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Edited by Shashi Kant and Janaki R. R. Alavalapati

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THE FAUSTMANN APPROACH AND THE CATALLAXY IN FORESTRY

Peter Deegen[1] *and Martin Hostettler*[2]

[1]PROFESSORSHIP OF FOREST POLICY AND FOREST RESOURCE ECONOMICS, FACULTY OF ENVIRONMENTAL SCIENCES, TECHNISCHE UNIVERSITÄT DRESDEN, 01735 THARANDT, GERMANY. DEEGEN@FORST.TU-DRESDEN.DE

[2]CYCAD AG, 3011 BERN, SWITZERLAND. MARTIN.HOSTETTLER@CYCAD.CH

Abstract

There exist two different classes of market theories. One class, which is the well-known standard microeconomics, deals mainly with the results of the market process. The Faustmann model belongs here: The optimal rotation length is the very result of market exchanges. The other class of market theory focuses on the understanding of the underlying process or, in the slogan of Vernon Smith, of the intention 'to make the "invisible hand" "visible"'. This class of theory is called catallactics. The key problems of catallactics are how individuals coordinate their decentralized knowledge through exchange, how prices carry that knowledge from individual to individual and how individuals discover new answers for unanticipated changes via market competition. Those questions are of major interest for understanding the complexity of forestry, contemporary and in the long term. Because catallactics is not as well established in forestry economics as its microeconomic counterpart, each section of this chapter comprises two parts. One part presents a brief introduction into the theoretical concepts of the market process from the catallactic point of view. The other part refers to, summarizes and systematizes selected contributions of forestry to the understanding of the inner process of coordination through selling and buying.

Keywords

Competition, coordination, entrepreneur, exchange, Faustmann model, human action, knowledge, prices, unanticipated changes

Catallactics, the economics for understanding the market process

This section is about the coordination of human actions through selling and buying applied to the field of forestry. The beginning of the study of this kind of coordination can be traced back

directly to Adam Smith. He discovered that selling and buying leads to satisfactory results for any individual in the society. Moreover, in his two main books, *The Theory of Moral Sentiments* (Smith, 1759/1984, p. 184f) and *An Inquiry into the Nature and Causes of Wealth of Nations* (Smith 1776/1979, p. 456), he speaks of the market coordination as if guided by an 'invisible hand'.

The first study of the results of the 'invisible hand' with particular reference to forestry is *The Isolated State* by Thuenen (1826/1990). He analyzes land rents accruing from different land uses such as the production of vegetables, lumber and rye as a diminishing function of distance on an overall homogenous area surrounding a central town. At each distance, the landowner selects the product promising the highest rent. In consequence, the regular patterns of the cultivated landscape – the Thuenen rings – are the very result of market exchanges (cf. Niehans, 1998). The second important model for studying the effects of coordination through selling and buying in forestry is the Faustmann model (Faustmann, 1849), which is well known to every expert in forestry. A current survey of this type of analysis in forestry is provided by Amacher, Ollikainen and Koskela (2009).

Both the Thuenen and the Faustmann models allow studying the *results* of the 'invisible hand'. For understanding the *inner nature* of the 'invisible hand', which tries to make the 'invisible hand' 'visible',[1] there is another class of market theories.

The key questions of this class of theories include the following: How does the decentralized coordination of millions of human actions work without any central supervisor? How is the knowledge on the globe utilized, when it is not given to anyone in its totality but is separated among billions of individuals? How do individuals mutually adjust their individual plans of life in cases of unanticipated changes in the society? According to the suggestion of Whately (1832, p. 6), we name this class of theories catallactics.

Thus, there exist two different classes of market theories. One class deals mainly with the *results* of the market process, which is the well-known standard microeconomics. The other class focuses on the *understanding of the underlying process*, which we call catallactics. In this chapter, we do not deal with the standard microeconomic market theory, but, instead, we focus on catallactics, or the study of how the 'invisible hand' works.

Nevertheless, catallactics is not as well established in forestry economics as its microeconomics counterpart. Therefore, every section of this chapter comprises two parts. One part presents a brief introduction into the theoretical concepts of the market process from the catallactic point of view. The other part refers to, summarizes and systematizes selected contributions to the understanding of the inner process of coordination through selling and buying. One group of the selected papers is from the field of forestry economics, which investigates forestry-related problems of market coordination. The other group of papers is from other economic disciplines, which offer contributions for a better understanding of coordination through selling and buying inside forestry.

The two classes of market theories work differently, however, not because of the underlying assumptions and methodologies. They both understand market exchange as interactions of purposeful individuals, and both are based on the methodological individualism (Kohn, 2004, p. 308). Instead, the differences of the two classes of theories stem from their different intentions. While *result*-related theories produce explanations which are satisfactory in comparison to empirical data, catallactical theories are employed for understanding the inner nature of exchange.

Thus, the 'invisible hand' is essentially a wonderful metaphor for *result*-oriented thinking. *The Isolated State* by Thuenen and the Faustmann model apply these class theories equally. They study the *results* of the market process. These are a well-structured, cultivated landscape and an optimal rotation length as the very *results* of market exchange. Let us move now from the study of results to the study of the inner nature of exchange.

The coordination of decentralized knowledge through selling and buying

In his seminal paper 'The Use of Knowledge in Society', Hayek (1945) characterizes the economic problem of society as a coordination problem, but not as a problem of the allocation of scarce means among alternative ends. The coordination problem arises because the knowledge of a society is separated among millions, or nowadays billions, of individuals. Therefore, it exists only bitwise, incomplete, contradictory and changeable in the minds of those individuals. There is no central body in the world where the knowledge of the billions of individuals is collected.

The story *I, Pencil* by Read (2008) gives illustrative assistance by showing the complexity of coordination for the production of an ordinary pencil. Read (2008, p. 4) starts with the assertion that no single individual on this earth knows how an ordinary pencil would be produced.

Although the specialists in the pencil factory know how to assemble a pencil, they do not know how to produce all the essential inputs. Let us look at the wooden material of the pencil: It may have come from a Brazilian or an Indonesian forest or from a plantation in South Africa. A lot of knowledge and continuous management over many years are necessary to produce timber for an ordinary pencil. Which tree species are suitable? How many plants are necessary? What is the best stand density for trees to grow in the right quality and with enough timber volume? Or look at the 'loggers to fell the trees'. They 'depend on specialized, high-tech equipment, as well as coffee, meals, clothing, health care, and countless other goods and services to do their job adequately. The logging equipment is made, in part, from steel. So steelworkers had a hand in the making of pencils, too, whether they know it or not' (Heyne, Boettke and Prychitko, 2010, p. 100). The steel in turn is made from ore. Miners, maybe in Brazil, in the Ukraine, in Canada or anywhere may have mined it. Sailors and truckers have transported the ore and the steel and the pencil machine and the pencil. At last, all the different components which are necessary for the production of a pencil are the results of hundreds and thousands of specialists. All these foresters, miners, steel producers, pencil machine producers, color producers, sailors, truckers, and so forth, were involved in the production of the pencil (Deegen, Hostettler and Navarro, 2011, p. 358).

> None of the thousands of persons involved in producing the pencil performed their task because they wanted a pencil. Some among them have never even seen a pencil and would not know what it is for ... These people live in many lands, speak different languages, practice different religions, may even hate one another – yet none of these differences prevented them from cooperating to produce a pencil.
>
> *(Friedman and Friedman, 1990, p. 12f)*

For visualizing the market process, we prefer a graph in which a single bilateral exchange among two parties is embedded in and related to many other bilateral exchanges (Figure 2.1) (cf. Vanberg, 1995, p. 47ff). Clearly, such a network diagram is only a small window of the countless bilateral exchanges which we call 'market'. It illustrates that every change in a single bilateral exchange affects all the other bilateral exchanges, sometimes slightly and sometimes stronger. However, every single change will be absorbed by the system while the individuals adjust their exchange actions and balance them with the other bilateral exchanges. In this manner, the gigantic network of bilateral exchanges is always and continuously in a never-ending movement in which individuals coordinate their individual plans through selling and buying.

A recent paper by Buongiorno, Raunikar and Zhu (2011) may serve as an illustration of the complexity of the decentralized coordination through markets. Buongiorno et al. (2011) show the projection of consequences for the global forest sector of doubling the rate of growth of bioenergy demand relative to a base scenario by applying the Global Forest Products Model

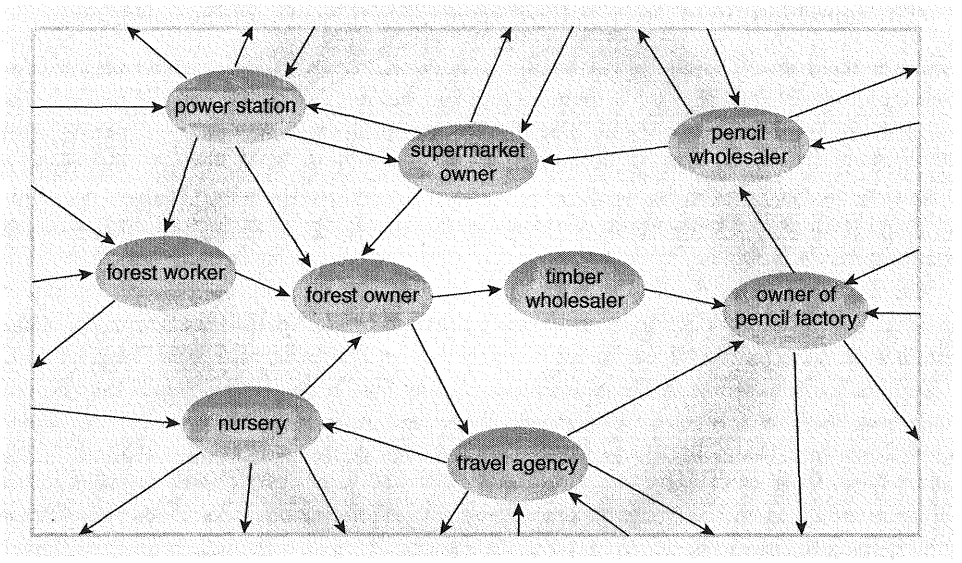

Figure 2.1 A network diagram for visualizing the coordination through market exchange.

(GFPM). They show, for instance, the prediction of the GFPM for the global forest stock change. Countries with the highest increases in fuelwood consumption, such as New Zealand with 364%, Germany with 334% and Canada with 329%, face only minor or even no reductions of their national forest stocks (i.e. 2%, 2% and 0%, respectively). As a consequence of the complex interdependencies of the global wood and bioenergy trade, forest stocks will decline significantly at completely different places of the world, such as in India by 50%, in Nigeria by 35%, in South Africa by 14% and in Indonesia by 10%. Although this study is far away from the complexity of the real world, it provides a little insight into the interweavements of global exchange.

Any concrete sale or purchase by an individual is embedded in and balanced with all other sales and purchases by the same individual (Figure 2.1). That means that each sale and each purchase unintentionally includes knowledge and preferences of all goods and services which the individual exchanges. To buy the ordinary pencil discussed previously is not only an action in the pencil market. Instead, it is an action that is simultaneously balanced with all other actions of the individual. Tullock (2005, p. 121) writes that the single individual makes something on the order of 15,000 to 20,000 buying decisions annually. This is a gigantic flow of information.

Illustrative forestry examples of the complexity of an ordinary individual action are also provided by studies of the determination of optimal rotation length of nonindustrial private forest owners when in situ preferences (Tahvonen and Salo, 1999), borrowing constraints (Tahvonen, Salo and Kuuluvainen, 2001) and nonforest income (Tahvonen and Salo, 1999; Tahvonen et al., 2001) are included. Because in those papers the same numerical example is applied, it can be used as an illustration for simultaneous balanced actions. The numerical examples in those papers show an optimal Faustmann rotation length of 83 years. However, considering the three components mentioned previously, the optimal rotation length ranges between 65 years and infinite, and it depends on the personal circumstances of the single forest owner.

Moreover, the single individual has to adjust his or her sales and purchases to the sales and purchases of the exchange partners. Therefore, buying the pencil is not only balanced with other

actions of the single individual, but also adjusted to all sales and purchases of the store owner. The bilateral exchange is a result of various balancing actions of two involved parties.

Furthermore, the single sale or purchase is not only adjusted to the actions of the exchange partner, but strongly coupled with the other exchanges with the exchange partners of the exchange partner. For instance, the action of the customer of the pencil is not only coupled with the actions of the store owner; it also is coupled with the owner of the petrol station who sells petrol to the trucker who in turn transports the pencils from the wholesaler to the store.

Prices as carriers of knowledge in society

Prices

The complex, decentralized coordination of millions of individual actions through selling and buying takes place without any collection of all the knowledge in any single mind. It is not used in its totality in the contemporary society but is separated among millions of individuals. Usually, the single individual does not know all that much about the particular needs of her exchange partners. And the question arises, how can the single individual contribute to the satisfaction of the needs of which she does not know, and even satisfy those of individuals whom she does not know?

The carriers of this information are the prices, which are the results of previous and successful exchanges. The single individual can only become acquainted with those aspects of the many other unknown individuals which are reflected in these prices.

Let us imagine for a moment a well-working forest market, in which at every moment thousands of forest owners sell thousands of forests, and where most of these are immature. In this way, thousands of individuals become forest owners by buying forests.

Consider that the optimal rotation length is 50 years. Only the owners of the 50-year-old forest stand watch the prices for timber and for bare land. However, the sellers of the 49-year-old forests do not watch the prices for timber and bare land; instead, they watch the prices for 49-year-old forests. Only the buyers of these 49-year-old forests watch the timber and bare land prices and use this knowledge for their own asks in the market of 49-year-old forests. In the successful cases of selling and buying in the market of 49-year-old forests, the realized prices for the 49-year-old forests contain some information about the timber and bare land prices, which are necessary for the 50-year-old forest utilization.

In the same way, the sellers of the 48-year-old stands do not watch the prices for timber and bare land; they watch the prices for 48-year-old forests. The buyers of the 48-year-old forests also watch the prices of the 49-year-old forests and use this knowledge for their own asks in the market of 48-year-old forests. The realized prices for these 48-year-old forests contain some information about the prices of the 49-year-old forests, which again contain some information about the timber and bare land prices at the rotation length, and so forth.

Like a cascade, the forest prices carry stepwise the timber and bare land prices from the older to the younger forests and, finally, to the planting action through selling and buying of forests. From individual to individual, the prices of forests carry the knowledge 'which [enables] the sellers and the buyers to provide for needs of which he has no direct knowledge and by the use of means of the existence of which without it he would have no cognizance . . .' (Hayek, 1976, p. 115).

In the Faustmann model, the complex price cascade of the forests exchanges through markets is reduced to the beginning and the end point of the price cascade. It combines only the final timber and bare land price as the beginning of the price cascade and the planting cost as

the end of the price cascade. As in every model, reductions in the Faustmann model are made for analytical reasons in order to find out the overall result of the market exchange but not to study the complex coordination through markets as a combination of many different sales and purchases.

However, the reduction of the price cascade to the beginning and the end point in the Faustmann model does not mean that the knowledge of timber prices at the end of the rotation is necessary at the moment of planting. With the help of prices, market exchange means exactly the opposite: to confine attention to the immediate circumstances of the individual actions.

The forest owner does not plant young trees because she knows that anybody will need wooden goods in 50 years. Instead, she plants trees because she expects that other individuals will buy her young immature forest stand when she sells the forest for various reasons, or as in the famous phrase by Samuelson (1976, p. 474): 'Even if my doctor assures me that I will die the year after next, I can confidently plant a long-lived olive tree, knowing that I can sell at a competitive profit the one-year-old sapling'.

For the same reason, an individual will buy an immature forest stand and conduct some precommercial thinnings, not because he knows which sorts of timber the demander at the time of the final rotation length will prefer. He conducts precommercial thinnings because he expects that another individual will buy the thinned forest stand for a satisfactory price (cf. Hayek, 1976, p. 115f).

Clearly, such a pure market process of many simultaneous exchanges of forests is a simplification because all these exchanges take place with some time lag: A forest owner plants trees not because he expects that other individuals will buy his young forest stand now and today, but, rather, he expects that other individuals will buy his forest stand someday in the future. As a consequence of unanticipated changes between the time of sale and the time of purchase, prices will change.

> It is these differences that bring about money profits and money losses . . . His (the entrepreneur's) success or failure depends on the correctness of his anticipation of uncertain events. If he fails in his understanding of things to come, he is doomed. The only source from which an entrepreneur's profit stems is his ability to anticipate better than other people the future demand of the consumers. If everybody is correct in anticipating the future state of the market . . . neither profit nor loss can emerge . . .
>
> *(Mises, 2007, p. 290)*

The adaptation of individuals to unanticipated changes by continuous price changes implies that the price cascade of forests is always in movement. Prices are not only the carriers of knowledge. Through selling and buying, the individuals substitute obsolete knowledge with new knowledge caused by the unanticipated changes. Thus, prices not only carry the knowledge, but also continually actualize the knowledge as well.

Nevertheless, the picture of thousands of simultaneous forest exchanges through markets illustrates how prices carry the information from exchange to exchange. When the forest owner sells an immature forest stand, it is neither possible nor necessary for him to have information on the future uses of this forest. Prices carry and actualize the whole complex of human knowledge and wants from individual to individual. When the individual considers the prices, he adjusts his individual actions with all the countless exchanges of all the other sellers and buyers. Nobody needs the information on the final needs, either for the present or for the future.

An illustrative case study for showing how individuals apply buying and selling for adjusting their living circumstances is the 'owner-consumer decisions on an amenity forest' by Christensen (1982). He describes the story of a New York businessman who bought a forest property with a number of different specific goals in view: He desired a rural retreat for his family as

well as a secluded business place to bring associates for conferences together, and he anticipated horseback riding on the old logging roads. Time passed, his children grew up, other circumstances in his life changed and his aims shifted or deteriorated. The forest became more and more useless. Finally, after 12 years, he sold his forest property. In other words, he adjusted his asset endowments to his changing living circumstances in the long run by market exchange.

A careful step toward an understanding of how prices work as impersonal guides for individual actions is the generalized Faustmann model by Chang (1998), which is based on the Faustmann school of thought. In this model, a clear distinction between current and future prices with respect to the optimal rotation length is realized. Nobody knows or needs the prices of timber and production factors of future rotations. Instead, current land prices are used as the only available estimation of future land uses. This thinking is extended by price and product class watching during the time (Chang and Deegen, 2011).

Although exchanges through markets are independent of the ages of the sellers and buyers, they comprise intergenerational transfers of forest stocks. The buyer can be older or younger than the seller of the forests. It follows that some exchanges of forest stocks are exchanges among generations, and others are exchanges within the same generation. Every sale of forest stock from an older to a younger individual and vice versa is a smooth intergenerational transfer. This type of intergenerational exchange, however, is totally different from intergenerational transfer by bequest, which can be often observed in forestry and which is studied with overlapping generation models (cf. Amacher, Koskela and Ollikainen, 2002). These two types of intergenerational transfer should be clearly distinguished.

Learning by acting

Prices are the carriers of information and the transmitters of coordination, as we have demonstrated previously. Catallactics deals with the questions of how information comes into the prices and how the exchange through selling and buying utilizes information (cf. Smith, 2006, p. 2f).

For answering these questions, it is necessary to understand the learning process of individuals when they sell or buy. Market learning does not mean primarily reading, thinking and writing, as academics commonly do. In contrast, individuals in the market learn by acting, watching and listening. Literally in an endless feedback process, they realize the results of exchanges and repeat them in the same or an adapted manner. Experimental economics tries to make visible the learning process through selling and buying with the help of laboratory experiments (e.g. Smith, 1991). For the demonstration, an experiment inside the double auction institution is used (Figure 2.2).

> This trading institution, used throughout the world in financial, commodity and currency markets, is a two-sided multiple unit generalization of the ascending bid auction for unique items. Buyers submit bids to buy, while sellers submit offers or asks to sell, with a rich rule structure for defining priority based on price, quantity and arrival time . . . Notice that the demand crosses the supply at a range of market clearing prices, where demand = supply = 10 units, given by the interval (356, 360). Any whole number in this interval is a competitive equilibrium price. Only you and I know this, the subjects in this experiment know nothing of these facts . . . The subjects were inexperienced, meaning that none had previously been in a double auction experiment . . . The behavior shown in the right panel of Figure 1 is typical.
>
> *(Smith, 2006, pp. 4–5)*

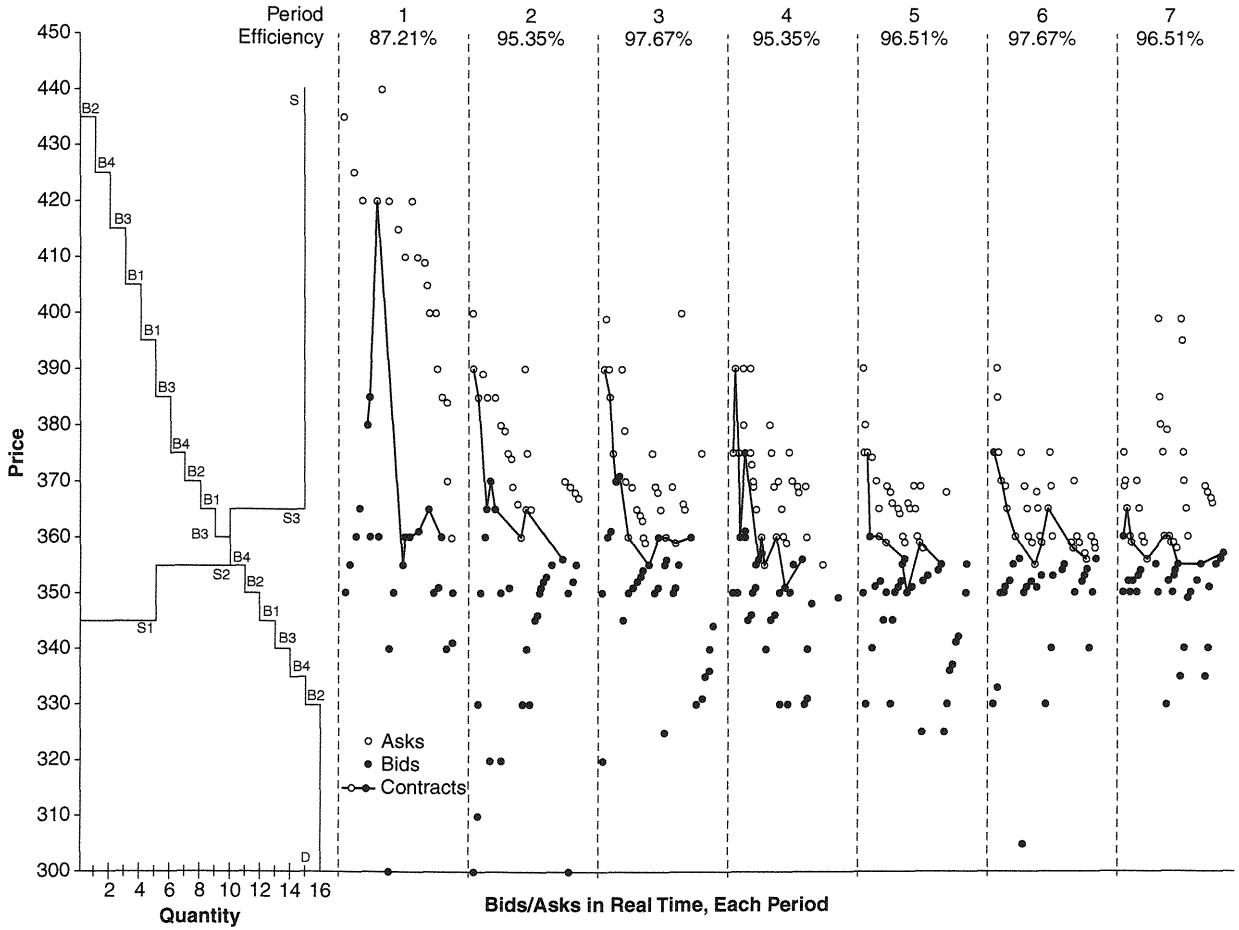

Figure 2.2 A double auction experiment. The economic environment for four buyers and three sellers is shown on the left. On the right, the sequence of bids, asks, and contracts in each of the first seven periods of trading is shown.

Reprint of Figure 1 in Smith (2006), with permission of John Wiley and Sons, Inc.

At the beginning, no participant has any idea about a 'realistic' bid or ask because there was not an auction before. Their offers come only from their individual wants and the initial expectations of the other participants. As a result, only a few bids find asks for an exchange contract. Most of them will be disappointed. Some of them do not adjust their individual expectations; others will change their asks or bids respectively. The successful traders learn as well. Their cognition involves that their expectations on the prices of other participants were not too bad. However, from period to period, the participants learn more and more about their own preferences and about the expectations of competitors and of trading partners via their own successful or unsuccessful trials of exchanges. During the periods, the participants learn more and more to coordinate their own actions with the actions of the other participants. During the periods, more and more bids and asks become successful. Or, in economic terms, the exchange process converges to the market equilibrium. The underlying way of learning is trial and error of acting, watching and listening, and of subsequent correcting or continuing.

During the bids and asks, individuals not only discover a little about how other individuals valuate goods. They often discover their own values that they give for the goods as well. After selling or buying, people are often astonished at how much they have paid for a good that they had valuated with a trifling amount of money at the beginning of the auction.

The evidence from approximately 150 to 200 individual economic experiments, conducted by many different researchers, studied for stationary, cyclical and irregular shifts in demand and supply in a wide spectrum of market institutions, such as posted-price, bilateral-bargaining games, continuous double auctions and others, shows that the participants converge with astonishing speed to the competitive equilibrium price and quantity (Smith, 1991, p. 226).

Thus, the microeconomic market theory is supported by the results from experimental economics: Market equilibrium is the consequence of the learning of individuals during the acts of selling and buying. From period to period, the participants watch their own success or failure to buy or to sell as well as the realized prices from the previous period, adapt their bids and asks in the present period to these observations and act again. Thus, the experiments visualize the learning process of the individual at the market.

Moreover, the many laboratory experiments with the wide variations of exchange rules show that no assumptions of price taking and of complete information are necessary for convergence to the competitive market equilibrium (Smith, 1991, p. 232). On the contrary, prices and quantity converge best to equilibrium under private incomplete information. Under complete information, the convergence process either fails or does less well (Smith, 1991, p. 803). Thus, the economic experiments support Hayek's (1945) hypothesis: 'The most significant fact about this (price) system is the economy of knowledge with which it operates, or how little the individual participants need to know in order to be able to take the right action . . .' (pp. 526–527). Or, in the words for testing the hypothesis at experimental markets, 'Strict privacy together with the trading rules of a market institution is sufficient to produce competitive market outcomes at or near 100% efficiency' (Smith, 1991, p. 223). These findings are also valid in the case of intertemporal competitive exchanges, which are typical in forestry (Miller, Plott and Smith, 1991).

In summary, selling and buying is a process in which individuals bring their own personal plans in accordance with the plans of the competitors and the exchange partners by learning stepwise with help of trial and error. Between the periods, prices carry and actualize the information of the exchange participants. The invisible hand of Adam Smith is nothing more than the learning process of humans by the trial and error of their actions.

As a consequence, the economic research on market exchange (microeconomics and catallactics) is on the right track. It shows that markets work in the way we think: Individuals

coordinate their dispersed actions by selling and buying in a way that is self-regulating. Often enough, this coordination is much better than we expect from the standard market models (cf. Smith, 1991, p. 802).

Competition as a discovery procedure for finding answers to unanticipated changes

The existence of unanticipated changes is so extraordinarily prominent that Hayek wrote in his seminal paper, 'Competition as a Discovery Procedure': 'It is useful to recall at this point that *all* economic decisions are made necessary by unanticipated changes . . .' (Hayek, 2002, p. 17).[2] These unanticipated changes ask for adaptation of the individual plans as well as for readjustments of the individual plans with all other individual plans of the other individuals.

Prices are the carriers of information to show which of the changed circumstances ask for adaptation and adjustment and which do not. They show the single individual 'that what they have previously done, or can do now, has become more or less important . . .' (Hayek, 2002, p. 17) because the change of prices changes '. . . the compensation of the various services . . . without taking into account of the merits or defects of . . .' (Hayek, 2002, p. 17) the involved individuals. 'The most important function of prices, however, is that they tell us *what* we should accomplish, *not how much*' (Hayek, 2002, p. 17).

The seminal paper 'The View from John Sanderson's Farm: A Perspective for the Use of the Land' by Hugh M. Raup (1966) illustrates the land-use process as a result of unanticipated changes and their ensuing adaptations.

In 1740, the first settlers entered the virgin forest landscape of Petersham in central Massachusetts and started with subsistence agriculture in only small parcels. From 1791 to 1830, settlement continued, the regional road system in the landscape became a developed net, industrial towns grew and flourished continuously, regional markets evolved and agriculture changed from subsistence to a regional market economy. In other words, Petersham prospered. By 1850, the region was a full agricultural landscape with only a small amount of forest area.

In 1830, the opening of the Erie Canal changed the economic conditions: Settlers moved west. Railroads completed the traffic network, including changes from a system of isolated regional nets to a national network. Foodstuffs, in far greater quantity and produced more cheaply due to superior soil qualities in the west, were transported from western to eastern states. At the same time, these expansions attracted large sums of eastern capital for investments into mechanization and industrialization. As a result, Petersham's agriculture became uncompetitive; its economy collapsed. Over the decades, farmers emigrated. Agricultural use of the land was abandoned. Therefore, forests of nearly pure white pine came back by natural seeding. In 1900, Petersham was a full forest landscape again, yet without any value for the individuals who owned these former agricultural properties. However, some individuals discovered the value of the 'green gold'. As a consequence, the great logging and milling era between 1900 and 1920 arose in southern New England, with a new and a much higher prosperity than 100 years before.

The changes in prices as results of unanticipated changes do not lead only to a more or less unconscious balancing of the changing circumstances in everyday life. More importantly, the changes in prices offer incentives for discovering new solutions.

The fact that the white pine in Raup's (1966) paper becomes a raw material for containers, which were in high demand during the time of US industrialization, has nothing to do with the trees themselves. White pine had existed for a long time; it existed long before humans existed. Primarily, white pines were natural things, but not good for humans. Humans discover which of

the billion different things in nature are goods. In the case of Raup's white pine, the pines came to maturity at the moment individuals demanded wood containers. Likewise, property owners from Petersham became aware that pines could be the raw material for those containers. Other people found niches in the price and wage structures of those days whereby the whole harvest process became economically feasible (Raup, 1966, p. 8).

> They all had first to be conceived in people's mind; then they had to be made attractive to investors so that capital would flow into them. A century earlier or even 50 years earlier, all that pine would have had very little value and most of it would, of necessity, have been cut down and burned to get it out of the way for farming.
>
> *(Raup, 1966, p. 8)*

In our economic analysis, we often reduce the adaptation to unanticipated changes to the rearrangement of the basket of the given goods according to the new price circumstances. But goods are not given. They are the result of human action (Hayek, 1948, p. 100f). Through market exchange, individuals do not make use of given knowledge. They discover, e.g. which natural things are goods, which technologies are most suitable for transforming things into goods, and so forth.

One great discovery in human history was the way to utilize ordinary trees as a raw material and as fuelwood because they existed at different places in the world in ancient and historical times in inconceivable dimensions in nature. Wooden raw material and fuelwood were not given as natural resources; instead, humans have discovered wood as material during history: Lips (1947) collected examples from the Stone Age and earlier of how humans discovered wood as common material.

Again, from century to century, individuals discovered more and more useful utilizations for this natural material (Perlin, 1997). When timber became scarce, humans were not troubled by this circumstance; instead, humans discovered substitutes and invented silviculture, the technology for producing 'natural' raw material. Kuester (1998, p. 69) remarks that the fast expansion of hazel after the Ice Age was a result of active 'silviculture' by humans during their resettlement of Central Europe. Koepf (1995/1996) notes that humans harvested forest trees in regular cutting cycles in the Modern Stone Age up to 4000 BC in southwest Germany as well as in Etruscan iron mining since 700 BC.

A recent example of discovering things as goods is the story of forest amenity evolution during the nineteenth and the twentieth centuries: Although forest scenic beauty has existed since time immemorial, the discovery of forest landscapes as a source of amenity services is a product of modern times (Mises, 2007, p. 645). Figures in Duerr (1993, p. 101), as well as in Anderson and Hill (1996, p. 516), give related illustrations of the increase in visitors to national parks during the twentieth century. Butler and Leatherberry (2004) show that the number of family forest owners in the United States has increased, and that the most common reason for these ownerships is enjoying beauty and scenery.

In the competitive market exchange, individuals also discover new technologies, new organizational solutions and new forms of cooperation as better answers to unanticipated changes. A typical example is silviculture, the forestry technology to reduce timber scarcity and boost forestland competitiveness. During the last 150 years, forestry practitioners have reduced the production time for timber (rotation length) from approximately 400 to 600 years (200 years ago) to nowadays 5 years in some forest plantations. According to Morozov (1928), forest practitioners first replaced succession with man-made forest regeneration. Secondly, they replaced slow-growing trees (oak and beech in Central Europe) with fast-growing trees (spruce and pine in Central Europe), and actually, they introduced biotechnology innovations (Sedjo, 1999,

p. 18f). That means forest practitioners have reduced interest costs for timber production of about 10^{13} euros/ha during the last 200 years, assuming a continuous interest rate of 5%.

An example of discovering new organizational solutions is the outsourcing of harvesters and forwarders. As an adaptation of vertical organization of forestry enterprises in Central Europe, they reorganized into specialized timber harvest companies. Before the introduction of harvesters and forwarders en masse, when harvest machines were mostly chainsaws, the timber harvest was typically part of forest ownership. After the introduction of harvesters and forwarders, both the capital cost and the cost of specialized knowledge and specialized organization increased and asked for adaptation. The adequate answer that forest enterprises found was the outsourcing of harvesters and forwarders and the foundation of specialized harvest companies.

An example of discovering new institutional arrangements as a reorganization of existing property rights is the story of conservation easements by forest trusts in the United States:

> [E]asements are based on the idea that property ownership is not a single indivisible right, but instead a collection of individual, often separable, rights. These individual rights include, for example, the right to erect structures, reside, grow crops and exclude other from property . . . The advantage of easements over ownership for land trusts is that they allow trusts to protect lands, not by acquiring the entire bundle of landowner rights, but by acquiring only those specific rights that are relevant to the trusts' conservation goals.
>
> *(Clark, Tankersley, Smith and Starnes, n.d., p. 2)*

The acting human: The maximizer and the entrepreneur

The underlying economic model of human action is the homo economicus: The individual maximizes her or his utility subject to constraints. This model is applied to the Faustmann model: The landowner maximizes the land expectation value with respect to the rotation length. Many different variations study various maximization and optimization problems, such as the optimal planting density (Chang, 1983) or the optimal choice between even- and uneven-aged forestry (Tahvonen, 2009).

The objective(s) is given, just as all involved products and production factors and their prices. The landowner in the Faustmann model knows every timber sort of her standing trees, knows every environmental service of her forest, which she can sell for known prices. Also, she knows everything about silvicultural and harvest technology. According to the underlying model structure, the economic choice of the forest owner is embedded in the objectives and their order, into the production factors and into the production functions which are all given. Choice means to find out the maximum or the optimal solution in the set of given factors and given objectives (Kirzner, 1979).

But the discovery procedure of competition needs the discoverer. As we pointed out in the fourth section of this chapter, the economic facts are not given but are the results of competition. Thus, although economic optimization is helpful for efficient allocation, it is only the second phase of human action. Before optimization can start, the identifying of objectives, products, production factors and production functions is necessary because these facts are not given. This part of discovery is called the phase of entrepreneur action (Kirzner, 1979).

Figure 2.3 illustrates the two phases of human action with the help of the structure of a Faustmann model: It shows the separation of human action into an entrepreneurial phase, in which the means and ends are discovered, and an economic phase, in which the means and ends are optimally allocated, where LEV is the land expectation value, P_j is the price of product class j, W_j is

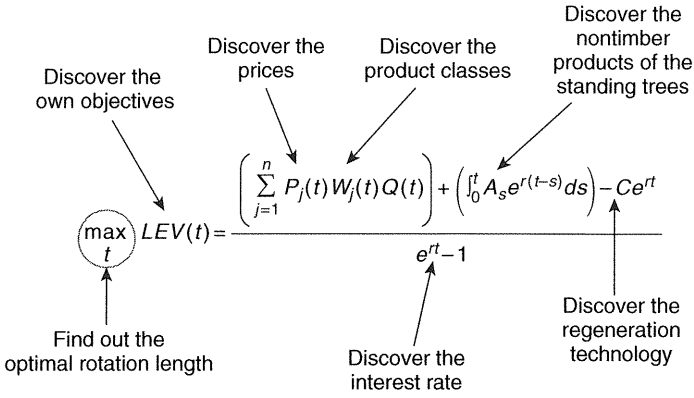

Figure 2.3 The distinction of human action into an entrepreneur phase and an economic phase, exemplified with the help of the structure of a Faustmann model.

the percentage of the product class j in the stand volume, Q is the total stand volume, A is the net revenue for the nontimber product of the standing trees, C is the regeneration cost, r is the interest rate, j is the number for a product class, t is the rotation length and s is the stand age with $s \leq t$.

The distinction of human action into an entrepreneur phase, in which the means and ends are discovered, and an economic phase, in which the means and ends are optimally allocated, is clearly an analytical tool. Every human is an entrepreneur and an economic person at the same time (Kirzner, 1979).

By studying the body of literature in the field of forestry economics with reference to market exchange, it is easy to see that the underlying model of human action focuses on the economic phase. Only a small amount of this literature deals with entrepreneurial aspects, such as Anderson and Leal (2001).

Conclusion

In this chapter, there is no presentation of catallactics as a unified, settled body of thought as the forest economist is accustomed to with the Faustmann school of thought. Instead, catallactics is more a progressive research program (Boettke, 2010, p. 159). Therefore, in this chapter, the main theoretical concepts of catallactics are combined with examples from the field of forestry-related research. This should be interpreted as an invitation to systematically inquire into the inner structure of the gigantic network of human exchanges. This comprises methodical challenges. One is the change in the point of view of what a theory of market coordination can explain because 'the predictive power of this theory is necessarily constrained to a prediction of the type of structure . . . that will result; it does not, however, extend to a prediction of particular events' (Hayek, 2002, p. 11). Another methodical job is the transformation of principally structural insight into operational theory, and lastly, to find ways for testing theorems empirically (Coyne, 2010, p. 26; Smith, 2006, p. 3; Boettke, 2010, p. 164f).

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Notes

1 This slogan I noted at the Hayek lecture 'Hayek and Experimental Economics' by Vernon Smith in Freiburg, Germany, 27 June 2008.

2 The emphasis is found only in the German original of the paper (Hayek, 1968/2003, p. 142) but not in the English translation.

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