Why are there so many trees in the forest?
An analysis of general mechanisms for coexistence in competitive markets

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Abstract

We discuss two different mechanisms that enrich our understanding of market structures in situations under incomplete information. In the first model, we focus on incomplete information leading to imperfect reach of a producer, opening space for inferior competitors to maintain a stable presence in the market. The second model shows the effects that incomplete information in the transmission of technological details can have, and the resulting differences in production structures in a company. We again find that different competitors can maintain a presence in competitive markets in equilibrium so that selection usually fails to produce uniform and optimally adapted firms and organizations. Our theoretical explanation of coexistence of diverse types of companies may not only contribute to our understanding of general market dynamics, but may also serve as advice for strategic behavior of companies.

Keywords: incomplete information, competition, market structures

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1. Introduction

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In evolutionary theory there exists an old problem which in a nutshell can be stated like this: Why do so many different species coexists in homogenous environments? For instance, why do so many different trees exist in a forest if the best adapted species – no matter how tiny its competitive advantage may be - should replace all others in the course of natural selection? This problem is called the "biodiversity problem" or the "Plankton Paradox": Even in the most homogenous environment of the sea, there coexist different species of plankton. At first glance this seems to be a clear violation of the competitive exclusion principle and it is also problematic with respect to one core idea of evolution, namely the idea of natural selection. The oldest and most prominent solution to this question is niche construction theory: The environment looks like a homogenous one, but in fact it is not: The environment is complex, both in temporal and in spatial respects. Each niche is characterized by a specific and unique configuration of (re-)production requirements. Therefore one may expect numerous possible niches that could in principle be occupied by the same number of species. However, as biodiversity research has shown, the actual number of existing species still seems to exceed even the vast amount of possible environmental niches.

In economics we face a similar problem: How can we interpret the fact that in (nearly) every industry very different firms, realizing different rates of profit, and economic agents coexist servicing more or less closely substitutable demand? Again, one answer that is given is niche exploitation or specialization, for instance based on the servicing of an existing preference for variety (as in Dixit and Stiglitz, 1977), or the success in creating demand for one's product or variety (e.g., Galbraith, 1958, 2007/1967; Scitovsky, 1978). In this article we will show that niche construction, as a differentiation of products creating smaller partial markets in an overall market is just one facet of the story.

The definition of a market is not without problems, from the point of view of making a coherent argument, as markets can be defined by homogenous products (basically, with a very high substitutability between products from different suppliers), or by products that are heterogeneous to some degree but still substitutable. Additional aspects concern the relevant context and potential overlaps, such as in a market for general transportation and a market for specific vehicles, for instance. We will employ a concept that can be interpreted as including heterogeneous products in both models we discuss in the main body of the article. The limits of the potential market are necessarily vague as a consequence.

Our interest here is concerned with the coexistence of different types of firms in what can be argued constitutes one market, not some efficiency implications of specific situations. Specifically, we will analyze the effects of incomplete information on market structures under certain conditions. To that end, we discuss two models that help identifying aspects beyond niche construction that contribute to the coexistence of distinct types of firms, or more generally agents, in a market.

The first focuses on the effects of incomplete information for matching supply and potential demand. If market penetration by one company is incomplete, unmet potential demand can be serviced by other companies, who can maintain a presence in the market in question. This holds true even if they are globally inferior competitors. The second model we discuss shows that a coexistence of competitors with different requirements in production is possible. Multi-resource competition in combination with simple growth dynamics can produce numerous patterns of changing market shares of several distinct (types of) companies. Here, incomplete information is reflected in the fact that technological specifications are not freely transmittable between firms. As a consequence, a coexistence of different types of firms can emerge already under very simple circumstances.

Our interest lies squarely with market structures and changes therein. Hence, we do not integrate representations of individual agents' decision rules, on the demand- or on the supply-side. This has a number of advantages. It avoids the problems of aggregation that standard market demand schedules are subject to, the postulation of unchanging exogenous preferences (and resulting control of 'the market' over companies, determining the static equilibrium outcome), and ex ante determined static allocations, including or without specific distortions. We therefore claim that the results of our model are valid, independent of individual decision making processes. As a consequence, we are able to discuss strategic implications of our setting based on the models presented, not as exogenously added claims.

The objective with this paper is to contribute to our understanding of real world competition and to answering the question why market selection usually fails to produce uniform and optimally adapted firms and organizations. The basic mechanisms we introduce may help to describe and thereby better understand and perhaps even forecast dynamic features in real world markets. Before turning to a discussion of the models in sections 3 and 4 of the paper, we briefly discuss the gaps that can be identified in models dealing with market structures, providing the justification for and underlining the importance of additional approaches to strengthen our understanding of competition mechanisms, and their outcome in environments characterized by incomplete information.

2. Central problems of the economic competition model and the natural selection analogy

Market Structures in Standard Market Models under Perfect Information

Standard economic models take the polypolistic market model as the reference point and evaluate the outcome in other set-ups in comparison to its results. The focus of interest is usually down to the question of the efficiency or inefficiency of specific structures, especially on the supply-side. A market is defined by homogenous products supplied by distinct producers. As homogenous products are sold in one specific market, and perfect information is assumed at the outset, a coexistence of different types of companies in one market is not possible.

The outcomes of specific supply-side structures are built around non-horizontal price-demand schedules for individual firms, which are assumed to represent market power. As only prices and quantities enter into consideration, focuses in model variations lay on market power that can be captured in a money-metric immediately. Alternatively, market power has an indirect impact in that metric, mediated through quantities supplied in the market under consideration. Results in these settings are typically not efficient, meaning unit prices received lay above the marginal cost for producing these units, reducing consumer surplus, and bringing a deadweight loss for society as a whole (Harberger triangle). The only exception is the basic Bertrand oligopoly model. The more modifications of the reference model-assumptions are introduced (e.g., different cost structures for supplying the homogenous product), the more pronounced is typically the degree of inefficiency that results. Different cost structures implying different types of firms are an interesting addition; but it is difficult to see how such extensions can be logically compatible to the rest of the model assumptions.

A general formulation of markets that are defined by imperfect substitutes is the Dixit-Stiglitz (1977) model of monopolistic competition. Depending on the elasticity of substitution between variants of a product, more or less companies service a market. Market exchanges happen at equilibrium prices only (given by the Amoroso-Robinson relation), and the market outcome is inefficient, even though the impact on consumers' welfare is modified here due to the recognition of the preference for variety in the standard utility function.

In all of these cases, supply is offered by either, directly identical companies, or, by equally fit companies who are identical in all relevant aspects of their technical specifications, but produce variations of the product that together constitute the overall market under consideration. The coexistence of different companies, with different technological specifications and different characteristics (cost structures) is not integrated into these models. Where possible extensions of basic models are discussed, the focus is then on additional implications for the efficiency that results (for instance, through potential competitors for a given market demand where differences in cost structures permit one of them to behave like a monopolist, or at least control the entire market at a price just below the cost of potential additional suppliers). In general it is difficult to see how such a setting could be justified given the information specifications and the assumptions regarding costs of transactions in the rest of the model.

What we add with regard to the results in this reference framework are two principle aspects, the possibility of distinct companies coexisting in equilibrium, and a set of parameters that offer the foundation for discussing strategic implications of these situations. Incomplete information is at the heart of these considerations. The second aspect also directly takes up a point discussed by Schumpeter (1911); Rothschild (1947), Galbraith (2007/1967), amongst others, namely, that companies can influence customers' consumption decisions.

Incomplete Information and Consequences for Market Structures

As pointed out, we will relax the assumptions regarding the information set that agents have access to, and analyze some influences that result from this with respect to market structures. Under more general approaches, incomplete information means that companies face situations in which they have to take precautions against a number of contingencies, and take action in order to establish structures that reduce the danger from uncertain future events. In fact, that companies have every incentive to engage in strategic behavior for enhancing their control over markets has been pointed out repeatedly over time (e.g., Veblen, 1904, Galbraith, 2007/1967, Kapp, 2012). This is difficult to represent formally in a meaningful manner, though.

But we can, already once problems of information are introduced into an analytical setting of an overall neoclassical bend, observe substantial changes in results, as well as in emphases for further questions (Stiglitz, 2000): Already very small modifications in the assumption regarding the information available to individuals lead to markedly different outcomes, in terms of efficiency. Thus, we find scope in the models to integrate firms that may be differentiated by their internal structures, for instance, and by extension by their relative fitness, as different prices for the same product may persist implying the possibility for different cost structures to be maintained (although this is usually not made explicit). In difference to these formulations, beyond the points mentioned in the introduction, we are interested in the outcome of processes of market structure-development and change. This is not integrated into the comparative static comparison of outcomes under different specifications.

In Nelson and Winter's seminal papers (e.g., Nelson and Winter, 1982) under extremely limiting assumptions, an outcome akin to the core models may stand at the end of an evolutionary process, but the likelihood of this is minimal. A temporal coexistence of competitors is far more likely there. Still, in the course of a competitive process – evaluated along a single dimension – an increasing similarity of companies along the core characteristics that define them becomes observable. Now, general replicator models can be modified to allow for a number of outcomes, even if evaluated along a single dimension for success (for an overview, Nowak, 2006). The usual result of these types of models is, however, that the best or fittest competitor survives, or under different assumptions, possibly that the first or the initially largest competitor comes to dominate a market, in any case, however, leading to a monopolization of supply. Modifications focusing on information availability becoming more complete usually lead to the emergence of identical companies (as far as their technological properties, and hence cost structures, are concerned, which are after all the relevant aspects of a company in these models).

As pointed out in the introduction, this is not a result we observe in nature; and, it is likewise not a result we observe in social situations, such as economic exchanges, either. The models we formulate in the following sections allow casting some light on why this may be the case, and show that even in a stable equilibrium outcome (as a first benchmark), strictly less fit competitors can survive in a market.

Competition, Natural Selection and Adaption

Our reference in the introduction to a biological example, the plankton paradox, is more than just an illustration. In theoretical biology many problems similar to market competition arise when it comes to competition in a population of species or sometimes even between different species in one habitat. Biological agents face environments that are limited by scarce resources (typically more than one) and usually we observe more coexistence of competing entities in nature than we would expect under conditions of natural selection. Of course, we are aware of possibly severe limitations that occur if someone transfers concepts of so distantly related disciplines such as evolutionary theory and economics. However, the perspective taken by biological theories may add some interesting points to its economic counterpart because of the following rationale: In contrast to economics and also in contrast to earlier biological approaches, modern biodiversity biology tackles the widespread coexistence of competing entities not as a side effect of some mode of imperfect competition, but positions coexistence as a central *explanandum* for theory.

Of course, the notion of competition is related to the theory of natural selection: in the long run competition leads to the selection of the most successful or most competitive agents. Early models of natural selection therefore suggest a strong link between competition in an environment (or a market) and consequentially adaption to the conditions of this environment. Thus, in the long run competition would lead to a homogenous population of competing agents, which are all displaying the best adapted structures for this environment. The condition for this evolution of the best adapted is called the "competitive exclusion principle": For one environment only the best competitor – which is the best adapted agent - will survive. In evolutionary theory this argument gave rise to the "adaptionist program". According to this program it is a valid argument to treat all products of the evolutionary process, *as if* they were more or less perfect adaptions to an environmental problem. This adaptionist paradigm also influenced economic theory. Milton Friedman's defense of axiomatic neoclassical economics (Friedman, 1953) is directly based on the (strong) adaptionist view on evolution. Economic agents will in the long run act, as if they were rational actors, because they are exposed to a natural selection-like process when competing in the market.

However, in biology, there is growing evidence that this view on competition and selection is too simplistic and can be, on the contrary, very misleading. For example, the analysis of the genome has shown that natural selection does not necessarily produce perfect adaptation to the environment and consequently no perfect competitors. This is due to constraints and trade-offs in ontological development (see also, Wilson, 2012, Schwesinger, 2013).[2] Another aspect is at the heart of this paper: Competition - and in the long run - selection between agents does not necessarily lead to uniform agents resembling the perfect competitor. In fact, competition does not even cause the extinction of a strictly inferior competitor under all circumstances, as we will show later on. Clearly, the chances of survival or even growth are much better for those who have some competitive advantage. However, in equilibrium, we do not find only perfectly adapted and therefore uniform survivors; this is true not only for biological entities but also for economic ones. In almost all industries we observe a variety of firm sizes, modes of production, organizational structure and governance regimes. Clearly, this cannot be explained by assuming perfect adaption mediated through competition. The following chapters will introduce two very basic mechanisms of competition, which both lead to stable competition of more than one (type of) competitor. To our knowledge these mechanisms of competition and coexistence have not been discussed in an economic context in the way proposed by us.

3. Competition in non-saturated markets

[2] Again there are parallels in economics. Developmental Theories of the Firm such as Penrose (1959) or Rathe and Witt (2001) emphasize developmental constraints during firm growth, which are driven by non-external, that is non-environmental or non-selection forces. Internal processes such as individual as well as collective learning are identified as major shaping forces of organizations. Cordes et al. (2010) propose a theory of evolving corporate cultures, which is based on similar processes of social learning.

In this section we will focus on a mechanism formulated by Tilman (1994) which was originally developed in the context of competing plant species. This model allows for a first representation of different types of companies, strictly rankable according to their fitness, and persisting in a market in an eventual equilibrium state.

We give up perfect information of the agents and start from the assumption that in general, markets are not completely saturated. Some potential customers realize their demand in every period, but not all of them. The markets we investigate are thus defined by the potential demand for a product, not by the realized demand, where different varieties of the product are available, each produced by one type of firm. A consumer only purchases one variant of a good during one period. This is mirrored in a spatial differentiation of agents, which has the effect that a company's realized growth rate depends on its stochastic access to untapped demand as well. What we see is that given a global fitness measure that determines how well customers can be reached by producers, oligopolistic market structures result in which weaker competitors can maintain a presence in the market under certain conditions. The fitness measures is reflected in the fact that customers may switch from less fit to fitter companies' products when purchasing a good, but not the other way around.

The volume of transactions increases until an equilibrium saturation of the market is reached in each period. It is important that at this point there is still potential demand open that is not realized. The equilibrium saturation refers to market shares of companies in that state, the consumers actually realizing a purchase in a given period may change.

Concerning the increase of the realized demand over time, this may be seen as due to increasing information, communication, as word-of-mouth or as advertising, and maybe even to changes in potential customers' requirements and the importance they give to different products. Up to some point, therefore, the information available to customers, and the realized demand that follows from this, can increase. Eventually, a point is reached where this is no longer the case. We may think of increasing costs for one company in reaching new customers that may be due to spatial separation, or other types of socio-economically backed separation, for instance. In any case, the ability to manage demand has its limits. (Obviously, one may also extend the argument here to integrate capacity constraints in production structures that simply do not allow extending production beyond a certain level.) In any case, incomplete information translates into an incomplete reach. The lacking capability to service the entire potential market opens room for less able competitors to service the remaining demand, in areas that the best competitor has not yet reached.

When we think of potential factors influencing the presence, and especially the superior competitiveness of type *1* throughout the market these may include supplementary conditions needed for production processes of type *1* such as the presence of public goods, for instance, from infrastructure through the human capital endowment in production. They may also contain proprietary technological information and capacities that potential competitors are unable to get a hold of or copy, or simply a superior ability to attract potential customer to the image of a product or attached brand. Still, given incomplete information on the customer side, the type *1* firm cannot reach the entire market at a given point in time. Some potential demand will not be met. Local variants of a product may therefore be able to establish themselves even though they are of globally inferior quality, along any of the dimensions just mentioned, and service the demand that type *1* firms do not reach. They will be able to maintain a presence even in an eventual equilibrium state of the market; here, given by an equilibrium saturation rate, with constant market shares for the different types of firms.

The Basic Model

We will start with a very simple consideration: Of the potential total market share k=100% the actual market share (p_1) is realized by *type 1* firms. This market share in turn depends on the average potential growth rate of the firms c_1 (which we assume to be positive). This is easily interpreted as a potential newly realized demand that had been dormant before. For the actual customers gained, this is combined with the assumption that this potential cannot be completely realized as not every potential customer can be reached (see the first term in equation 1). The other component is the average rate of losses of existing customers, m_1, that we can interpret as a share of customers that are not buying the product again in the subsequent period. Both rates are assumed to be constant over time at this point. A specification of the production function is not necessary given the interest pursued here. The average rate of change of p_1 is given by:

$$\frac{dp_1}{dt} = c_1 p_1 (1 - p_1) - m_1 p_1 \qquad (1)$$

Therefore in equilibrium the potential market k is not saturated as long as $m_1>0$:

$$\widehat{p_1} = 1 - \frac{m_1}{c_1} \qquad (2)$$

In the next step, we can add a second type of firm (type *2*) who is an inferior competitor compared to type *1*. The market share of this type is p_2 and changes according to:

$$\frac{dp_2}{dt} = c_2 p_2 (1 - p_1 - p_2) - m_2 p_2 - c_1 p_1 p_2 \qquad (3)$$

The superior type *1* is unaffected by type *2* as she is able to outcompete type *2* at any part of the market where both are present. Type *2* is therefore only able to survive in parts of the market where type *1* is not present. Type *2*’s market share in equilibrium is given by:

$$\hat{p}_2 = 1 - \frac{m_2}{c_2} - p_1 \left(1 + \frac{c_1}{c_2}\right)$$

The equilibrium share of type *2* firms is larger, the larger the difference between c_2 and c_1. This condition points to one interesting effect in the model, namely, that it is not necessary that it is the fittest company that controls the largest share of the market.

The condition for coexistence of the two types is given by:

$$c_1 > m_1 \tag{4}$$

and

$$c_2 > \frac{c_1(c_1 + m_2 - m_1)}{m_1} \tag{5}$$

Interpretation

According to a global fitness measure, type *1* firms are better able to exist in the market under consideration. Due to a lack of reach into the entire potential market, only a part of the existing potential demand is satisfied by these companies. As a consequence, other companies, of the inferior type *2*, can maintain themselves in the market, servicing a share of potential demand that type *1* does not reach. They are not automatically able to do so, however, as the condition for existence as given in equation 5 has to be fulfilled.

More concretely, type *1* firms remain in the market as long as the rate at which they gain customers lies above the rate at which they lose customers (1). For type *2*, the condition for its survival in the market (5) does not only include the relation between the rates at which it gains and loses customers. Here, the rate at which it gains customers must in fact be larger than the rate at which it loses customers by a certain factor that depends on the conditions for type *1* firms (as $c_1/m_1 > 1$). This relatively larger share of new customers that has to be acquired is due to the fact that customers who get in contact with products from type *1* firms may switch, but not the other way around.

In consequence, we find two general strategic variables for every type of firm, the rate at which customers are gained, and the rate at which customers are lost. An increase in one, and a reduction in the other increases the chances for companies to maintain a presence in a market. Put differently, companies that are worse competitors in their production environment have to be better at acquiring customers and keeping them (before they get in contact with better varieties). m and c can be seen as functions of strategic variables for companies with changes in them mirroring shifts in companies' policies and potentially changing market shares as functions of such shifts.

Extension

The model can easily be extended to include multiple types of firms. The change of their respective market share reads as follows:

$$\frac{dp_i}{dt} = c_i p_i \left(1 - \sum_{j=1}^{i} p_j\right) - m_i p_i - \sum_{j=1}^{i-1} c_j p_j p_i \tag{6}$$

The saturated market potential in equilibrium is given by:

$$\widehat{p_n} = 1 - \frac{m_n}{c_n} - \sum_{j=1}^{n-1} \left[\widehat{p_j}\left(1 + \frac{c_j}{c_n}\right)\right] \tag{7}$$

The non-saturated market potential $\widehat{s_n}$ is consequently:

$$\widehat{s_n} = 1 - \sum_{j=1}^{n} \widehat{p_j} = \frac{m_n \widehat{s_{n-1}} + \sum_{j=1}^{n-1}[\widehat{p_j} m_j]}{c_n \widehat{s_{n-1}}} > 0 \tag{8}$$

If we assume that all firms have the same average decline or death rate we can calculate the required growth rate of the *n*-th type of firm as follows:

$$c_n > \frac{m}{\widehat{s_{n-1}}^2} \tag{9}$$

Therefore, given that the non-saturated market potential decreases for any newly entering type, the growth rates of new entrants have to eventually be extremely high as they are rising with the second power of the remaining market size.

The requirement for survival of less fit types becomes more demanding, insofar as the potential rate of acquiring new customers has to increasingly grow relative to those of the better competitors. Different strategies of customer acquisition are nevertheless a possibility, and therefore the situation of a number of types of firms servicing the realized demand out of the potential market is not trivial.

4. Competition for more than one key resource and temporal dynamics

In this section we will build on a model by Huisman and Weissing (1994), adapted from the biology literature as well, in this case with a focus on diversity that results if different resources may be constraining the growth of companies in a sector. In contrast to the model discussed in section 3, the model presented here thus offers a view on the production side, again with heterogeneous companies being present in a market at any given point in time.

The general idea behind our adaptation of the model is linked to the recognition of the importance of routines in organizations such as companies (Nelson and Winter, 1982). These develop and change over time, building on initial conditions, and without following a predetermined path. Rather, coincidences during the process shape the path eventually identifiable (for path dependence, Arthur, 1994). As a result, then, it can be expected that companies develop different ways of producing certain sets of products that are offered in one market; i.e., heterogeneous products that are seen as variants of some basic type, with sufficient substitutability between them.

The different paths followed over time will have resulted in different production structures. And these different production structures will signify different requirements of the companies. Put differently, the input matrix will look differently for different companies. Problems of appropriating knowledge and transmitting information will mean that companies could not copy the entire production design of another company, even if they wanted to. The limited availability of information, in this context, has an effect on the production side of a market. We neglect the demand side for the time being, and at first simply assume that products that are produced are sold.

In his seminal paper of 1991, Barney gives an in-depth analysis concerning the role of resources in firm competition. He especially emphasizes the heterogeneity of resource composition within an industry as well as their immobility. Many resources are immobile in the sense that they are not easily transferred or acquired. Their usage is therefore limited by endogenous structures of the firm. Consequently the resource availability and the firm's competence in resource utilization should be of considerable importance in market competition.

In a global perspective, some technologies, i.e., productions structures, should be better suited for achieving specific purposes, at least given the conditions at a certain moment (see also Kauffman's (1993) fitness landscapes). This need, of course, not be lasting. But there is, again, no reason to suspect that less well suited companies would necessarily be competed out of the market. The fact that different input factors play a role and that different production structures may face constraints in different areas, therefore, means that there exists a noticeable potential for dynamics of change in response to environmental changes, and for innovation aiming at overcoming the specific constraint felt to be most pressing for a company.

The Basic Model

The average growth rate of firms χ_i is now dependent on the resource availability R_j. There are many essential resources determining the growth a firm, with different industries having to build on different key resources, and, different firms within an industry showing differences in the details of their resource requirements. Hence, there are two aspects to this supply-side view on differentiated market structures, the degree to which firms can access a certain resource and the amount of that resource that is required for the firms' specific production structures to operate. We focus on the second aspect first. Again there also exists an average loss of sales m_i.

Imagine *n* types of firms and *k* resources. N_i denotes the abundance of type *i*:

$$\frac{dN_i}{dt} = N_i(\chi_i(R_i \dots R_k)) - m_i \quad i = 1, \dots n \tag{10}$$

For the sake of simplicity, for the moment we assume that there is a given amount of resources in an industry, like the amount of skilled workers, researcher personnel, venture capital, etc. The resource supply is modeled by the following expression:

$$\frac{dR_j}{dt} = D(S_j - R_j) - \sum_{i=1}^{n} \varphi_{ji}\chi_i(R_i \dots R_k)N_i \quad j = 1, \dots k \tag{11}$$

Here S_j is denoting the supply concentration of resource *j* and *D* is the system's turnover rate. The left term represents the exogenous regeneration of resources over time. The usage of resource *j* in firm type *i* is labeled φ_{ji}. We assume that the growth rate of a firm of type *i* is determined by the most limiting resource (Liebig's law):

$$\chi_i(R_1 \dots R_k) = \min\left(\frac{r_i R_1}{K_{1i} + R_1}, \dots, \frac{r_i R_k}{K_{ki} + R_k}\right) \tag{12}$$

The actual average growth rate χ_i is depending on the maximal possible growth rate r_i (where all resources are present in abundance) and the so-called half saturation constant K_{ki}. This constant is a measure of the speed by which a firm would incorporate or use resources. It gives the concentration or availability of a resource, where the maximum possible growth rate is 0.5.

The different growth rates are what concerns us here. Different growth rates mean changes in the market structures, which is what we investigate. These changes are a function of the requirements of the companies' respective production structures in relation to the availability and abundance of these inputs on the other hand.

In equilibrium (no explicit solution given here) this standard model predicts that there coexist at most so many types of competitors as there are resources k, or $n \leq k$. In the case of two resources, where one type is limited by resource 1 and another type is limited by resource 2, the dynamics of the system are relatively simple. In this case both competitors stably coexist. However, numerical solutions of the model show a very different pattern already in the case of 3 resources, if certain conditions are met. For instance, oscillations in abundance of types arise if three competitors displace each other in a cyclic manner. Assume, type 1 is the best competitor for resource 1 but limited by resource 2, type 2 is the most successful competitor for resource 2 but limited by resource 3 and type 3 is the outcompeting all others for resource 3 but limited by resource 1. Depending on the realized growth rates of all types, the amplitude in oscillations may vary. If now we let intermediate competitors enter into our model, up to nine competitors are sustained in this industry. This result holds in a similar way for high - as well as low – amplitude – systems. In the 4 resource case the number of coexisting types is increased substantially. In the 5 resource case the pattern begins to become irregular and even chaotic, even more competitors are coexisting, while all abundances are bounded as the resources are limited.

Interpretation

Development along a certain path means that the routines that were established over time as well as the technical requirements in production (input mix) have taken a shape that is specific to single companies. This specificity means that some companies are better suited to meeting the (resource)-constraints they face on the input side, than others in that situation. This is translated into more advantageous production conditions for these companies. Such more advantageous conditions allow companies to grow relatively faster, as they are better able to deal with a given set of constraints.

Different routines in companies, as the result of different paths along which companies have developed can result in different growth rates. Still, companies that operate under a set of routines that is less well-suited to a given environment than those of others companies can maintain a presence in the market in question. Given differing developmental paths and different sets of routines, the efficiency in resource acquisition and in resource use may be different and independent from one another. Integrating competition for resources may thus further complicate the dynamics in the model, without offering particular additional insights, however.

Regarding the implications for companies' strategic behavior, an identification of limiting factors and then a determination of possible ways for dealing with resulting constraints has to be the focus. Whether incremental or radical changes appear to provide a more promising way forward, depends on the overall situation faced. This may very well be influenced by the knowledge about the structures in other companies, the ability to integrate this knowledge in the own company, as well as the potential presumed for competitors to change their structures. In the framework proposed, incremental innovations can be depicted as situations where (some) companies are able to reduce their general resource requirements, or reduce the necessity of utilizing some stronger than others, so that different factors may be becoming the limiting ones for companies' growth rates. More radical innovation may be represented by changes in the resource requirement in a way that the resource environment changes (such as that substitutes for currently utilized inputs are integrated, e.g., machines over labor). In addition, dynamic markets may allow for windows of opportunities and temporal niches, which increase the number of coexisting competitors further.

5. Conclusions

We have presented two mechanisms which allow for the coexistence of even large numbers of distinct competitors in a single market. The first model employs a universal fitness concept, and shows that in markets where not all potential demand is serviced there is the room for strictly inferior competitors to persist, and be present in an eventual equilibrium state. The second model is somewhat more extended, differentiating competitors by their ability to use different resources that are necessary inputs in production processes. No fitness measure is integrated here, but differences in production structures and hence requirements in a shared environment are likely to mean that some companies are advantaged over others. Still, different competitors survive in such an environment.

Despite their straightforwardness, both models are providing arguments for how widespread coexistence of diverse economic agents can be sustained und thus may contribute to our understanding of market competition and provide the foundation for addressing such widespread phenomena as substantially differing profit rates within industries. In contrast to classical organizational ecology (Hannan and Freeman, 1989), our approach is capable of explaining the diversity and the coexistence of a wide variety of organizational forms of firms as a possible outcome of market competition.

So, the formulations allow for companies that show different degrees of competitiveness (in a given situation) to be present in a market, and for long periods of time. Given the reality of constraints in the economic system, a coexistence of distinct companies is a plausible result. To the degree that the mechanisms explored here can in fact be expected to reinforce each other in more realistic scenarios, this becomes even more likely.

These results also underline that the naïve use of natural selection metaphors is anachronistic; the extensive concentration on the optimizing and leveling effect of market selection is still a central obstacle to understanding economic competition.

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