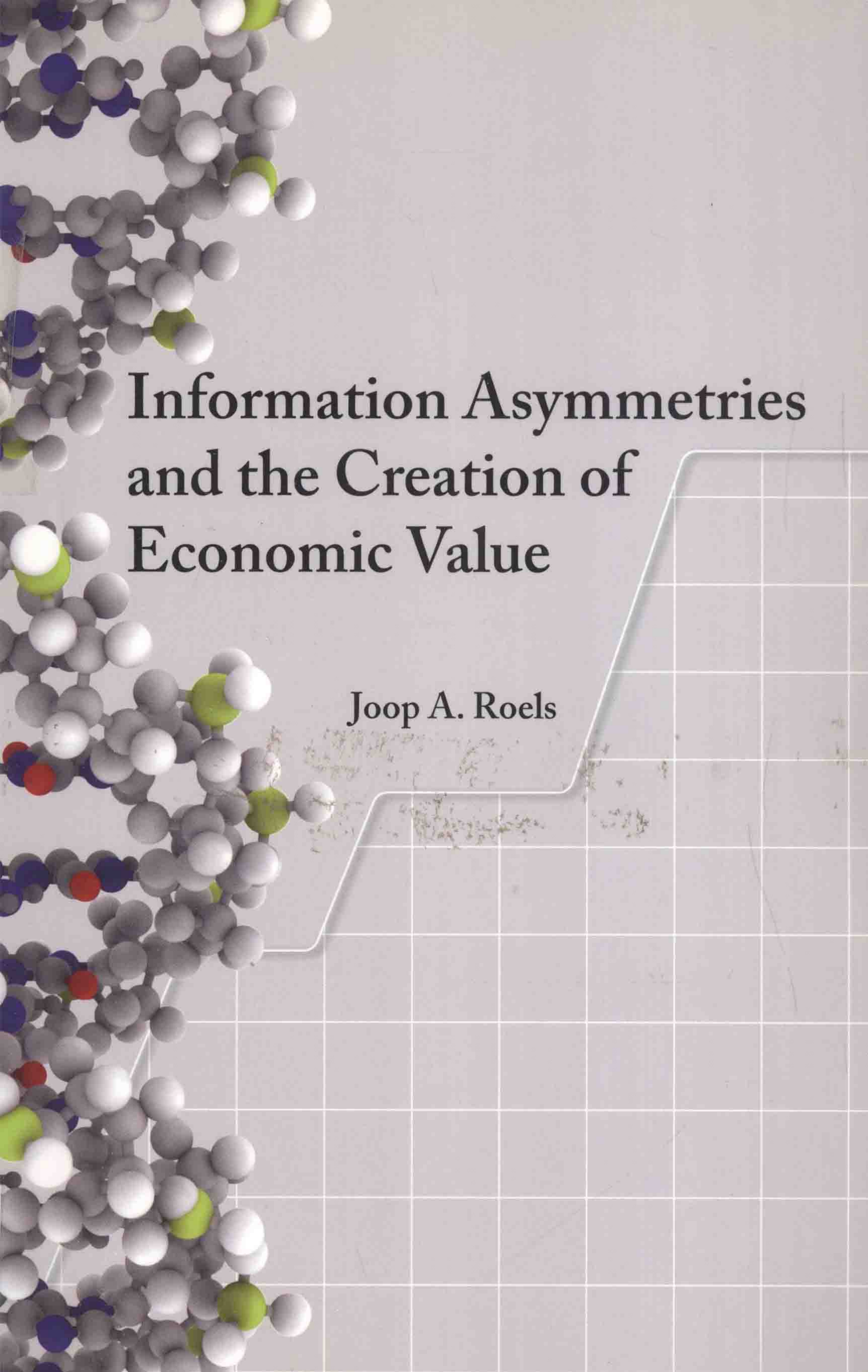

Information Asymmetries and the Creation of Economic Value

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A Theory of Market and Industry dynamics

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Preface

The writing of this book takes place in the year in which we celebrate the 150th anniversary of Darwin's theory of evolution. This theory revolutionized the understanding of evolution as a key principle underlying the development of biological species. It largely displaced the creationist view on the origin of life. Some 50 years earlier Sadi Carnot published a remarkable paper that made him one of the founders of thermodynamics; the science that allows understanding of transformations of energy and matter. Carnot's work on the heat engine led to the discovery of the second law of thermodynamics. The second law of thermodynamics provides an arrow of time to the direction in which spontaneous processes evolve. It has been formulated in a variety of ways in the years after its discovery by Carnot. One of the popular formulations is that systems that are left alone develop in the direction of increasing disorder. Buildings that are left alone develop into ruins; the reverse process requires the input of solid and skilled labor.

The combination of the theory of evolution and the second law of thermodynamics has puzzled many early investigators. Evolution clearly proceeds in the direction of increasing complexity, ordered systems, such as human kind, evolved apparently spontaneously out of an initially unordered state. Fortunately, developments in the 20th century led to a reconciliation of thermodynamics and evolution. Prigogine and his coworkers formulated what could be called a general systems theory of evolution. It became clear that the evolution of "Order out of Chaos" is a necessary consequence of the second law of thermodynamics if we consider complex systems that operate in an environment that is not in thermodynamic equilibrium.

The discovery of DNA and RNA as the basis of life led to the understanding that biological evolution is of an informational nature. In biology the storage and processing of information forms the basis of the evolution of increasingly complex organism.

Evolution in biology was for an extensive period of the history of life on earth based on the further refinement of the immortal coils that characterize the double helix of DNA macromolecules. Later on in evolution other ways of developing and transferring information emerged when the brain appeared and evolved to sophistication when the humanoids and later on *Homo sapiens* appeared on the stage. This triggered the so-called exogenic evolution; evolution based on transferring and developing information beyond the information carrier DNA. This led to the development of the socioeconomic system, with its institutions such as universities, economies, markets and firms. It is the ambition of this book to investigate the relation between the theories mentioned above and the storage, processing and transfer of information to grasp the dynamics of economies, markets and industries.

Most of the systems that are of interest to physicists, chemists and biologist are far too complex to be modeled in all detail. This certainly also holds for systems such as industries, economies and markets. In physics this leads to the widespread use of macroscopic models in which only part of the microscopic details of the system is taken into account. A reduced information picture of the system is developed. This approach leads to limitations to the predictability of the future behavior and to limitations to the extent to which potential value can be made free from the sources of value in the system. The extent of this loss is characterized by the statistical entropy of the macroscopic description.

The ambition of the author is to develop a consistent theory of evolving systems with special reference to industries, markets and economies. We show that the basic driving force behind the transactions that take place in our markets, industries and economies rest on the creation and maintenance of asymmetries in information. Furthermore, the value (and the cost) of the information is quantitatively defined in terms of the concept of statistical entropy. This results in a general value transaction theory to be applied to socioeconomic systems.

This basic formalism is applied to systems in which asymmetries in information exist and develop. The theory is analyzed in terms of accepted economic theories such as the perfect competition model, transaction costs economics, the concept of dynamic capabilities and the evolutionary approaches to organizations. Particularly evolutionary approaches are seen as promising and the theories of evolution and complexity are analyzed from the perspective of physical, chemical and biological systems. It is then argued that these approaches can be generalized, evolution is, as said, a general feature of complex systems of which we can only have a limited information picture. This leads to the conclusion that the application of evolutionary approaches to markets, industries and economies does not have to be understood in terms of an analogy with biological evolution but as a reflection of a general evolution theory of complex systems. We argue that there are both similarities and differences between biological and socioeconomic evolution. In the last chapter of the book the theory is analyzed in terms of a number of characteristics of industries and markets. The theories underlying the approach (thermodynamics of complexity, information theory, statistical thermodynamics, theory of evolution,) are not free from mathematical intricacies. This book tries to avoid mathematical intricacy as much as possible without sacrificing rigor. Most of the concepts are discussed in a verbal way to explain the mathematical formalism to a multidisciplinary community of readers.

The main distinguishing feature of this book is that it develops a conceptually and mathematically consistent framework for the existing concepts used in organizational economics in a way that should be accessible to readers that are not familiar with modeling approaches in physics, chemistry and biology. Some parts of the present literature in "econophysics" lack that consistency and accessibility. The author hopes that this book will thus augment on and complement existing approaches in the literature on organizational economics and evolutionary approaches to organizations.

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CHAPTER 1: INTRODUCTION.

1.1. General introduction.

The objective of this work is to develop a theory of "transactions", more specifically transactions in economies, markets and industries. The theory will cover a range of social and economic processes such as market transactions, the emergence, growth and decay of industries, the competition between industries and the dynamics of industry structure. To achieve this, the force that drives transactions is identified. This force drives the establishment of organized structures, such as industries and markets, by a process of self-organization. This self-organization process leads to the establishment of increasingly complex structures called dissipative structures because they need a constant source of "fuel" to maintain their integrity.
Examples of evolutionary approaches to socioeconomic problems have appeared in the literature (Nelson and Winter (1982), Dopfer (Ed.) (2005), Wit (2003), Nelson (1987), Beinhocker (2007)). In this respect, the approach in this book is not new. What is new is the development of a consistent mathematical framework. The author has chosen not to review the literature, but rather to develop a new, internally consistent approach, based on established physics inspired principles.
An important source of inspiration for this work is the theory of macroscopic thermodynamics. It is the theory of the transformation of matter and other forms of energy. In my earlier work, macroscopic thermodynamics was extensively used to understand the efficacy of growth and product formation in microorganisms (Roels (1980, 1983)). Microorganisms are organized forms of matter in which many molecular species "cooperate".
The theory of non-linear non-equilibrium thermodynamics analyzes self-organization phenomena. In non-linear thermodynamics self-organization and evolution phenomena are an important topic in the last odd fifty years. In systems away from equilibrium ordered structures appear that may increase in complexity if the distance from equilibrium grows. The emergence of these dissipative structures depends, as stated above, on the availability of a source of energy that is used to grow and maintain these non-equilibrium structures. Complete accounts of the relevant theories are well documented (Glansdorff and Prigogine (1971), Nicolis and Prigogine (1977), Prigogine (1980), Prigogine and Stengers (1984)). This book summarizes the most important concepts of non-equilibrium thermodynamics and shows their application to the description of market transactions and the establishment and dynamics of (industrial) organizations. The formalism of thermodynamics is extended to include these systems.
The approach in this book reconciles the well established approach to thermodynamics that is deeply rooted in the physical sciences, with some of the principles from biological evolution, aspects of strategic management (Porter (1980, 1985)), concepts of organizational economics (Barney and Ouchi (1986), Douma and Schreuder (2008)) and the theory of capital markets (Jensen (1972), Sharpe (1970), Elton and Gruber (1984)). Chapters 2, 3, 5-8 treat the thermodynamics inspired formalism and show its generalization to socioeconomic systems.
The theories discussed are mathematically intricate. However, we discuss most of the results verbally to assist the reader in understanding the concepts behind the mathematics.
As a final remark to this general introduction, we stress that the application of evolutionary principles to socioeconomic systems is not to be interpreted in terms of an analogy with biology, but as a general feature of an evolutionary systems approach. Both economies and organisms are examples of complex systems that operate removed from equilibrium, beyond a critical limit. In such systems, evolution becomes a necessary feature. In chapter 9 where we conclude on the nature of the firm this is discussed in more detail.

1.2. Industry: Competition, growth and decay.

Standard classical microeconomic theory introduces the perfect competition model (Williamson (1971), Barney and Ouchi (1986), Baumol et al. (1982), Chamberlin (1933), Hirshleifer (1976)). This model is based on the following assumptions:

- There exists a large number of buyers and sellers
- Products and services from different sources are the same to the buyers, there is no product differentiation.
- There are no costs associated with market transactions

These assumptions lead to a situation in which, after initial transients, equilibrium is reached. This state is characterized by:

- Supply and demand are balanced
- The players in the market earning only normal profits, just enough to keep their assets in operation
- A "socially optimal" situation in which resources are efficiently allocated.

Coase (1937) noted a further consequence of the traditional microeconomic theory. According to this theory, organizations such as industrial corporations should not exist; the market is a far more effective way to arrange transactions.
This strongly reminds of the results of thermodynamic theory. In a system at thermodynamic equilibrium, ordered structures cannot be maintained. This argument and its consequences are further developed later in this book.
There are, in addition to the fact that industrial organizations exist, several other problems with the classical microeconomic approach:

- There are often differences in the products and services (in the remainder of this book we will indicate products and services collectively by products) that are offered on the market. Apparently, there is room for product differentiation. This finds no place in a perfect competition world where efficient suppliers supply one optimal product.
- The existence of firms, individuals and organizations that earn above normal profits, which again finds no place in the world of perfect competition.

In the chapters that follow the perfect competition world shows to be rather dull. Reality is far more exiting. We observe a world where firms and over average profits exist or, more correctly phrased, where an environment is created in which firms and over average profits exist.
This treatment now continues with the development of a model of the firm. This verbal model serves as a stepping-stone for the development of more quantitative reasoning.
Industrial activities derive from the fact that the products needed by society cannot be adequately sourced from the environment in a direct way. In addition, the need for specialization and the need to rely on teams of specialists to efficiently collect or produce the products importantly contribute to the appearance of firms. Finally, there can be significant economies of scale and scope that drive the emergence of industrial activity.

In summary, "hunter-gatherer" strategies, in which individuals obtained the products to supply their needs directly from the environment, supported the evolution of humankind for only a limited period. Conversion of resources to the products needed, initially in an artisanal

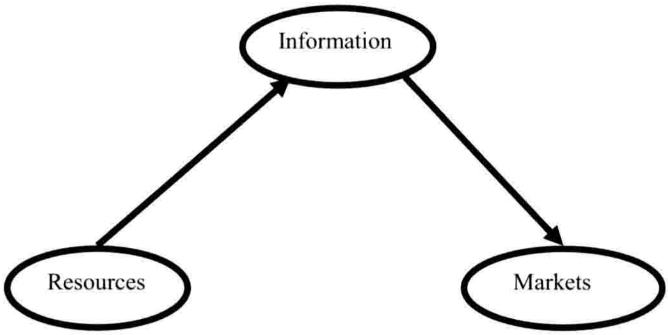

Fig. 1.1. A schematic Model of Industry

way, later on increasingly in firms, started to dominate the market. In this evolution industrial activity increasingly depended on distinctive assets and competences (such as refined technological capabilities) to produce and supply in an efficacious way.
Fig. 1.1 depicts a model of industry. Industry is using (captive) information and associated assets and competences to source materials, information and services from the environment and to transform these into products that supply a market need. This process adds value as perceived by the buyer. If the firm operates well the buyer is prepared to pay more than the amount the firm has to spend to produce the product. In this way, the firm obtains a profit. It can invest part of this profit to generate new competences or assets and to develop new processes and products. This causes the information set of the industry to change. In this model, industry emerges because of the needs that exist in the market. Industry develops the information set needed to efficiently supply products that satisfy those needs.
Another important concept that shapes industrial activity is competition. Generally, several firms are willing and able to supply products that satisfy a need. These firms compete for the value associated with satisfying that need. The firms are not equally efficacious and because of competition, some firms may grow their share of the market whilst others are less successful. In addition, shaped by the forces of competition an evolution of the industry takes place. This leads to the familiar life cycle of an industry or a market (Fig. 1.2.).
A new industry or market emerges because of an innovation in the resource base of the industry, the competences and assets base, the way of supplying the target need, or a combination of these. This triggers the so-called embryonic phase of the industry. In the subsequent growth phase of the industry the forces of competition shape an evolution in which a process of learning by doing triggers the development of increasingly efficacious ways of satisfying the target need. The market grows in value. In the growth phase both the development of better products (product innovation) and the development of better processes to produce a given product (process innovation) take place. In most cases, the number of players in the industry will increase. A phenomenon called evolutionary radiation in biology.

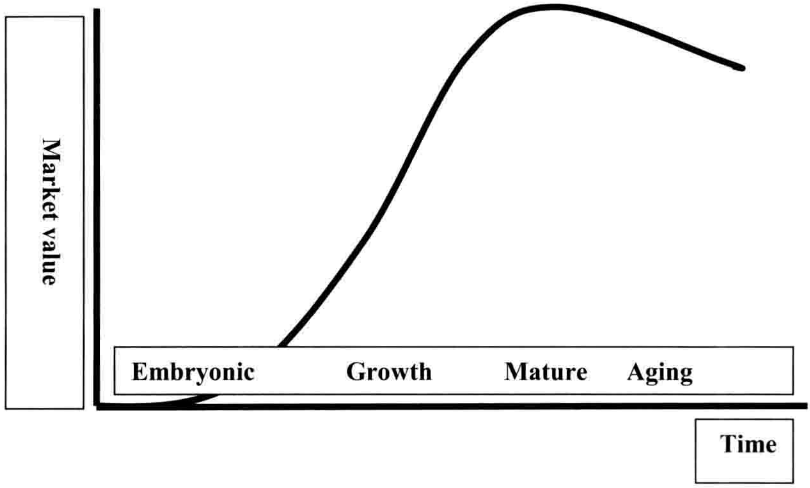

Fig. 1.2. Industry Evolution: The life cycle

In the further evolution of the industry, when we enter the mature stage, further optimization of products and processes becomes increasingly difficult. A unit progress needs more and more effort. The growth of the value of the market stagnates. The number of players decreases by forcing out the less effective ones. Finally, the industry may enter the decay phase. This is often caused by an innovation that changes the way the target need is satisfied. Sometimes the target need disappears. Fundamentally better or cheaper concepts substitute the existing products. An important feature of this model is that an industry structure does not exist in the way Porter discussed this in his influential publications (Porter (1980, 1985)). The industry structure is a dynamic consequence of evolution under the forces of competition.

Note 1.1.

We use the term industry for a group of products and underlying industrial activities that supply one defined need in society. Innovation that leads to the decay of an industry does not necessarily mean that the existing players decay with the industry. It may be one of the leading players in the old industry that pioneers the new approach. However, often a period of fundamental innovation gives opportunities to new entrants and poses a threat to the companies that were well entrenched in the old industry

1.3. The nature of value and value transaction processes.

The ambition of this work is to lay the foundation for a quantitative approach towards the development of industries and markets. Therefore, it is necessary to identify the driving force behind industry evolution. Chapters 3, 5 and 6 present the theory to achieve this.

The model derives from the notion that a need in society allows a corporation to earn a profit if it succeeds in more or less efficiently satisfying that need. The need presents an opportunity to successful companies. To develop a quantitative approach we introduce a number of concepts, such as:

- The distinction between true value and so-called free value. True value is the intrinsic value of an asset or a product. Free value is the value to an actor that has only limited information about the asset. This distinction is an analogue of the distinction between internal energy and free energy in thermodynamics and the concepts underlying the Capital Assets Pricing Model of finance (Chapter 4). Free energy is the amount of energy that is available to do useful work. It differs from internal energy due to the limitations of the information about the exact state of the system. This leads to the situation that only a limited amount of the internal energy is available to do useful work.
- The distinction between true value and the price obtained in the market. This in contrast to the perfect competition model in which price is equal to value

The model predicts a difference between price and value. This is a direct consequence of the fact that industries create asymmetries in information that lead to a non-equilibrium situation and different perceptions of free value to buyers and sellers. The relation between value, free value and price depends on the incomplete information the various players in the market have about the true value of resources and assets and the asymmetries in that information between actors involved in a transaction. As stated, the structure of the model bears close resemblance to macroscopic non-equilibrium thermodynamics. Free energy is a concept that measures the value of a source of energy to drive processes in physical and chemical systems. An analogous concept can specify the free value of an asset in terms of its ability to drive a market transaction.

Thermodynamics is the prime example of a reduced information theory, a so-called macroscopic theory. These theories provide a simplified picture of reality fitting the limited information the observer has about the system. Nevertheless, these theories remain valuable to make some predictions about the likely behavior of a system. Reduced information theories are used in physics and chemistry because the overwhelming majority of the systems of interest to physicists and chemists are far too complex to allows analysis in detail. Real systems exist of a vast number of molecules, atoms and sub-atomic particles. Structures are complex and intricate patterns of interaction are common. As an example, a piece of iron of 56 grams contains 6.10^{23} atoms and a detailed analysis in terms of this vast number of atoms is impractical and impossible. Clearly, a complete picture, a full information description, is impossible to a non-divine observer. In the physical sciences, a distinction is made between a microscopic description, in which the detailed and intricate microscopic structure of reality is taken into account, and a macroscopic description in which only limited information about the salient averaged properties of a large collection of microscopic objects is considered. This is the subject of statistical mechanics. Chapter 3 gives an outline of this theory and generalizes it to economic transactions. The macroscopic description is typified as a reduced information approach. The fact is considered that we have only limited information about the exact microscopic structure of the system of interest. This is caused by the limitations of the observation process and the related uncertainty. The macroscopic description contains far less information than is needed to specify the future evolution of the system in all microscopic detail.

A macroscopic description introduces the uncertainty about the exact microscopic state of the system. Hence, also the future evolution is subject to uncertainty. This uncertainty emerges as a direct consequence of the reduced information description of the system. Thermodynamics quantifies the uncertainty as the entropy of the reduced information description, a statistical notion. Macroscopic thermodynamics shows that in systems away from equilibrium, new structures, so-called dissipative structures, appear because of self-organization phenomena. Beyond a well defined limit these structures may evolve into ever increasing complexity. This

development brings evolution of complex structures in an initially unstructured system within the realm of macroscopic theories. An example of such a system is the biosphere on earth including human society with its markets and organizations such as firms.
The next section briefly discusses the theory of dissipative structures. Chapters 6, 7, 8 and 9 provide far more detail. This paves the way to extend the formalism of macroscopic thermodynamics to include the description of economic aspects of the evolution of firms and markets.

1.4. Self organizing systems: Dissipative structures.

Macroscopic thermodynamics leads to the conclusion that an isolated system, that is a system that does not exchange material or energy with the environment, evolves to a final state called thermodynamic equilibrium. At thermodynamic equilibrium the state in terms of the reduced information macroscopic description does no longer change. Macroscopic changes can no longer be observed in the system. Changes at the microscopic level continue to take place, but these cannot be observed in the reduced information description.

> *Note 1.2.*
>
> *The macroscopic description is a reduced information description of a system. This implies that often a vast number of microscopic states are observed as one macroscopic state. Processes that transform the system's state to another macroscopically indistinguishable microstate do not appear to take place to the reduced information observer. This can be compared to a poker game in which the types (clubs, diamonds, hearths or spades) of the cards are indistinguishable. In such a game there would be far less different hands and opportunities to win or lose than in a normal game where clubs, diamond, hearths and spades are observed as different.*

Thermodynamic equilibrium is a state in which, given our macroscopic information, we have reached maximum uncertainty about the microstate the system is in. The lack of information of the observer has reached a maximum. The second law of thermodynamics highlights this. It can be phrased in a number of different ways. An example is the statement that a system evolves towards a state of maximum disorder or minimum organization. The second law predicts the direction in which the evolution of a system takes place in the eyes of a macroscopic observer. The realm of the second law will be extended to include the description of economic transactions and organizations such as firms. Biological systems, markets, economies and industrial corporations are characterized by some kind of organization. The existence of galaxies, the earth, life and biological evolution, human civilizations, economies, industrial enterprises and markets shows that evolution proceeds towards increasing complexity. This is in apparent conflict with the second law that predicts an evolution towards maximum disorder or decreasing organization and complexity. Many early investigators have assumed that life, human society and evolution belong to a class of phenomena that escapes the second law. Developments in thermodynamics during the last fifty years have highlighted that in systems that are not isolated but exchange matter and/or energy with the environment, an evolution takes place in which the development of order and organized structure becomes a direct consequence of the second law. What is required is to move away from equilibrium. The increasingly complex ordered structures that evolve have been termed dissipative structures. Dissipative structures can indeed only evolve and be maintained if matter and/or energy can be exchanged with the environment. Also dissipative structures are both a product and the source of non-equilibrium and constantly evolve rather than exist in a given state. This latter phenomenon is highlighted in a book of the Nobel laureate Prigogine (1980). It is titled "From Being to Becoming".

Note 1.3.

The classical example of the difference between dissipative structures and equilibrium structures is the distinction between a snowflake and a microorganism. Snowflakes are structures composed of ice crystals and have a beautiful ordered appearance. Snowflakes are equilibrium structures. Microorganisms on the other hand, being a marvel of order at the molecular level, need to be supported by a constant flow of a source of nutrition such as sugar. Microorganisms are dissipative structures. The same applies to a city. A city only maintains its structure and order if a continuous flow of food and energy can be obtained from the environment.

Evolution of ordered structures of increasing complexity is a necessary consequence of the second law. "Order out of Chaos", as it has been termed by Prigogine and Stengers (1984) in their illuminating book. The basic prerequisites for the appearance of dissipative structures, as is more fully discussed in chapters 6, 7, 8 and 9, are the following:

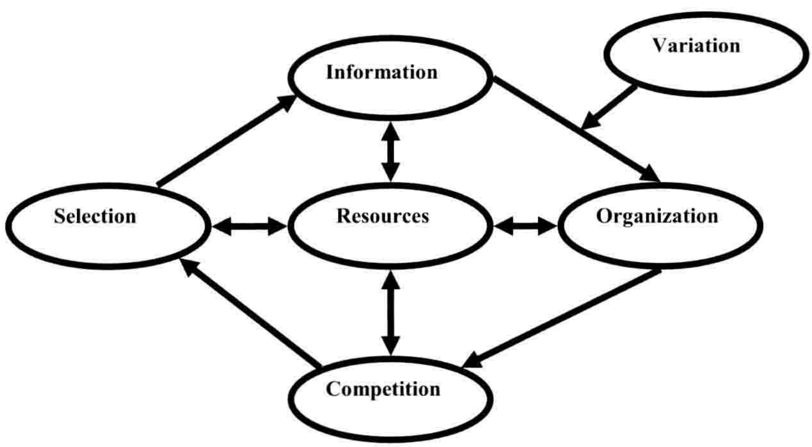

Fig. 1.3. The evolution of dissipative structures: Learning systems

- A sufficiently large exchange of matter and/or other sources of energy and information is needed to create a sufficient distance from equilibrium. The basic flux that feeds industrial firms has been identified in fig. 1.1: The need for products in the market. In chapters 2, 3, 5, and 6 we will develop the formalism to describe this driving force.
- The processes that take place in the system need to be characterized by non-linear kinetics e.g. autocatalytic phenomena, in which a system enhances its own rate of growth. Competition, growth and decay are examples of processes with such characteristics. This is extensively discussed in chapters 7, 8 and 9.