a lasting doubt about the real usefulness of economics for the society, particularly during the last years with all kinds of economic crisis. Thus, I had some prejudice about the content of Smith's book before reading it. Fortunately, the book provided a surprise for me: economic theories can be used to understand human behavior, even when the results are not desirable.

A. Osterwalder, Y. Pigneur, 2010, *Business Model Generation*, Hoboken, New Jersey: John Wiley & Sons.

I have used this illuminating book about business models as a guide when writing about business aspects in communications ecosystem. If I have had this book ten years ago, it could have been highly beneficial in the venture project I led at Nokia. Now when the book is available, any entrepreneur should use the procedures and methods explained in the book to direct their business generation process.

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