Part I.

Knowledge Assets

Unfortunately, traditional knowledge management systems are like communism: nice in theory, if you ignore basic human tendencies... users benefit only from other users' submissions; they gain little from their own submissions. So there is little incentive to participate.

Red Herring (March 6, 2001)

2. Knowledge Assets and their Transfer Mechanisms

In this chapter we shall firstly discuss different concepts of knowledge. Afterwards different characteristics of knowledge assets and their impact on knowledge sharing and trading shall be presented. Finally two different knowledge-transfer mechanisms shall be proposed: an open knowledge repository and a knowledge market.

2.1. Knowledge

In the following section a short introduction to different definitions and dimensions of knowledge is presented. This claims by no means to be an extensive survey (for an overview see e.g. [126]), but should analyze the particularities of knowledge with respect to knowledge transfer. The implications of the different knowledge views on knowledge sharing and trading are also stated.

2.1.1. Classical Knowledge View

In the classical Socratic dialog "Theaetetus" [152] knowledge is described as "justified, true belief."

A subject S knows a proposition P if and only if the following three conditions are fulfilled (cf. [76] and [42, p. 30]):

1. **Belief: S believes that P.** A belief (or opinion) can be every statement about the world. An example would be the belief that "this coin shows *heads*."

2. **Truth: P is true.** A belief is true if it is an accurate representation of the world. In our example the statement would be true if indeed the coin would show *heads*.

3. **Justification: S is justified in believing that P.** The justification ensures that we do not know something just by chance. A justification in our example would be that you have turned the coin one minute ago to *heads* and nobody has touched the coin since. Otherwise if you have just flipped the coin and

> have not seen the side yet, your belief (coin shows *heads*) could turn out to be true, but you can not justify the truth. You have to be able to explain why you think a belief is true [67].

However, Gettier [76] saw a flaw in this definition and presented some counterexamples of justified, true beliefs that are not knowledge. Since then, there are some attempts to improve the definition [161]. However, the counterexamples are of a more theoretical nature and focus on obscure cases. Therefore, this definition is sufficient for our purpose.

A consequence for knowledge sharing and trading is that it is not sufficient to transfer the proposition P, but also a justification for P.

2.1.2. Semiotic View of Knowledge

Data, information and knowledge can be represented with symbols [9]. Additionally, data has to be just a series of symbols, a syntax that regulates the correct combination of signs [9]. For example, a stock quote must be formatted in a specific way, as shown in the bottom of Figure 2.1. Data is a syntactically correct series of symbols but has no meaning itself.

According to Aamodt and Nygård [9], data needs semantics to become information. In our example in Figure 2.1 the number means the current stock price of DaimlerChrylser. Kenneth Arrow summarizes a line of research in which information is defined as a signal across a channel and Shannon's theorem on entropy is used as a basis to assess the amount of information in the channel [16]. Davenport and Prusak [51] use the same definition to observe that only the receiver of the signal can characterize it as information (as opposed to mere data).

If information is connected with other information, embedded in a context, and applicable to achieve a goal, it is called knowledge [9, 162]. In our example, we need to know additional information about stock markets to use the stock quote. So we can base our decision e.g. on the price earning ratio (PER) and conclude that the stock price is cheap in relation to other stocks. This leads to a decision and action—in our example, to buy the stock. So knowledge provides the ability to perform effective actions (see also Section 5.10.2).

In the knowledge pyramid (see Figure 2.1), knowledge is exploited for decision making, and has thus direct and immediate value for a decision maker in an organization.

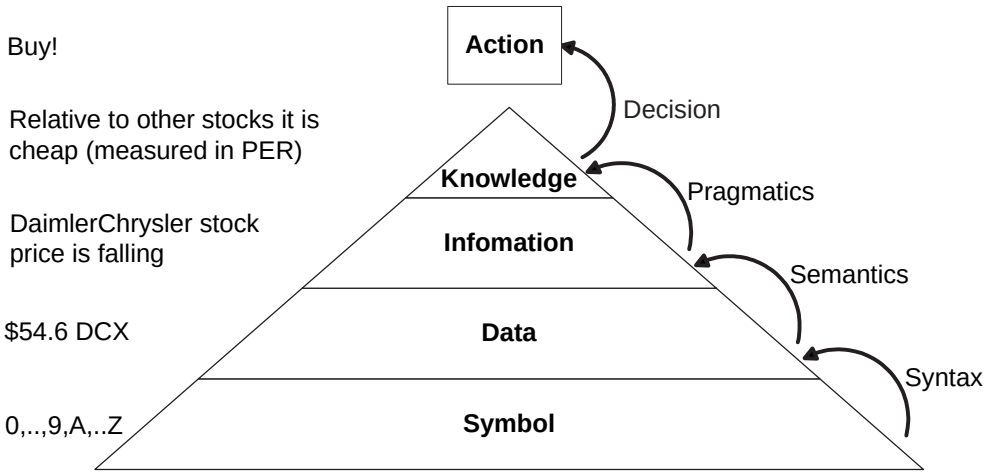

Figure 2.1.: Knowledge Pyramid, partially derived from [162, p.6]

2.1.3. Know-that and Know-how

Ryle [169] distinguishes between *know-that* and *know-how*. This is in line with Aristotle's differentiation between epistêmê (theoretical knowledge) and technê (craft or practical knowledge) [67]. The term know-that refers to know facts. An example would be "Berlin has been the capital of Germany since 1990." The term know-how refers to skills or the knowledge of how to do things. Examples are designing a chair or constructing a combustion engine. However, know-that and know-how are interwoven. The design of an engine (know-how) is not possible for example without the know-that of the physical properties of the used material. Choo et al. [42, p. 31] distinguish similarly between propositional and non-propositional knowledge.

2.1.4. Implicit, Tacit, and Explicit Knowledge

Polanyi [153] introduced the concept of tacit knowledge. Tacit knowledge is hard or even impossible to express and verbalize and is not easy to reduce to rules and recipes. Or as Polanyi phrased it: "We can know more than we can tell" [153]. Polanyi further explains: "We know a person's face, and can recognize it among a thousand, indeed among a million. Yet we usually cannot tell how we recognize a face we know. So most of this knowledge cannot be put into words" [153].

Nonaka and Takeuchi build upon Polanyi and classify knowledge into implicit and explicit knowledge [145, p. 59]. Implicit knowledge cannot be completely ar-

ticulated. It can only be transferred from person to person, for example through an apprenticeship relationship. An example would be knowledge inheritance in the Middle Ages of "The Art of Cathedral Design and Construction". Explicit knowledge is articulated, codified, stored, transferred through (electronic) media, and then shared among people. In [145], the process of generation and transfer of knowledge is captured in the "SECI Model": implicit knowledge is transferred from person to person through **S**ocialization; knowledge is made explicit through **E**xternalization; new knowledge is created by **C**ombining pieces of externalized knowledge; finally, people absorb externalized knowledge by **I**nternalization.

The implication for knowledge transfer is that only implicit and explicit—but not tacit—knowledge can be shared or traded. A knowledge marketplace should support both: person to person knowledge transfer and the exchange of externalized knowledge in the form of documents.

2.1.5. FAW Four-Level Model

The FAW[1] approach [156] takes a system-theoretic view that is inspired by biological systems and biological evolution. A central concept is the so-called *superorganism*. Superorganisms are complex systems that have to achieve their performance through the coordination of several simpler elements in order to be viable. *Radermacher* [156] assesses that not only humans, but also primates, insect colonies, and information systems are superorganisms. Consistently, companies are also viewed as superorganisms. These superorganisms often have subelements that are viable in themselves, as the human subsists of billions of cells or an organization has "viable" departments.

The FAW model uses a broad concept of knowledge. It differentiates between four levels of knowledge processing (see Figure 2.2). These levels evolved one after the other and are also built up materially on each other. Knowledge is represented in all levels through the construction and the transformation of patterns. However, the patterns are represented differently in the consecutive levels.

Physical Level. The first level consists of the physical or signal level. The knowledge is represented in the form of a three-dimensional fit or a physical/chemical formation. An example is the immunological system that works on the basis of a key-lock-principle. The "knowledge" of the immunological system about past infections and the proper reactions is captured in the physical/chemical docking capability of an antibody with a virus. Other examples of this em-

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bodied "knowledge" are architectures or tools that capture a problem solving experience in their form.

Neural Level. The second level uses neural networks or "holistic methods" to process input. Between the first and the second level filters are used to select features out of all possible signals. The knowledge is represented as a (dynamic) equilibrium of activity levels in a neural network [168]. All sensorimotor knowledge that enables humans (and animals) for complex body movements are placed at this level.

Also, the intuition of an expert in a complex situation can be placed at this level. An example would be the intuition of a designer for good form. In [78] Gladwell presents numerous examples of how experts make complex decisions in a "blink" of an eye. Often the quality of the choices is comparable with a long analytical decision process. However, the experts were often incapable of explaining why they thought this was the right choice. The experiences of the experts are stored in a more holistic or "neural network" manner than as a set of rules. This is comparable with an (artificial) neural network, that also doesn't have the capability to "explain" an output. A human is not capable of understanding the meaning of a neural network representation [168, p. 592]. The tacit dimension of knowledge from Polanyi [153] can therefore be explained by this level.

Symbolic Level. The third level is knowledge in the form of language, logic, and symbolic inference. It can be shown that a Turing machine can be coded as a neural network [98]. Therefore, the neural level can work as the foundation for the symbolic level. A key for the performance of this level is the classification of world states in the form of concepts. This reduces the description complexity of a situation. Argumentation in the form of language, rule-based expert systems, and logic are placed at this level. The majority of the explicit knowledge can be positioned at this level. Examples are safety norms in factories that capture the experiences of former accidents. These norms do not have to be based on one's own experience but can also be transferred from other organizations. Language can explain and justify these norms. Another example is the linguistic argumentation of good design.

Model Level. At this level the knowledge is represented in mathematical or scientific models or theories of the world. Examples are Maxwell's equations for electromagnetism or an Operations Research model that captures the different consequences of a decision problem. Another design example is the mathematical apportionment of a distance by using the golden ratio.

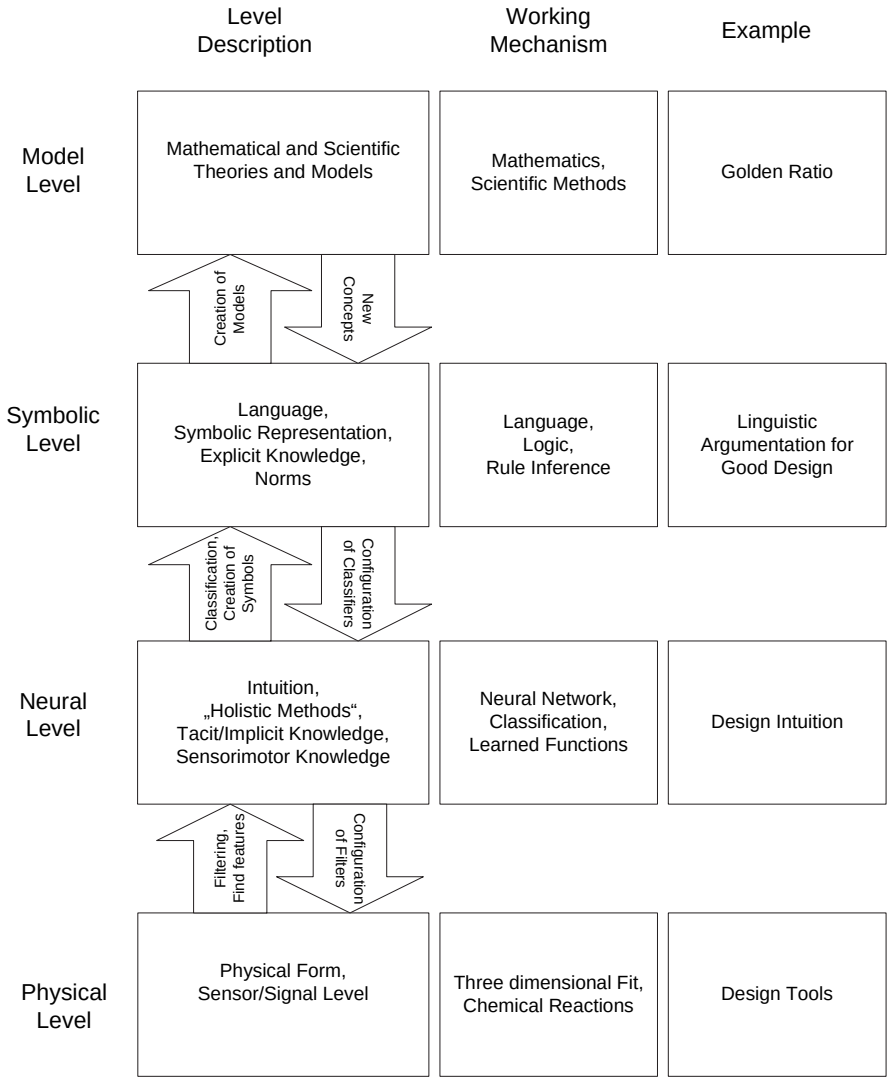

Figure 2.2.: FAW Four-Level Model, adapted from [156]

2.1.6. Impact for Knowledge Sharing and Trading

In this thesis we shall limit ourselves to the knowledge types that are (easily) transferable. We use the definition of knowledge as justified, true belief (cf. Section 2.1.1), which means justification for the knowledge also has do be transferred. We are in particular interested in enhancing business decisions and action with knowledge transfer (cf. Section 2.1.2). Both know-that and know-how—as far as there are transferable—are considered (cf. Section 2.1.3). We discard implicit knowledge and will only analyze knowledge assets that are transferable in short-term interaction rather than through a socialization phase. (cf. Section 2.1.4). In the FAW model (cf. Section 2.1.5), only knowledge at the physical, symbolic, and model levels is transferable.

2.2. Knowledge Assets

We define a *knowledge asset* as any product or service shared or traded with the primary goal of knowledge transfer.

2.2.1. Online Expert Advice and Digitally Documented Knowledge

We concentrate on knowledge assets that are shared or traded by online interactions. Therefore, we shall limit the analysis to only two knowledge assets: online expert advice and digitally documented knowledge. Online expert advice is the instant answer from an expert delivered online. Digitally documented knowledge is written down by an expert and stored in digital form.

2.2.2. Positioning of Knowledge Assets

Before observing the characteristics of knowledge assets we position knowledge assets among related goods concepts like *digital products* and *information goods*.

Shapiro and Varian define *information goods* as all goods that can be digitalized or transformed into a stream of bits [179, p. 3]. According to this definition, an information good can be intangible, e.g. a stock quote, or tangible, e.g. a book.

Loebbecke [123] placed the emphasis on the online trading of goods and introduced the term *online delivered content* (ODC) to describe those products “that consist *only* of content and whose total value therefore can, and usually is, produced, traded, and delivered on-line” [123]. Examples for ODC are music, searchable databases, and consulting.

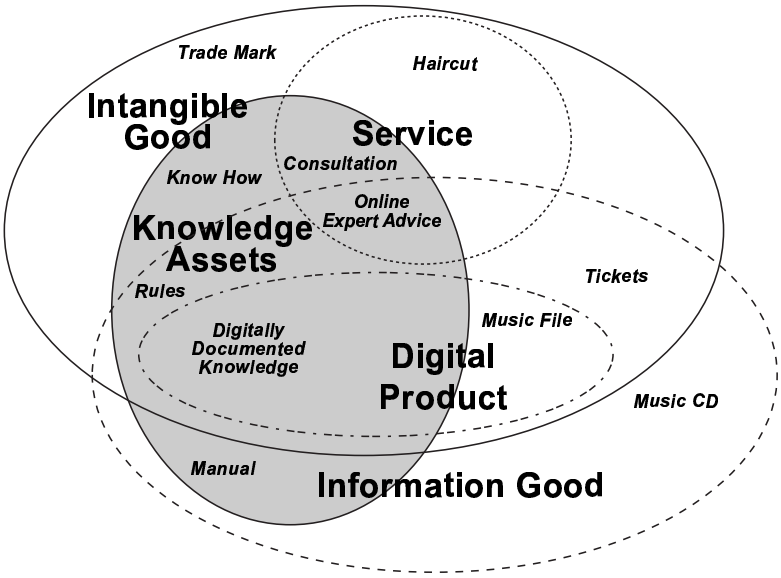

Figure 2.3.: Positioning of Knowledge Assets, partially derived from [125, p. 20]

Luxem [125] defines *digital products* as information that is already stored completely in digital form and can be transferred over communication networks. With the requirement of a stored digital representation Luxem explicitly excludes from digital products services like online consulting. Services are not storable and they need a so-called external factor, like a question from a customer. Luxem also excludes concert tickets, airline tickets or similar certificates from digital products, because they are only digital or material representations of the right for a service or a material product. The object of the right is not a digital product but a service or a material product. Luxem [125, p. 17] emphasizes that these rights have different properties than digital products. In contrast to the definition of Luxem, Whinston et al. [201] also include services and tokens that represent rights (like digital airline tickets) in the term digital product. In this thesis we adhere to the definition of Luxem for the term “digital product”.

We also make a separation between goods that have a material nature and those products or services that can be traded but have no physical substance. For the latter, we use the term *intangible goods*; examples include services, rights, patents, licences, concepts and know-how.

In Figure 2.3, we display intangible goods, digital products, information goods,

and services as overlapping sets. For each category, we present at least one instance in *italics*. Knowledge assets are overlapping all categories. In this figure, we show next to each knowledge asset another instance of the same ancestor category that is not a knowledge asset. For example, the knowledge asset *consultation* is a service, similar to *haircut*. *Digitally documented knowledge* is a digital product, similar to a *music file*.

Knowledge assets differ from other goods or services in the same categories by certain properties that affect their appropriateness for trading. In the following, we elaborate on these differences. As mentioned previously, we concentrate on two types of knowledge assets: *digitally documented knowledge*, which is a digital product, and *online expert advice*, which is a digitally traded service.

2.2.3. Characteristics of Knowledge Assets

In literature [111, 125, 123, 201], different dimensions of intangible goods are examined: value determination, perishability, transferability, complexity of product use, individualization, transfer mode, cost structure, excludability, and rivalry in consumption. We take these dimensions and analyze the characteristics of online expert advice and digitally documented knowledge.

Value Determination

The value of the knowledge for the user is determined by the value of the actions or decisions supported by the knowledge. It is often not easy for the buyer to estimate *ex ante* the degree of improvement of action through the new knowledge. But even after knowledge transfer it is not easy to identify the transferred knowledge as the cause for an improved action.

We can distinguish among three kinds of goods: search, experience, and credence goods [111]. Search goods are goods where its quality can be determined by the consumer prior to buying. The quality of experience goods can only be assessed after a purchase, as for example the taste of food. Finally, the quality of credence goods is difficult to evaluate even after purchase or consumption: the recipient has to trust either the provider, a certification, or a third party. Medical diagnosis belongs to this category.

Online expert advice and digitally documented knowledge can be characterized as an experience or credence good: obviously, its quality is unknown until its usage. Since expert advice is intended to provide an answer or solution to an explicitly stated problem, the recipient can only make assessments about the quality of the advice with

respect to the original question. The categorization of specific expert advice as an experience good or a credence good depends on the prior knowledge of the recipient.

Like expert advice, digitally documented knowledge is not a search good. Under the assumption that a knowledge seeker searches for assets that contribute to the solution of a problem at hand, the same observations as for expert advice apply: Documented knowledge assets are experience goods or credence goods dependent on the prior knowledge of the receiver. If documented knowledge is acquired for future use, as might be the case with seminar materials or with reports about successful projects of a company, it should rather be observed as a credence good only.

These observations lead to the need for quality assurance mechanisms for knowledge transfer, as discussed in Section 5.10.

Perishability

Whinston et al. [201, p. 78] study the impact of time upon the value of intangible goods and distinguish between time-dependent and time-independent values. The value of a knowledge asset may be time-dependent. For example, basic physical laws that are not (yet) falsified can be assumed as time-independent. In contrast, specific knowledge needed for decision making may have no value after the decision is made. Know-how about programming or usage of software tools may age and become obsolete.

The value of expert advice is time-dependent. The time span in which its value does not vanish is the time span in which the associated question, project, or problem remains relevant. The value of documented knowledge is time-dependent and is subject to aging.

We can differ between basic knowledge like programming C++ and knowledge that is specific to a problem like how to change the battery of a Pocket PC. Knowledge that is related to a specific problem is only relevant for a limited time after the problem occurs.

Transferability

The knowledge assets displayed in Figure 2.3 are transferable in the sense that one person can acquire them from another. Nonetheless, the overhead of such a knowledge transfer varies: a person can learn the content of a manual by acquiring and reading the manual, while the elicitation of an expert's know-how demands a close interaction with the expert. Know-how is partially tacit and can be transferred mostly through a master-apprentice relationship according to the socialization phase in the

SECI model of Nonaka and Takeuchi [145]. We concentrate on knowledge assets that are transferable in short-term interaction rather than through a socialization phase.

Explicit knowledge can be codified into documents. In this case the borderline between information and knowledge is fading out: a book contributes to the knowledge of its readers but is not knowledge itself. A case study contributes to the knowledge of its reader only if its applicability on similar cases can be deduced from the study's context. Davenport and Prusak consider the categorization of content, the specification of context and the elimination of errors as prerequisites for characterizing an asset as information [51, p. 4]. Characterizing an asset as knowledge requires an association of a problem or target specification as well as the identification of further relevant knowledge assets related to it [51]. Knowledge assets of this type are easily transferable. However, their owners must provide guarantees on their quality.

Expert advice is an explicit knowledge asset. It is transferable but requires the interaction between recipient and expert. This transfer does not correspond to the socialization phase but rather to the phases of explication and combination according to the SECI model [145]: The recipient formulates a project or a query and the expert provides an answer by making his knowledge explicit on the subject. Often it is also combined with the knowledge of the recipient as well.

Complexity of Product Use

The ease of consumption is another characteristic of intangible goods [111]. A haircut can be consumed by anybody. The consumption of music is exceedingly more complex than one would intuitively assume, as any fan of European baroque music can verify upon listening to 12-tone music or Japanese music. Both expert advice and documented knowledge are complex in their use, because they presuppose background knowledge to which they can be related and combined. For example, a book about statistics is only useful to somebody who knows at least basic mathematics, while a prediction of market trends presumes understanding of both finance and statistics.

Transfer Mode

Whinston et al. [201] make a distinction between delivered products and interactive products. Delivered products are acquired (i.e. on the internet: downloaded) at once; after the delivery any interaction stops. Interactive products require a more or less continuous interaction.

It has become clear that expert advice is an interactive product, formed during the interaction of expert and recipient. In contrast, digitally documented knowledge is

submitted to the repository by its contributor or acquired by any number of authorized recipients, without any interaction with or reference to the original owner.

Individualization

A comparison between *digitally documented knowledge* and *online expert advice* reveals differences with respect to the interaction between the knowledge owner and seeker. Digital documents are intended for a target group of individuals with common features (like age, language, education, etc). They should be able to process, interpret and explore them without interaction with the author. In contrast, expert advice is an answer to a question asked by a person. It is formulated during the interaction between the expert and this person. The two types of knowledge assets differ along the dimension *individualization*.

Consulting encompasses a continuum from the mere selection of information pieces like stock prices and market analyses up to the answer of a question that is first formulated during the interaction. For example, investment consulting ranges from the analysis of a specific market segment to the specification and management of a complete investment portfolio. Between these two extremes, consultant and investor interact and make joint decisions about an investment [133]. The fact that the knowledge recipient is involved implies that the knowledge asset finally produced is individualized.

Cost Structure

The cost structure for an intangible good refers to the overhead of creating the good. In the case of digitally documented knowledge, the fixed costs are high. However, the cost of delivering a document electronically is negligible, so that its reproduction has nearly no variable costs. This implies that the average cost decreases with the number of recipients.

Expert advice has, in contrast, low fixed costs. The main costs occur in the process of consulting. These costs often incur each time a question is answered. Therefore, the average costs of expert advice are nearly linear.

Excludable Goods

Economists term a good as a “pure public good”, if it is non-rival and non-excludable [80]. A good is non-rival if its consumption by one recipient does not reduce the amount available to other recipients. A good is non-excludable, if it is impossible to exclude anyone from its consumption. Classic examples for pure public goods are

national defence and lighthouses. Whether a knowledge asset is excludable is mainly a question of technology and law. A car is excludable, because one can lock it by technology and stealing it is not allowed and will be punished by law. Documented knowledge is protected by copyright law. The equivalent of locks could be a digital rights management (DRM) system. The accessibility of a DRM can be subject to access rights. Expert advice may be available to anyone, but the expert can reject anybody. Hence, both documented knowledge and expert advice are excludable goods. However, online expert advice is more easy to exclude than digitally documented knowledge.

Rival in Consumption

Intuitively, rivalry is associated with scarce goods like bandwidths. There exist knowledge assets where the utility of the recipient depends on the existence of other persons in possession of the same asset(s). This dependency can be positive, as for example in the mastering of a language like Esperanto, or negative, as is the case for knowledge about a new technology or a pending patent. Therefore, for both knowledge-asset types rivalry can be high or low.

Summary of Characteristics

A summary of the characteristics and their values for the two knowledge asset types is displayed in Table 2.1 and 2.2.

2.3. Knowledge Transfer Mechanisms

2.3.1. Research Framework

To determine the appropriateness of a knowledge market we analyze the different factors that influence knowledge transfer (see Figure 2.4). The main phenomenon of interest in this study is *knowledge transfer*. Knowledge transfer is influenced by the *knowledge-transfer mechanism* and different *influential factors* like culture, incentives, etc.

We can distinguish between two main knowledge-transfer mechanisms: an *open knowledge repository* and a *knowledge market*. The activities of the former we call *knowledge sharing* and these shall be analyzed in Part II. The activities of the knowledge market we call *knowledge trading* and those shall be analyzed in Part III.

Digitally Documented Knowledge			
Characteristic	**Value of Characteristic**		
Value Determination	Search Good	Experience Good	Credence Good
Perishability	Time Dependant	User specific Time Dependant	Not Time Dependant
Complexity of Product Use	High	Low	
Transferability	Easy	Difficult	
Individualization	Easy	Difficult	
Transfer mode	Delivered Good	Interactive Good	
Fixed Costs	High	Low	
Variable Costs	High	Low	
Excludable	Easy	Difficult	
Rival	High	Low	

Table 2.1.: Characteristics of Digitally Documented Knowledge

Online Expert Advice			
Characteristic	**Value of Characteristic**		
Value Determination	Search Good	Experience Good	Credence Good
Perishability	Time Dependant	User specific Time Dependant	Not Time Dependant
Complexity of Product Use	High	Low	
Transferability	Easy	Difficult	
Individualization	Easy	Difficult	
Transfer mode	Delivered Good	Interactive Good	
Fixed Costs	High	Low	
Variable Costs	High	Low	
Excludable	Easy	Difficult	
Rival	High	Low	

Table 2.2.: Characteristics of Online Expert Advice

2.3.2. Knowledge Sharing

Internal knowledge management systems have often a digital place where all the documents can be stored and all users can search and view the knowledge assets, depending on their user rights. We define an open knowledge repository as an element of a knowledge management system where all codified knowledge can be stored for open access in the company. In this situation, there is no person-to-person knowledge sharing but all knowledge assets are shared through a central open repository (see Figure 2.5). In the following, we abstract from the technical details of the open knowledge repository like access rights, search, views, structured, or unstructured representation. The presented knowledge sharing theory is applicable for different technical features—however some features may have an impact on knowledge sharing in our theory. For example, the anonymity of a user hinders the identifiability of the actors (cf. Section 3.3.1).

We define knowledge sharing as the transfer of knowledge in an open knowledge repository situation. We can measure knowledge sharing using different indicators:

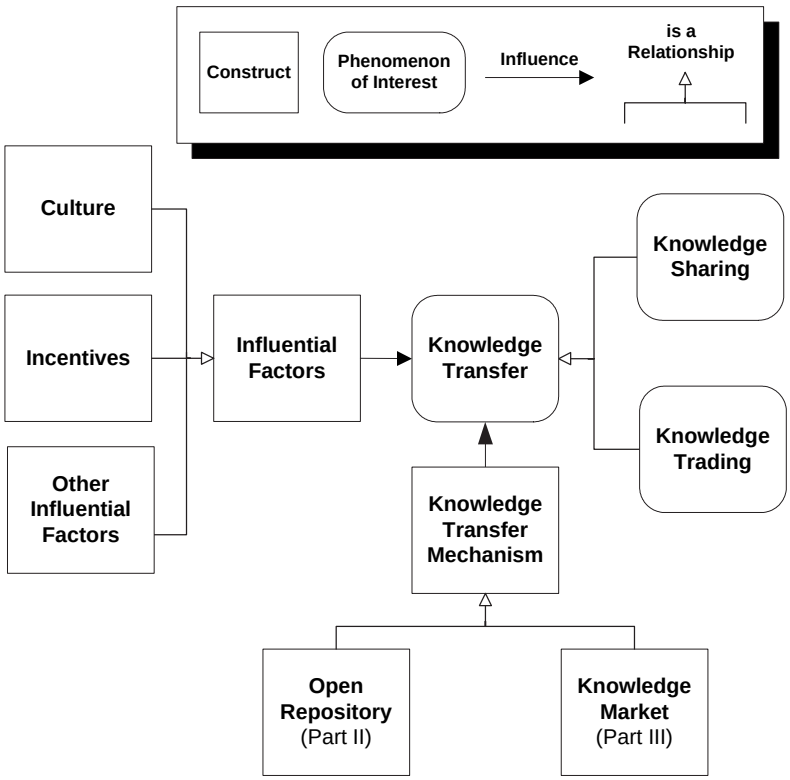

Figure 2.4.: Research Framework

by the time an employee spends on externalization of his knowledge, by the number of documents somebody shares, or by usefulness ratings of knowledge seekers.

In an open knowledge repository, knowledge sharing relies on the individual knowledge possessor's effort. Therefore, it is crucial to the success of a system to understand the knowledge sharing motivations of the participants (see Chapter 3).

Documented knowledge assets in an open knowledge repository have the characteristics of a public good: knowledge assets are freely distributable at nearly marginal costs to everybody in the organization (cf. Table 2.1). Also, consumption of the knowledge assets does not preclude consumption by another employee. The sharing of knowledge without incentives and exclusion is a private provision of a public good.

Private provision of a public good often leads to free riding and to an undersupply of the good as e.g. [96] showed for network bandwidth and [10] for peer-to-peer networks. This phenomenon is also called the "tragedy of the [knowledge] commons"

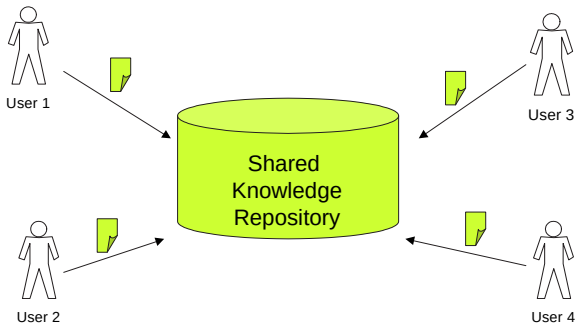

Figure 2.5.: Sharing of Knowledge

[84]. In the context of a shared knowledge repository we can call it a knowledge-sharing dilemma [135, 39].

Therefore, in Part II we analyze knowledge sharing with an open knowledge repository and model this situation as a public-good game.

2.3.3. Knowledge Trading

The alternative to an open knowledge repository is a knowledge market in which knowledge trading takes place. The term *knowledge market* was first coined by Davenport and Prusak [51]. But they used the term in a metaphoric way because the knowledge transfer was free of monetary charge.

We define knowledge trading as the transfer of usage rights for knowledge assets in exchange for a monetary payment with the help of a market mechanism. In this situation, we assume excludability (cf. Table 2.1). Knowledge markets have the appealing characteristics of being applicable not only inside an organization, but also between organizations and individuals or in a virtual company. Knowledge trading can be viewed as a form of a subsidized free incentive system for knowledge transfer.

In Part III we develop a model for knowledge trading which considers the in this section analyzed particularities of knowledge assets.