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Evaluating Market Attractiveness: Individual Incentives vs. Industrial Profitability

by

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Abstract

In this paper we employ an agent-based industry simulation model to study the effects of the interplay between individual firms' market evaluation strategies on the extent of product innovations and overall industry development. In particular, we show that a homogenous industry consisting of companies with focus on historical profits yields high overall industry profits but is very unstable. The introduction of a single firm oriented towards market growth rather than profits is sufficient to trigger a severe drop in profits and a transformation towards an industry with strong market growth orientation and a large number of marketed product innovations. Furthermore we show that the degree of horizontal differentiation of product innovations from existing products is of significant importance for the individual incentives to adopt market growth orientation and the effects of such a development on overall industry profits.

Keywords: agent-based simulation, innovation dynamics, market attractiveness
JEL Classification: D83, L11, O32

1 Introduction

An important factor in determining success or failure of business firms is the selection of the right markets or market niches to be targeted. It is crucial to be able to generate the product mix optimally adapted to both the structure of the producers and the properties of the industry environment and demand schedule. Basically, the firm generates this mix either by imitative product diversification steps – entering existing markets – or by introducing product innovations into the market. In both cases the firm has to evaluate carefully the merits and risks of the new product it plans to add to its range.

The management literature has developed several standard approaches how to develop a useful evaluation of markets not covered by the current product range. The quintessence of these approaches is to identify some key factors that are important to estimate future profit possibilities on a market and to assign certain weights to these factors. A well known example is the GE approach (see e.g. Kottler (1997)) where market attractiveness is determined as the weighted sum of several factors. Among others, overall market size, market growth rate, historical profit margin and competitive intensity are the most important in the list. Clearly, the actual choice of the list of factors considered and in particular the weights assigned to the different factors is a strategic decision to be taken by the company. It will determine the firms diversification strategy in general but also the approach towards product innovations in particular. A strong weight on market growth rates will lead companies to focus on young innovative markets. This comes with the risk of investing in markets which never take off or of neglecting established products with large current profitability. On the other hand, a strong focus on (historical) profits makes a firm vulnerable to missing new developments with respect to products or technology which might turn out to be essential for future success. This effect has been highlighted under the name 'Innovator's Dilemma' in Christensen (1997). Using several case studies he points out that leading companies in different markets have lost their industry leadership because they reacted too late to the existence of initially small and unprofitable but growing markets which eventually replaced their core business. One of the main reasons for their failure was that firms were focused on profit and revenues and existing business plans for these small but growing markets did not succeed internally to be implemented.

The focus of this paper lies on the examination of the effects of (historical) profit orientation versus growth orientation not only from the point of view of the individual firm but mainly from the point of view of industry development. In particular, we are interested in studying how the choice of market evaluation strategies of competitors in the market influences individual incentives for growth respectively profit orientation and whether these individual incentives lead to desirable outcomes from an overall industry profit point of view. Another point to consider is how the choice of market evaluation strategies influences the long run frequency of product innovation and the resulting product diversity in an industry. Whereas market evaluation has been an important topic in the managerial literature to our knowledge there exists no systematic analysis of these issues from an industry perspective. Obviously, the questions posed here can only be answered in a dynamic industry framework with multiple products where market development is determined endogenously by the interplay of the firms innovation and production strategies.

We employ an agent-based simulation model to incorporate all these important effects into our analysis. Our market environment is that of an oligopoly where different variants of the same

basic good are traded (e.g. different types of soft-drinks). New variants are introduced and old variants loose their market appeal from time to time. The model incorporates diversified producers, endogenous product life cycles driven by innovative activities and profit based firm growth and decline. A firms strategy in our framework involves besides the choice of the market evaluation rule also product and process innovation decisions, market exit and entry decisions, output decisions and fund allocation decisions. Market exit and entry as well as fund allocation and product innovation activities are based on market evaluations and therefore influenced by the choice of the evaluation strategy. In this paper we will hold the basic rules determining exit, entry, innovation and fund allocation fixed and study the impact of different market evaluation strategies for a given rule set. In Dawid and Reimann (2003) we have taken the opposite approach and examined the interplay of different innovation and diversification strategies for a given evaluation function. The main insights of this paper are that there is a clear relationship between the average degree of diversification in an industry and the incentives to reduce the development time and quality of product innovations. Individual incentives lead in industries with increasing degree of diversification to a reduction of average quality although such a development has negative effects on the profits of an average producer in the market.
As far as the methodology is concerned the paper is embedded in the stream of literature in the fields of evolutionary economics, organization theory and agent-based computational economics, which was motivated by the work of Cyert and March (1963), Nelson and Winter (1982) and Simon (1978, 1983) and studies adaptive, rule based behavior of economic entities like firms. Deviating from the neoclassical paradigm that behavior is always determined by maximizing behavior it is argued in this literature that in many complex decision problems a firm faces, the task of determining the optimal action is either too demanding or too costly for a firm. In reality the actions of firms are rather determined by heuristic rules which are comparably easy to follow and have proved successful in the past. Studies in this tradition employ computer simulations which allow them to deal in a more realistic way with the complexity of interactions present in real world markets. In our case we are able to integrate closely related production and innovation decisions in a dynamic heterogeneous market framework. A wide range of issues like market development, price dynamics, information spreading and firm organization has been analyzed in the past using models of this type (see e.g. Chang and Harrington (2000, 2003), Dawid et al. (2001), Natter at el. (2001) or the special issues edited by Tesfatsion(2001a,b,c).
The paper is organized as follows. In the next section we present the model, continue with a brief discussion of the simulation setup in section 3 and present two benchmark simulations in section 4. Section 5 introduces an adaptation dynamics and studies the evolution of the distribution of evaluation strategies. In order to gain a better understanding of the obtained dynamical results

we carry out a detailed analysis of individual incentives and industry profitability under different industry frameworks in section 6 and conclude in section 7. The Appendix gives the ranges for all parameters used in the simulation run.

2 The Model

In order to be able to deal with the questions discussed above we use a rather extensive industry-simulation model. The framework we use incorporates interlinked dynamic life-cycles of the sub-markets in the industry which is an important feature to understand the dynamic interplay of market evaluation strategies, product innovation decisions, exit/entry and industry growth. The production side of the industry is represented by an agent-based model allowing for heterogeneities of cost-structures and production strategies among the industry firms. On the other hand, the demand side is highly stylized employing the concept of a representative consumer.

2.1 Market Demand and Life-Cycles

We consider an industry consisting of n producers. At any point in time t there exist m_t sub-markets within this industry, where each sub-market represents a variant of the product considered. Consumers are assumed to have love-for-variety preferences where the representative consumer has a utility function

$$u_t(X_{1,t}, \ldots, X_{m_t,t}) = \left(\sum_{j=1}^{m_t} (a_{j,t} X_{j,t})^b \right)^{\frac{1}{b}}. \tag{1}$$

The parameters $a_{j,t}$ denote the current attractiveness of product variant j and $X_{j,t}$ consumption of product variant j. The degree of substitutability between the different product variants is expressed by $b \in [0, 1]$. Values of b close to zero correspond to complementary goods whereas the variants are perfect substitutes for $b = 1$[1]. This utility function is maximized subject to the budget constraint

$$\sum_{j=1}^{m_t} p_{j,t} X_{j,t} \leq B(t), \tag{2}$$

where $B(t)$ denotes the overall amount of money allocated by consumers to purchases of goods produced in this industry. We will assume that it increases with the number and attractiveness of

[1] The elasticity of substitution between two products is given by $1/(1-b)$.

product variants, however at a decreasing rate:

$$B(t) = msize \frac{\sum_{j=1}^{m_t} a_{j,t}}{A + \sum_{j=1}^{m_t} a_{j,t}}.$$

Here $msize$ gives the maximal amount of money that could be allocated to purchases in this industry and A governs how fast the allocated funds grow with increasing overall attractiveness of the sub-markets. By making this assumption we intend to capture that the goods produced in this industry do not only compete among themselves but also compete for consumer budget allocation with outside products. A concave relationship between attractiveness of markets and total consumer expenditures can for example be derived by incorporating utility of money with an exogenously given attractiveness in the consumer's utility function.

All producers in this industry set production quantities for all the sub-markets they are in and prices are determined by market clearing. Straightforward calculations then yield the following inverse demand curve for a market j:

$$p_{j,t} = B(t) \frac{a_{j,t}^b}{X_{j,t}^{1-b} \sum_{k=1}^{m_t} (a_{k,t} X_{k,t})^b}, \tag{3}$$

where $X_{k,t}$ here denotes the aggregate variant k production quantity of all producers at time t.

Now let us be more specific about the evolution of the attractiveness parameters $a_{j,t}$. At any point in time one of the producers might introduce a new product variant and thereby open a new sub-market (we will discuss this process in more detail below). At the time $t_{ini}(j)$ when sub-market j is founded a market potential $P_j \in [0, 1]$ for this variant is determined. This market potential depends on the amount of effort invested in the product development (see below) and gives an indication of the maximal level of attractiveness this variant might attain. The actual attractiveness of this product variant then evolves according to the following stochastic dynamics:

$$\begin{aligned} a_{j,t_{ini}(j)} &= 0 \\ a_{j,t+1} &= a_{j,t} + (1 + \epsilon_{j,t}) P_j h'(t - t_{ini}(j)) \qquad t > t_{ini}(j), \end{aligned}$$

where $\epsilon \sim \mathcal{N}(0, \sigma_a^2)$ is a noise term and $h(t)$ is a function describing a typical normalized life-cycle. To capture the main life-cycle properties h is assumed to be a unimodal convex-concave-convex function with peak at $L/2$ and $h(0) = h(L) = 0, h(L/2) = 1$. The parameter $L > 0$ gives the expected length of the life cycle. A sub-market dies if at a period t there is either no demand ($a_{j,t} \leq 0$) or no supply ($X_{j,t} = 0$). Dead markets cannot be revitalized. The stochastic formulation chosen on one hand allows for a certain predictability of market growth in dependence of market age, but, on the other hand, also captures path dependencies in a sense that the actual size of a sub-market not only depends on the technical quality of the product but also on an aggregation of stochastic shocks during the market evolution. It follows from (3) that given $B(t)$ the size of the demand for a product variant depends only on the relative attractiveness compared to that of the other variants currently offered. Absolute levels of attractiveness however have some impact because the overall market size $B(t)$ increases with the sum of all attractiveness parameters.

2.2 R & D Stock and Product Innovation

The number of sub-markets in the industry can be increased by product innovation. In case a firm decides to introduce a new product-variant in t (the way this decision is made is described below) a new sub-market is founded where initially the founder is the only producer. The potential of this new market is assumed to depend on the amount of product R & D previously invested in the development of the new variant. To model this we use a product R & D stock variable $RD_{i,t}$ which is gradually increased over time by product R & D investments of the firm. Analogous to the market potential the range of $RD_{i,t}$ is restricted to $[0,1]$ and the potential of a new market founded by firm i in period t is uniformly randomly selected from the interval $[(1-\chi)RD_{i,t}, \min(1,(1+\chi)RD_{i,t}))]$. The parameter $\chi \in [0,1]$ measures the uncertainty associated with the success of a new product innovation. The entire stock of R & D investments is used up for developing an innovation and a new product development has to start from scratch. ($RD_{i,t}$ is set to zero).

The build-up of a knowledge stock for innovations has the property that it is a time consuming process where experience and knowledge is step by step accumulated over time. Hence, large investments in one period are only an incomplete substitute for past R & D investments and experience. Furthermore, it is assumed that returns to investments measured by increases in $RD_{i,t}$ decrease as the company approaches the frontier of $RD_{i,t} = 1$. Formally, we set $RD_{i,t} = 0$ at $t = 0$ and whenever the firm starts a new project after a product innovation. After that we update the stock as follows:

$$RD_{i,t+1} = 1 - (1 - RD_{i,t})\frac{1 + \beta_i^{RD}\alpha_i^{RD} I_{i,t}^{prod}}{1 + \alpha_i^{RD} I_{i,t}^{prod}}.$$

Here $I_{i,t}^{prod}$ denotes the investment in product R & D by firm i in period t, whereas $\alpha_i^{RD}, \beta_i^{RD}$ are firm-specific parameters. The parameters $(\alpha_i^{RD}, \beta_i^{RD})$ describe the ability of the firm to develop new products and the efficiency of the use of R & D funds. In particular, firm i can each period reduce the gap to the current frontier ($RD = 1$) at most by the factor β_i^{RD}. It could be argued that this parameter is closely related to the knowledge base built by the company in the past and hence should depend on aggregated previous product R & D investments, but for reasons of simplicity it is taken as exogenous here.

2.3 The Cost Structure of Producers

Each of the n firms in the industry can in every period produce for each of the active sub-markets. The decision process of the firms involves three steps: first, to decide on the set of markets the firm intends to service, second, to determine the output quantities for each of these markets, and third to decide on investments in process and product innovations. We will discuss the way these decisions are made in the next subsection and first line out the cost structure of the firms.
We denote by $M_{i,t}$ the set of markets the firm produces for in period t and by $x_{i,j,t}$ the output quantity of firm i on sub-market j. The firm's production costs are given by

$$C_{i,t}(x_{i,t}) = F_{i,t} + \sum_{j \in M_{i,t}} c_{i,j,t} x_{i,j,t}^2.$$

The fixed costs

$$F_{i,t} = |m_{i,t}|^{\mu_i} \Phi_i \qquad \mu_i \in [0,1]$$

depend on the number of sub-markets, where the parameter μ_i indicates how fast fixed costs go up with the number of variants produced. This can be seen as a measure of centralization of the firm where centralized firms have high values of Φ_i but small μ_i whereas for companies where the different sub-markets are managed in a decentralized way this relationship is reversed.
An important aspect of our model is the fact that production costs can be decreased over time through process improvements and accumulation of tacit knowledge. The variable cost parameter $c_{i,j,t}$ is a result of such process improvements. At the time where firm i starts producing variant j we have $c_{i,j,t} = c_{i,j}^{ini}$ but afterwards i can invest in every period t where $j \in M_{i,t}$ in cost-reducing process improvements in the production of j. We assume that there is a maximal fraction $(1 - c^{min})$ by which this cost parameter can be reduced through process improvements. Similar to the build-up of the product R & D stock the cost reduction is realized in small steps over time where the maximal percentage reduction per period is given by $(1 - c^{min})(1 - \beta_i^c)$. This formulation stresses the fact that early entrants in a market tend to have advantages in know-how and production costs which cannot be easily equalized by late-comers even with large monetary investments. Formally, we have

$$c_{i,j,t} = c_{i,j}^{ini}(c^{min} + (1 - c^{min})\tilde{c}_{i,j,t}),$$

where

$$\begin{aligned}\tilde{c}_{i,j,t_{ini}(j)} &= 1\\ \tilde{c}_{i,j,t+1} &= \tilde{c}_{i,j,t}\frac{1+\beta_i^c\alpha_i^c I_{i,j,t}^{proc}}{1+\alpha_i^c I_{i,j,t}^{proc}} \qquad t > t_{ini}(j).\end{aligned}$$

Here $I_{i,j,t}^{proc}$ is the investment of firm i in process improvement for variant j at time t and α_i the efficiency of such an investment. The parameters (α_i^c, β_i^c) characterize the technological expertise and the quality of process management of firm i.

Given this cost structure, profits of firm i in period t are given by

$$\pi_{i,t} = \sum_{j \in M_{i,t}} (x_{i,j,t}p_{j,t} - C_{i,t}(x_{i,t})).$$

To keep the model as simple as possible we ignore all investments other than that for product and process innovation and also any distribution of dividends. Profits remaining after investment are added to the savings of the firm

$$S_{i,t+1} = (1+\rho)S_{i,t} + \pi_{i,t} - \sum_{j \in M_{i,t}} I_{i,j,t}^{proc} - I_{i,t}^{prod},$$

where ρ is the (real) interest rate on savings. Each firm is endowed with initial money stock S_0.

2.4 Decision Making

Having described the market framework and the cost structure of the firms in this industry we are now in a position to deal with the decision making process of the individual producers. As pointed out above, each firm every period has to make three types of decisions: market selection, output decisions and investment decisions. The following time-line shows the sequence of events within each period t:

1. Firms evaluate all existing markets and potential new product variants.
2. Firms select their markets and might introduce product innovations.
3. Demand functions on all existing markets are updated (life-cycle).
4. Output quantity decisions are made.
5. Market clearing prices are determined and profits realized.
6. Investments in process improvements and product innovations are made.

The model is initialized with m_0 markets of identical given potential P_{ini}, where each firm is active in one randomly chosen market.
The focus of our study lies in the analysis of the market evaluation strategies of firms in the industry. Therefore this choice is modelled explicitly making the weights assigned to the different factors important strategic parameters. We will first describe the way this evaluation function is constructed, then deal with the innovation and market entry-exit decision, describe the rules used by the firms to decide on their output on all sub-markets and finally discuss the investment decisions.

2.4.1 Market Evaluations

The change in the market portfolio a firm holds is modelled as a sequence of rule-based market exit and entry decisions. The exit and entry rules rely on an evaluation of all existing markets carried out at the beginning of each period. It is assumed that at the end of a period all firms can observe the attractiveness each product variant had in the current period, the number of producers and the average profits in each sub-market. Furthermore, firms know the founding period of each sub-market and the shape of the expected life-cycle curve $h(t)$. Using this information firms estimate the market potential of each market, $\hat{P}^t_j$, and future values of the attractiveness parameters $\hat{a}^t_{t+l,j}$, where the superscript t indicates that the estimate is made in period t. Since all firms have identical information about the attractiveness of the markets these estimates are homogeneous. Based on the estimated evolution of the attractiveness each firm calculates an estimated average market growth rate

$$\xi_{i,j,t} = \frac{1}{\tau_i} \sum_{l=1}^{\tau_i} \frac{\hat{a}^t_{j,t+l}}{a_{j,t}},$$

where τ_i is the planning horizon of firm i. The evaluation function of a sub-market j takes into account current profits, short term market growth and long term market potential. We use a function of the form

$$v_{i,j,t} = \pi^{3\delta_{i,\pi}}_{i,j,t-1} \xi^{3\delta_{i,\xi}}_{i,j,t} \left(\frac{\hat{P}^t_j}{\hat{P}^t_{av}} \right)^{3\delta_{i,P}} . \tag{4}$$

The exponents satisfy $\delta_{i,\pi} + \delta_{i,\xi} + \delta_{i,P} = 1$ and are important parameters of the firm's diversification strategy since they represent the weights assigned to profits, growth rates and potential of a market, respectively. The profit term is given by $\pi_{i,j,t-1} = p_{j,t-1} x_{i,j,t-1} - c_{i,j,t-1} x^2_{i,j,t-1}$ if $j \in M_{i,t-1}$ and by the observed average profit made on sub-market j if the firm did not produce the variant in the previous period. The expression $\hat{P}^t_{av}$ denotes the average of the estimated potential of all existing markets, which means that the third term gives a ratio of actual to average market potential and is unit free. If the firm puts equal weight on all three factors ($\delta_{i,\pi} = \delta_{i,\xi} = \delta_{i,P} = 1/3$) and it is assumed that profits grow at the same rate as the product attractiveness, then $v_{i,j,t}$ gives the expected average payoff (excluding fixed costs) over the time-horizon τ_i for firm i on an average-potential sub-market j.

2.4.2 Product Innovation

Every period firms decide whether they consider their ongoing product innovation efforts sufficiently advanced in order to take the new product to the market. They base this decision on a comparison of the expected attractiveness of the new product (which is determined by the quality level reached at that point) with the anticipated development of the attractiveness of the existing products. To this end firms calculate the anticipated average attractiveness of existing products at the end of their planning horizon $t + \tau_i$. This expression is given by

$$\hat{a}_{i,av} = \frac{1}{m_t} \sum_{j \in m_t} \hat{a}^t_{j,t+\tau_i}$$

The expected market potential of a product the firm could introduce in period t is given by [2] $RD_{i,t}$ and the firm chooses to introduce a new product whenever

$$RD_{i,t} > \kappa_{i,innov} \hat{a}_{i,av}$$

The strategy parameter $\kappa_{i,innov}$ is therefore the crucial factor determining the quality level of a firm's product innovations. A high value of $\kappa_{i,innov}$ corresponds to higher aspirations with respect to product quality but a smaller number of product innovations whereas a low $\kappa_{i,innov}$ implies a speeding to the market strategy. We have also tried to introduce a rule where the expected potential of the new product is compared to the maximum of an absolute quality level and the relative quality level given above and it turned out that positive absolute quality requirements always had detrimental effects on firm profits. Hence we do not consider this option here any further.

To guarantee a certain degree of appropriability of returns from product innovation we assume that no competing firm can enter this market for $d_p \geq 0$ periods. The duration d_p will be referred to as patent length, however it should be noted that there are various factors other than patent protection which might guarantee delays in market-entry of imitators like information protection measures, lead times, costs of duplication (see e.g. Dosi (1988)). Which of these factors is actually most important for appropriability differs between industries. For reasons of simplicity

[2] Strictly speaking this is only true as long as $RD_{i,t} < \frac{1}{1+\chi}$. In our simulations α_i^{RD} and β_i^{RD} were always chosen in a way that this inequality was never violated.

we will refer to patents as the means of guaranteeing appropriability. With $d_p = 0$ the innovator has a guaranteed monopoly position only in the founding period.

2.4.3 Market Exit and Entry

The exit and entry decisions of the firm rely on the comparison of the evaluations of markets among each other and on the comparison with the marginal change of fixed costs induced by a change of the number of variants produced. In the exit step the firm considers all sub-markets in $M_{i,t-1}$ whose current profits do not cover the corresponding fraction of fixed costs and stops producing a variant if

$$v_{i,j,t} < \kappa_{i,ex} \left(|M_{i,t-1}|^{\mu_i} - (|M_{i,t-1}| - 1)^{\mu_i} \right) \Phi_i.$$

This means that markets are only dropped if there is little hope that the market will be able to cover fixed costs in the future. The parameter $\kappa_{i,ex} \geq 0$ determines the inertia of the firm's market exit strategy, where the degree of inertia decreases with increasing κ_{ex}. In the extreme case of $\kappa_{ex} = 0$ a market is only dropped if anticipated prices cannot even cover variable costs. Large values of κ_{ex} on the other hand correspond to a selective strategy where markets are only kept if large future profits are expected. As long as capital availability is no constraint expected profits are only compared to allocated fixed costs but in case the capital constraint was binding for the production decision opportunity costs have to be considered as well. In this case the firm also drops all markets with

$$v_{i,j,t} < \tilde{\kappa}_{i,ex} \bar{v}_{i,t},$$

where $\bar{v}_{i,t} = \frac{1}{|M_{i,t-1}|} \sum_{k \in M_{i,t-1}} v_{i,k,t}$. The rationale for this measure is to avoid over-diversification with large fixed costs but only small output quantities. It is further assumed that firms grant each market an 'examination-period' and do not leave markets they have just entered in the previous period. For new product innovations the examination period can be seen as a market exploration phase where the firm 'tests' a developed innovation with minimal output numbers. Exit of the firm which has developed the product right after the examination-period is then interpreted as the firm's decision not to put this developed product on the market.

After the firm has eliminated all dissatisfactory variants from its product portfolio, it considers entering a new market. Because of the organizational and managerial challenges of market entry, at most one new market can be added to the portfolio per period. This includes own product innovations which means that market entry decisions are only considered in periods where the firm has not opened a new market.

To make the entry decision the firm ranks all available markets it does not currently serve according to their evaluations and determines the best existing non-served market as the entry candidate. The set of available markets consists of all existing product variants which are currently not protected by a patent. The entry candidate is added to the portfolio if[3]

$$v_{i,j,t} > \kappa_{i,en} \left((|M_{i,t-1}| + 1)^{\mu_i} - |M_{i,t-1}|^{\mu_i} \right) \Phi_i.$$

The parameter $\kappa_{i,en} > 0$ is again an inertia parameter and represents the aggressiveness of the firm's entry policy. The optimal value of this parameter is a priori not clear. Entering a market which currently does not cover the additional fixed costs might be profitable because cost reductions achieved by process improvements now might be very valuable in the future if demand grows sufficiently fast.

2.4.4 Quantity Decisions

In order to describe the rules which govern the quantity decision making of the firms we should first be more explicit about the amount of information firms can use. We assume that the aggregate output quantities and the number of firms in all sub-markets at $t-1$ can be observed by all producers including those that were not active in this market. Furthermore, the price elasticities of demand for these quantities are also common knowledge ($\epsilon_{j,t}$). Each firm has in all periods perfect information about the own fixed and marginal costs of production of all product variants. Firms however do not have perfect information about the exact shape of the entire demand function and also do not know other firm's cost structures.
Given the set of sub-markets $M_{i,t}$ firm i tries to maximize

$$\max_{x_{i,j,t}: j \in M_{i,t}} p_{j,t} x_{i,j,t} - c_{i,j,t} x_{i,j,t}^2$$

subject to the constraint that current production has to be paid for by the current stock of savings (to keep things simple we do not allow firms to borrow):

$$|M_{i,t}|^{\mu_i} \Phi_i + \sum_{j \in M_{i,t}} c_{i,j,t} x_{i,j,t}^2 \leq S_{i,t}.$$

The corresponding first order conditions read

$$\begin{aligned} p_{j,t} + x_{i,j,t} \frac{\partial p_{j,t}}{\partial x_{i,j,t}} - 2c_{i,j,t} x_{i,j,t} - \mu_{i,t} 2c_{i,j,t} x_{i,j,t} &= \\ MR_{i,j,t} - 2(1 + \mu_{i,t}) c_{i,j,t} x_{i,j,t} &= 0 \quad \forall j \in M_{i,t}, \end{aligned} \tag{5}$$

[3] Strictly speaking this is only true if the capital stock is sufficiently large such that fixed costs plus variable costs can be covered even with an additional sub-market. If this is not the case the firm compares the evaluation of the best non-served market with the worst market in the portfolio and exchanges these two if the ratio is larger than $\tilde{\kappa}_{i,en}$.

where $\mu_i \geq 0$ is the Lagrange multiplier of the firm's budget constraint and $MR_{i,j,t}$ the marginal revenue. Due to the limited information about the shape of the demand function and the competitor's production costs firms cannot simply determine the Nash equilibrium of this quantity setting game. Rather they use some heuristic approximations to determine their output quantity. They assume that price elasticities of demand are constant and hence approximate marginal revenue by the following expression typically used in standard markup pricing formulas

$$\hat{MR}_{i,j} = \hat{p}_{j,t}\left(1 + \frac{x_{i,j,t}}{\hat{X}_{j,t}\ \epsilon_{j,t}}\right).$$

Note that $p_{j,t}$ and $X_{j,t}$ are unknown at the time of the decision making and hence estimates have to be used. Firm i believes that all producers in the industry change their output quantity by the same factor $\lambda_{i,j,t}$ which means that $\hat{X}_{j,t} = \lambda X_{j,t-1}$ and $\hat{p}_{j,t} = p_{j,t-1}\left(1 + \frac{\lambda-1}{\epsilon_{j,t-1}}\right)$. For firms that have been in sub-market j in period $t-1$ inserting these expressions into (5) gives the output quantity $x_{i,j,t} = \lambda_{i,j,t} x_{i,j,t-1}$, where

$$\lambda_{i,j,t} = \frac{p_{j,t-1}(\epsilon_{j,t-1} - 1)(X_{j,t-1}\epsilon_{j,t-1} + x_{i,j,t-1})}{2c_{i,j,t}(1+\mu_{i,t})x_{i,j,t-1}X_{j,t-1}\epsilon^2_{j,t-1} - p_{j,t-1}(X_{j,t-1}\epsilon_{j,t-1} + x_{i,j,t-1})}. \tag{6}$$

It becomes obvious from this expression that the actual rates of change of output are heterogeneous and the homogeneity assumption of the firms is in general violated. Nevertheless this formulation captures the effect that output quantities of all firms in markets with increasing or decreasing attractiveness tend to move in parallel and avoids extreme overshooting which for example would be induced by naive expectations. The approach might look like a conjectural variation model with variation parameter plus one but here firms do **not** believe that changes in their own quantity directly influence the output decision of the other firms. Rather they believe that each firm will independently arrive at the same quantity adjustment factor from one period to the next.

A firm which did not produce variant j in period $t-1$ but added this sub-market in t first tries to estimate the change of output quantity of the incumbents and determines its optimal quantity based on this. The expected rate of change of output of the incumbents in the market is determined analogous to (6) where $x_{i,j,t-1}$ is replaced by the average output of a producer of variant j in period $t-1$. The expectation of firm i about total output in t in such a case is $\hat{X}_{j,t} = \lambda_{i,j,t}X_{j,t-1} + x_{i,j,t}$. Inserting into (5) implies a production quantity of

$$x_{i,j,t} = \frac{X_{j,t-1}}{2p_{j,t-1}}\left(2(1+\mu_{i,t})c_{i,j,t}\lambda_{i,j,t}X_{j,t-1}\epsilon^2_{j,t-1} - p_{j,t-1}(\epsilon_{j,t-1}(\lambda_{i,j,t}+1) + \lambda_{i,j,t} - 1) - \sqrt{SQRT}\right), \tag{7}$$

where $SQRT = \left(p_{j,t-1}(\epsilon_{j,t-1}(\lambda_{i,j,t}+1) + \lambda_{i,j,t} - 1) - 2(1+\mu_{i,t})c_{i,j,t}\lambda_{i,j,t}X_{j,t-1}\epsilon^2_{j,t-1}\right)^2 - 4p^2_{j,t-1}\lambda_{i,j,t}\epsilon_{j,t-1}(\epsilon_{j,t-1} + \lambda_{i,j,t} - 1)$. Finally, there is a minimal production quantity $x_{min} > 0$ which has to be produced by any firm which decided to keep this sub-market in its portfolio. If the result of the quantity calculations above is below this level the firm still produces x_{min}. Also in the initial period when a new sub-market is founded the quantity x_{min} is produced by the founder.

2.4.5 Investment Decision

At the end of a period each firm decides on its investments in product and process innovation. The R & D investment quota for product innovation is denoted by q_i^{prod} and accordingly product R & D investments are $I_{i,t}^{prod} = q_i^{prod}\pi_{i,t}$. This investment increases the R & D stock $RD_{i,t}$ as described above. The overall investments for process innovation are $q_i^{proc}\pi_{i,t}$. Since process investment leads to a reduction of per unit costs of production the firm allocates these funds to the different sub-markets proportional to an adjusted expression of its current output in each market, where the adjustment takes into account future growth potential. In particular the following expression (compare the market evaluations (4)) is used:

$$\tilde{v}_{i,j,t} = x(i,j,t)\xi_{i,j,t}^{\delta_{i,\xi}/(\delta_{i,\xi}+\delta_{i,P})}\left(\frac{\hat{P}_{j,t}}{\hat{P}_t^{av}}\right)^{\delta_{i,P}/(\delta_{i,\xi}+\delta_{i,P})}.$$

Hence, we have $I_{i,j,t}^{proc} = \frac{q_i^{proc}\pi_{i,t}\tilde{v}_{i,j,t}}{\sum_{k\in M_{i,t}}\tilde{v}_{i,k,t}}$ for all $j \in M_{i,t}$. As discussed above, these investments in process improvements lead to reductions of the unit costs for the corresponding product variant in $t+1$.

Summarizing the rather lengthy discussion of the rule-based decision making of our producers we like to point out that a strategy of a firm is determined by the following four types of parameters:

1. The exponents in the market evaluation function: $\delta_{i,\pi}, \delta_{i,\xi}, \delta_{i,P}$.
2. The parameter governing the speed and quality of product innovations: $\kappa_{i,innov}$
3. The inertia parameters of market exit and entry: $\kappa_{i,en}, \kappa_{i,ex}, \tilde{\kappa}_{i,en}, \tilde{\kappa}_{i,ex}$.
4. The investment quotas: q_i^{prod}, q_i^{proc}.

The industry simulation model described above is of quite general structure and could be used for the analysis of numerous questions concerning industry development. Here, the focus is on the tradeoff between profit oriented and growth oriented market evaluation. Therefore we will always treat the parameters $\delta_{i,\pi}, \delta_{i,\xi}, \delta_{i,P}$ δ_{ξ} as our main objects of interest. The other strategy parameters will be fixed or determined stochastically as described in the following section.

3 Simulation setup

In order to obtain valid results from the model presented above a careful choice of the numerical simulation setup is necessary. This includes both model calibration and parameter sensitivity testing.

Model calibration deals with the choice of parameter value ranges that allow the model to find reasonable and more important robust results. In particular, long run viability of the industry is by no means certain in this model and hence viability requirements already put certain bounds on the ranges of parameters to be considered. We performed a large number of runs with different parameter settings to obtain these ranges.

However, varying parameters within these ranges parameter may still have considerable impact on the dynamics of the model. Also, one has to be aware that the model has a significant stochastic component and hence results are not deterministic either. We are interested in the structural qualitative impact of the variation of certain key control parameters. To measure the impact of different values for our control parameters, and to avoid picking up effects caused by particular settings for the other parameters or by noise, we generated 100 different profiles of all model parameters excluding only the ones determining the very basic structure like the number of periods considered (T), the degree of complementarity (b), the number of firms (N_F), patent length (d_p), overall market size ($msize$) or the expected length of a life-cycle (L). The profiles were generated randomly, where each parameter was drawn from the uniform distribution bounded by its range as we determined it before. The structure parameters mentioned above were fixed in our random profiles because changing them would have had severe impact on the ranges for the other parameters which guarantee viability[4]. However, we will also comment on the robustness of our results with respect to changes in these parameters below. Note that values of L and d_p chosen are consistent with empirical observations if one period in our model is interpreted as a quarter of a year.

Each particular setting for our control parameters was run over all 100 profiles and the results obtained were averaged over these runs.

Summarizing, all the results below were found to be very robust under the settings we discussed above, namely 100 distinctly different runs, with profiles based on parameter ranges that were determined by plausibility checks beforehand.

[4]The actual ranges for all parameters used for the generation of the stochastic profiles are given in Appendix A.

4 Industry comparison

The focus of this paper is on the evaluation and analysis of firms' market evaluation strategies. In what follows we will compare two types of qualitatively different market evaluation strategies, which we will describe now. The first type of firms can be thought of as *present profit oriented, conservative, laggard* firms, which assign a low weight δ_ξ^L on future market growth opportunity, and a high weight δ_π^H on current profitability. As discussed above, potential problems associated with this strategy are i) the danger of not introducing or of discarding product innovations before they become profitable, and ii) too little process innovations in young and growing but little profitable markets. In what follows the tag *profit oriented firm* will be used for this type of firm, although of course all firms try to maximize (discounted) profits. The second type of firms can be classified as *innovation oriented, risk loving, early adopter* firms, which assign their market evaluation weights the opposite way, i.e. $\delta_\xi = \delta_\xi^H$ and $\delta_\pi = \delta_\pi^L$. These firms face the risks of i) holding on to product innovations of poor quality, and ii) investing heavily in very young and possibly not profitable markets.[5]

We are interested in both industry profits and individual incentives to change behavior under different distributions of firm types and different market scenarios, which we will discuss now. Let us first consider the two extreme cases, where either all firms are of the *profit oriented* type, or all firms are of the *innovation oriented* type. Table 1 shows for the average industry profits and average number of markets for each of the two cases. Substitutability between markets here is characterized by $b = 0.5$. Clearly, industry profits are larger, while average number of markets are smaller if all firms are *profit oriented*.

	Industry	
	profit oriented	innovation oriented
avg. number of markets	4.4	6.6
avg. industry profits	148.4	140.3

Table 1: Average number of markets and industry profits in profit vs. innovation oriented industries

Closer inspection of the results reveals the reason for these profit effects. In an *innovation oriented* industry the quality of an innovation is of secondary importance for the decision to place a new product in the market. Therefore, many low quality markets are active over a long time

[5]In our numerical simulations high values of δ_ξ typically correspond to 0.4, low values to 0.25. The only exception are the runs for $b = 0.75$ reported at the end of our discussion. If not noted otherwise the parameter δ_P always has the value $\delta_P = 0.33$ and the values for $\delta_\pi^H, \delta_\pi^L$ follow from the condition that the weights sum up to one.

period and the average quality is significantly below the level in a *profit oriented* industry. In the *innovation oriented* industry firms have to cover higher fixed costs generated by the increased degree of diversification but the overall demand curve for the industry – which depends on the sum of the attractiveness parameters of all active markets – does not shift to the right sufficiently. Before we examine the micro-effects underlying this observation in more detail we consider the question which long run state will be reached if the number of *innovation oriented* respectively *profit oriented* companies is endogenously determined.

5 Adaptation dynamics

Let us now consider an industry where firms may change the type of evaluation strategy they are using over time. Should we expect convergence towards pure innovation or profit oriented industries as considered above or maybe a mixed population where both types coexist? To study this question we consider a very simple adaptation dynamic which combines the 'satisficing' approach (see Simon, 1978) with imitation dynamics.

We focus again on the choice of δ_ξ and δ_π. As our analysis focuses on oligopolistic industries with a rather small number of firms we keep the number of potential strategies as small as possible. In particular, we assume that firms can choose from four possible strategies[6], namely $(\delta_\xi^H, \delta_\pi^H), (\delta_\xi^H, \delta_\pi^L), (\delta_\xi^L, \delta_\pi^H), (\delta_\xi^L, \delta_\pi^L)$. This is motivated by the fact that we are interested in qualitative comparative statements rather than in the determination of 'optimal' values for δ_ξ and δ_π. To account for the fact that the parameters under consideration govern rather basic decisions of the firm with strong connection to the strategic business plan we consider imitation dynamics with a large degree of inertia.

We consider dynamics of a satisficing type where only dissatisfied companies contemplate changing their strategy. With a given frequency 'updating periods' arise during the simulation. In such an updating period all firms calculate their average profit since the last updating period and compare it with the profits earned by the other companies in the market. The n_{sel} companies with the lowest payoffs are dissatisfied and look for strategy improvements. In order to determine which strategy to adopt the firm tries to estimate the expected gain of a change for each alternative strategy. Let $\bar{\pi}_i$ denote the average profit of firm i since the last updating period and $\bar{\pi}_\delta$ the average profit of firms in the market that have chosen the strategy $\delta = (\delta_\xi, \delta_\pi)$. The probability that firm i changes to strategy δ is proportional to $\bar{\pi}_\delta - \bar{\pi}_i$ where only strategies different from the current one are considered. The dynamic adaptation model used here is of extremely simple structure. It is not supposed to be a realistic picture of firms' strategy

[6] Note that in two of these four strategies the third evaluation parameter δ_P differs from its standard value of 0.33.

adaptation processes but merely a tool to illustrate size and direction of the basic incentive effects at work in our framework.
We start with a uniform initial distribution of all strategies in the population. Figure 1 shows the results of the dynamic adaptation process.

Insert figure 1 here

More precisely, the average levels of δ_ξ and δ_π in the industry are plotted over the adaptation periods. Clearly, the industry converges towards the sub-optimal setting where (almost) all firms are *innovation oriented* and (almost) no firm is *profit oriented.* Additionally, the average industry profits, while slightly increasing in the course of strategy adaptation, are always below the profits in the benchmark case of a completely *profit oriented* industry. This is shown in Figure 2, where the dotted line corresponds to the benchmark profits in a homogeneously *profit oriented* industry.

Insert figure 2 here

To better understand these dynamic results we will now return to a setting with a fixed distribution of evaluation strategies in the population and analyze the relationship between individual incentives to choose δ_ξ^H and δ_π^L and industry profitability in different industry settings. This is done in the following section.

6 Market evaluation in heterogeneous industries

Let us first turn to the effects of different industry levels of δ_ξ and δ_π on the individual incentives to be an *innovation oriented* firm. In what follows we will measure these incentives as $\iota_\xi = \frac{\bar{\pi}(\delta_\xi^H)}{\bar{\pi}(\delta_\xi^L)}$, i.e. the ratio between the average profits of *innovation oriented* firms and those of *profit oriented* firms. The third parameter δ_P is again fixed at $\delta_P = 0.33$.
Concerning the degree of substitutability of traded products, as measured by our parameter b we will start with a setting where $b = 0.5$ and the degree of diversification and the quality of product innovations are chosen randomly from their respective domains.
Figures 3a and 3b show the average industry profits (a) as well as the firm incentives ι_ξ for innovation orientation (b) in scenarios with an increasing number of firms with $\delta_\xi = \delta_\xi^H$ (and therefore a decreasing number of firms with $\delta_\pi = \delta_\pi^H$).

Insert Figure 3 here

From Figure 3a we see that industry profits fall dramatically with the entry of an *innovation oriented* firm into a *profit oriented* industry. This effect can be understood as follows. If all firms are *profit oriented* the industry is in a state where the market evaluation fits with the prevailing quality standards for new product innovations. More precisely, the firms will market new products only if they satisfy a minimum level of profitability in the introduction phase, thus discarding low quality innovations. An *innovation oriented* firm entering the industry will lead to a decrease in the average quality level of products in the industry as it tends to have lower profit requirements for its product innovations and thus introduces and keeps new products on the market even if they are of relatively low quality. Following the change in industry quality standards, the new product innovations developed by market participants will on average be of lower quality[7]. This implies, that product innovations are less profitable in the initial phase. Looking at single simulation runs one easily realizes that because of these small initial profits the profit oriented firms withdraw many of their new products from the market within one or two periods. As noted in section 2 we interpret the initial periods of a product life-cycle in this framework as a market exploration phase and therefore view such behavior as a decision of a producer not to market a developed innovation. By not putting a large fraction of their product developments on the market *profit oriented* firms are wasting large parts of their R & D investments. In the long run, profit oriented firms introduce less and less new products such that their degree of diversification falls which lowers their profits. Hence, the entry of an innovation oriented firm into a population of profit oriented producers lowers the total number of traded products in the market significantly (see Figure 4). This contraction leads to a decrease in the overall amount of money spent by consumers in this industry, to more competition and thus to lower overall profits.

Insert figure 4 here

As the number of *innovation oriented* firms increases further, industry profits start to go up. The reason for this effect is that with a larger number of *innovation oriented* firms the number of product innovations introduced to the market increases and therefore the industry converges towards a state with a large number of markets of relatively low quality. The more homogeneous the population becomes the larger are average profits. However, as pointed out in the last section profits in an industry with such mixed quality levels are below those in a *profit oriented* industry, where quality is homogeneous and higher.

We have tested the robustness of these results for different scenarios like diversified,

[7]Note that the target quality of new products is always determined relative to the anticipated average quality level of existing products.

non-diversified industries, high-quality and low-quality industries and found the same qualitative results. Thus we will not describe these results in detail here.

Concerning individual incentives for firms to be *innovation oriented* rather than *profit oriented* we find that these incentives fall with an increasing number of *innovation oriented* firms as shown in Figure 3b. Two reasons for this should be pointed out. First, as more and more firms tend to be *innovation oriented* their new product innovations compete heavily for market shares such that profits fall. On the other hand, *profit oriented* firms profit from falling competition as they tend to become strategy outsiders or niche players among all the *innovation oriented* firms. In particular, they choose markets for investment and production which might differ from the choice of the majority of producers.

Let us now analyze whether the effects mentioned above change if the degree of substitutability between the traded products changes. In Figures 5a and 5b we consider a market where the elasticity of substitution between product variants is lower ($b = 0.25$) and realize several changes.

Insert figure 5 here

First, from Figure 5a we see that profits are generally higher than in the case where $b = 0.5$. At first glance this might seem an obvious effect due to decreased competition induced by increased market separation. However one has to consider that – at least if we neglect changes in the sum of the attractiveness parameters – the overall amount of money spent in the industry does not change and therefore additional profits can only stem from better allocation of resources and thus more efficient production with lower costs. The reason for the more efficient production seems to be that production schedules are more balanced with $b = 0.25$. With such low degree of substitutability the situation resembles that of a set of independent markets of approximately identical size. Therefore firms tend to produce similar amounts in all their active markets which is more cost efficient than unbalanced production schedules. Second, the effects of the entry of one *innovation oriented* firm into a *profit oriented* industry are far less pronounced than in the scenario discussed above. This is caused by the fact that product quality has less effects on initial profitability of new innovations. Since the degree of substitutability between products is lower the demand for a new product which opens a new highly differentiated market is higher and there is less competition from established products with on average lower production costs. Thus, in such a scenario *profit oriented* firms will market more of their product innovations even if they are of lower quality and the entry of the *innovation oriented* firm causes less disruption. This can be clearly seen if we again consider the average degree of diversification of firms, which in this scenario grows after the entry of the first *innovation oriented* firm (see Figure 6).

Insert figure 6 here

Moreover, comparing the degree of diversification in the two cases $b = 0.25$ and $b = 0.5$ one also realizes that the overall increase in diversification is much less pronounced in the case of $b = 0.25$. Third, although the qualitative features of the curve describing the average degree of diversification in the industry are very similar to the case $b = 0.5$, profits do not increase as the number of *innovation oriented* firms increases (see Figure 5a). Again, this fact is strongly tied to the observations about diversification made above. Since demand functions on active markets are relatively similar to each other even with only one innovation oriented firm, the growing degree of homogeneity coming with the increase in the number of innovation oriented firms does not improve industry profits.

The observation that with highly differentiated markets the distribution of evaluation strategies in the population is of relatively little importance for individual profits is also confirmed by looking at individual incentives to use a high δ_ξ. We see in Figure 5b that incentives are practically independent of the number of *innovation oriented* firms. Whereas not extremely surprising the observation is not trivial since evaluation strategies do not only determine the amount of competition between different sub-markets but also the number of competitors active in each sub-market.

Finally, let us briefly analyze a situation where the traded products are close substitutes, i.e. $b = 0.75$. As has to be expected the effects of different market evaluation strategies become more pronounced. First, a *profit oriented* industry can not survive in the long run. The reason for this effect is, that substitutability reduces profits of small, new markets. Thus, a *profit oriented* firm will discard almost all of its product developments and market them only if they happen to be of very high quality or the competing products are already very unattractive. This effect can be seen from Figure 7a, where the average degree of diversification is shown for a typical run. As noted above the industry is initialized with $m_0 = 6$ markets of fairly good attractiveness. Firms initially have to build up their R & D stocks but we can see that after period 15 firms have developed product innovations which they try in the market. However, due to the profit orientation of the firms none of these innovations is kept in the market sufficiently long to build up its own sub-market. This behavior turns out to be lethal when the established products loose their attractiveness due to their age and firms have no alternatives to switch to. Hence the entire industry goes down.

Insert figure 7 here

Second, an *innovation oriented* firm[8] entering such a *profit oriented* industry ensures that the industry survives by regularly introducing new product innovations. This is illustrated in Figure 7b where the development of the number of active sub-markets over 100 periods is depicted for a typical run in such a scenario[9]. The brief peaks of active markets – which results from activities of profit oriented firms which try their developed innovations in the market but never seriously introduce them – are similar to those in Figure 7a but the existence of the innovation oriented producer ensures the existence of at least a few young alternatives once old established markets loose attractiveness. By generating these alternatives, the innovation oriented firm earns significantly larger profits, compared to the *profit oriented* producers. Their passive, imitative behavior puts them at a huge cost disadvantage when entering new markets and does not allow them to earn monopoly profits under the protection of an active patent. Thus, incentives to change the market evaluation strategy to *innovation oriented* should be very strong. On the other hand, the monopoly rents to be earned are lower than in scenarios with a lower degree of substitutability between old and new products which reduces the incentives for innovations. Due to these opposite effects the overall incentives to switch to an innovation oriented market evaluation strategy lie between the values for $b = 0.25$ and $b = 0.5$ (see Figure 8b). Third, average industry profits increase as more *innovation oriented* firms populate the industry and this profit increase is much more pronounced than in the case of a lower degree of substitution between products (see Figure 8a). It should be noted that no average industry profit is reported in Figure 8a for the case of a completely profit oriented industry since the industry does not survive in such a scenario.

Insert figure 8 here

Similar to the observations made for $b = 0.5$ we can observe a strong increase in the average degree of diversification as the number of innovation oriented firms increases. This is shown in Figure 9. Consistent with our previous observations this effect gets even stronger as we increase b from $b = 0.5$ to $b = 0.75$.

Insert figure 9 here

[8] To make this point we had to use the numerical value $\delta_\xi = \tilde{\delta}_\xi^H = 0.5$ for innovation oriented firms in our simulations.

[9] Other than the change in strategy distribution the parameter set used for the runs in Figure 7a and Figure 7b is identical.

7 Conclusions

The agenda of this paper was to examine the effects of the interplay of different market evaluation strategies in a dynamic innovation-oriented heterogeneous industry. In particular we have addressed the question whether following individual incentives leads to results where industry profits are maximized. Using an agent-based simulation model we have derived the following main conclusions:

- Adaptation dynamics in heterogeneous industries lead towards a population of growth oriented, or, put differently, innovation oriented firms.

- If the degree of horizontal differentiation of product innovations from existing products is small, industry profits increase as the population becomes more innovation oriented. If the degree of differentiation becomes too small industries entirely oriented towards current profits cease to generate successful product innovations and decline.

- If the degree of substitutability between existing and innovative products is small (strong horizontal differentiation) industry profits are highest in an industry where all producers are profit oriented. Such a state however is unstable and vulnerable to the entry of single innovation oriented companies. Adaptation of strategies leads to a trend away from the state where average industry profits are maximized.

- The incentives to change to a growth oriented evaluation strategy decrease as the number of competitors using such a strategy goes up. A change in the degree of substitutability has ambiguous effects on the individual incentives to change to a growth oriented industry.

We have focused on a few main findings here and have not discussed among other things the impact of changes in market structure parameters other than b, like number of competitors, size of total demand or length of patent protection. Numerical examinations of these issues have been carried out by the authors but have lead to rather predictable results which we decided not to include here.

The findings of the paper which point to a kind of dilemma at least for industries with strongly differentiated sub-markets must of course be seen with some caution. In the model used here the number of firms in the industry as well as the degree of horizontal differentiation are exogenous. Clearly both aspects should be endogenized, in particular the degree of horizontal differentiation of an innovation should be considered a strategy parameter of the innovator. The approach taken here is in this sense a compromise between keeping the model manageable and adding more realistic features.

Also, the focus here was on the industry profits rather than on welfare. Apart from the the standard problems of determining the weights of the different parts of society in a social welfare function the focus of the model on one particular industry makes a sensible determination of consumer surplus in our setting difficult. An (implicit) assumption in our framework is that the industry competes with other industries for budget allocation of consumers where higher overall attractiveness of the different sub-markets attracts more consumer expenditures. This reallocation of consumer funds must lead to decreased consumption in other industries but this effect is not picked up in the model. Therefore, considering consumer surplus generated on the considered markets would give a picture biased towards scenarios with numerous high quality markets. Keeping these problems in mind we still believe that the results demonstrate how dynamic industry wide effects of individual strategy choices can be examined in a systematic way using agent-based simulations. The results here about the effects of market evaluation strategies can be seen as complements to the analysis carried out in Dawid and Reimann (2003) where the interplay between product diversification and innovation strategies was analyzed for a given evaluation strategy. Putting the two together and examining the individually and socially optimal fit between evaluation strategies, diversification and product innovation choices is a topic for future research. The framework developed in these two papers is not only suited to address these problems but also a wide variety of different questions ranging from the design of industrial policy to the evaluation of firms' business strategies.

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Appendix A

In Table 2 we list our fixed parameters that describe the basic model structure together with their values.

Parameter	Value	Parameter	Value	Parameter	Value
T	150	m_0	6	n	8
ρ	0	x_{min}	0.01	L	28
msize	60	S_0	10	b	0.5
σ_a^2	0.1	χ	0.5	A	1
P_{ini}	0.25				

Table 2: Fixed model parameters

In Table 3 we list the variable parameters used for our model, together with their respective ranges given by upper and lower bounds for their values. For each of the 100 profiles we generated, these parameters were independently, uniformly random drawn between these bounds. Note, that we have omitted firm indices in Table 3 as our firms are identical with respect to the listed parameters.

Parameter	Lower Bound	Upper Bound
τ	3	10
α^c	1.5	2
β^c	0.75	0.95
α^{RD}	3	4
β^{RD}	0.75	0.95
c^{min}	0.2	0.4
Φ	0.25	0.35
μ	0.75	1
c_{ini}	0.4	0.6
κ_{ex}	0.5	1.5
$\tilde{\kappa}_{ex}$	0	0.5
κ_{en}	0	0.5
$\tilde{\kappa}_{en}$	0	0.5
κ_{innov}	1.5	3
δ^{ξ}	0.3	0.4
δ^P	0.3	0.4
q^{proc}	0.25	0.35
q^{prod}	0.4-q^{proc}	

Table 3: Model parameters and their respective ranges

Figure Captions

Figure 1: Evolution of the average population values of the parameters δ_ξ and δ_π under the adaptation dynamics and an initial uniform distribution of strategies.

Figure 2: Evolution of the average industry profits under the adaptation dynamics and an initial uniform distribution of strategies. The average industry profit in an industry where all firms have $\delta_\pi = \delta_\pi^H, \delta_\xi = \delta_\xi^L$ is indicated by the dotted line.

Figure 3: Average industry profits (a) and incentives to choose $\delta_\xi = \delta_\xi^H$ (b) depending on the number of firms in the industry using $\delta_\xi = \delta_\xi^H = 0.4$ All firms have $\delta_P = 1/3$ ($b = 0.5$).

Figure 4: Average number of markets served by a producer each period depending on the number of firms in the industry using $\delta_\xi = \delta_\xi^H = 0.4$ All firms have $\delta_P = 1/3$ ($b = 0.5$).

Figure 5: Average industry profits (a) and incentives to choose $\delta_\xi = \delta_\xi^H$ (b) depending on the number of firms in the industry using $\delta_\xi = \delta_\xi^H = 0.4$ for the case of weak substitutability between product variants ($b = 0.25$).

Figure 6: Average number of markets served by a producer each period depending on the number of firms in the industry using $\delta_\xi = \delta_\xi^H = 0.4$ for the case of weak substitutability between product variants ($b = 0.25$).

Figure 7: Development of the number of existing product variants for a typical run in a scenario with strong substitutability between product variants ($b = 0.75$): (a) a completely profit oriented industry, (b) an industry where one firm uses $\delta_\xi = \delta_\xi^L$ and all other firms are profit oriented.

Figure 8: Average industry profits (a) and incentives to choose $\delta_\xi = \delta_\xi^H$ (b) depending on the number of firms in the industry using $\delta_\xi = \tilde{\delta}_\xi^H = 0.5$ for the case of strong substitutability between product variants ($b = 0.75$).

Figure 9: Average number of markets served by a producer each period depending on the number of firms in the industry using $\delta_\xi = \tilde{\delta}_\xi^H = 0.5$ for the case of strong substitutability between product variants ($b = 0.75$).

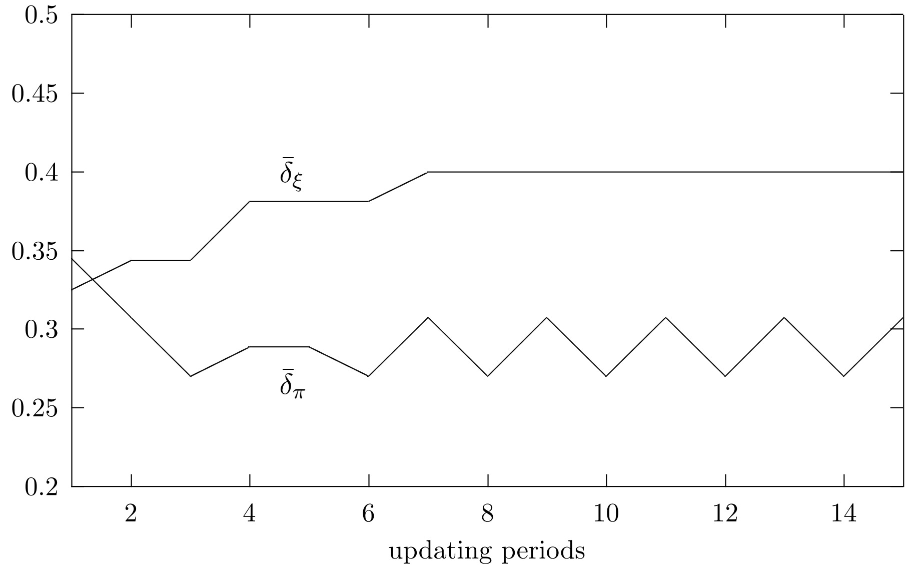

0.5
0.45
0.4
0.35
0.3
0.25
0.2
2
4
6
8
10
12
14
updating periods
$\bar{\delta}_\xi$
$\bar{\delta}_\pi$

Figure 1

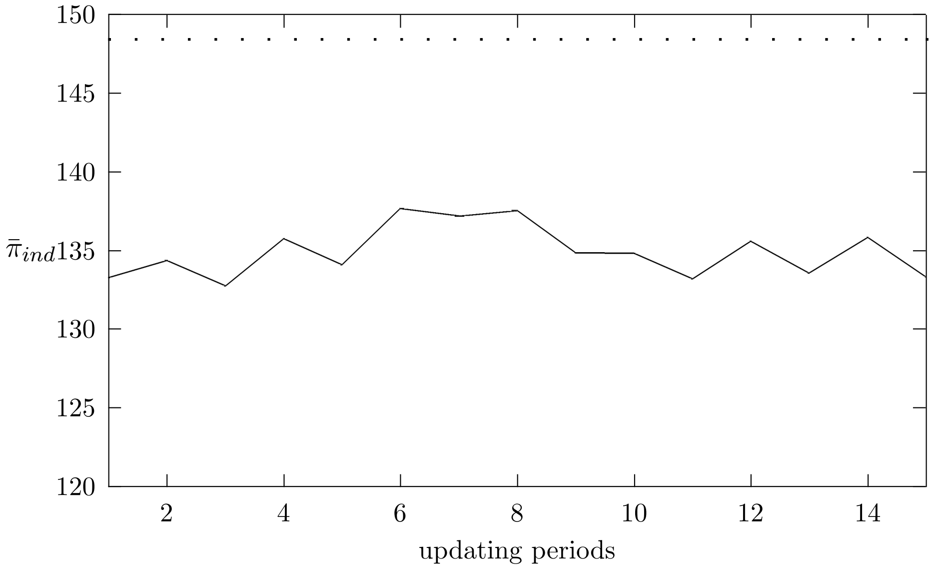
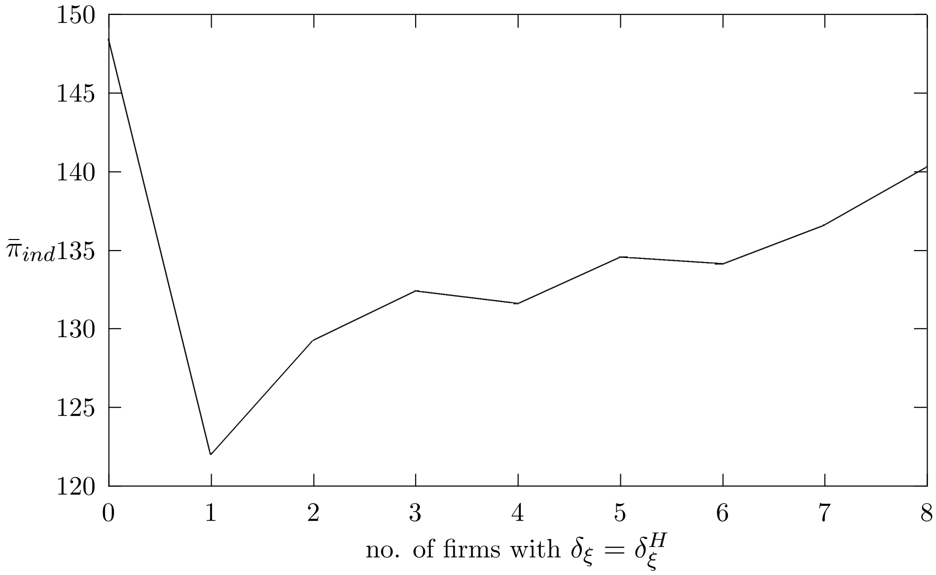
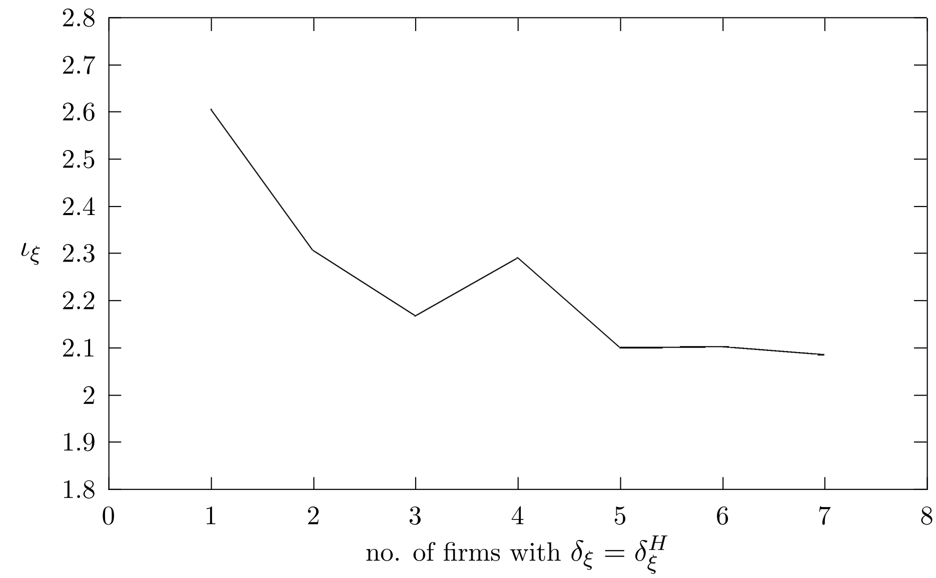

150
145
140
$\bar{\pi}_{ind}$
135
130
125
120
2
4
6
8
10
12
14
updating periods

Figure 2



150
145
140
135
130
125
120
$\bar{\pi}_{ind}$
0 1 2 3 4 5 6 7 8
no. of firms with $\delta_\xi = \delta_\xi^H$

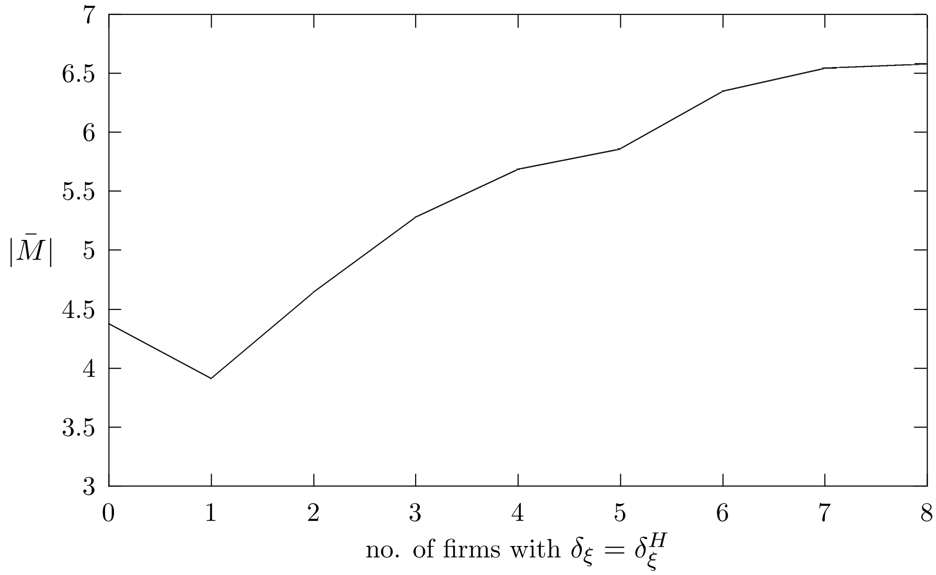
(a)



2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
ι_ξ
0 1 2 3 4 5 6 7 8
no. of firms with $\delta_\xi = \delta_\xi^H$

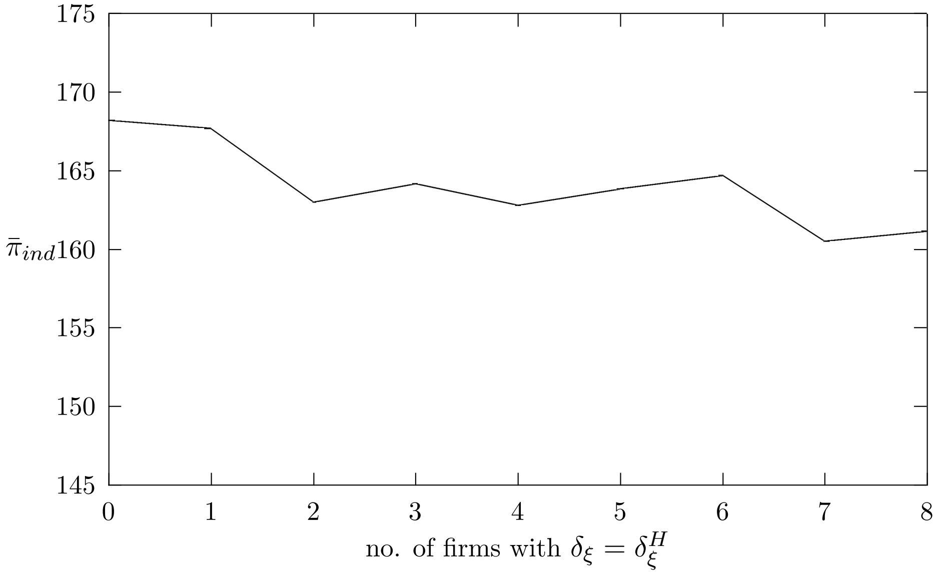
(b)

Figure 3

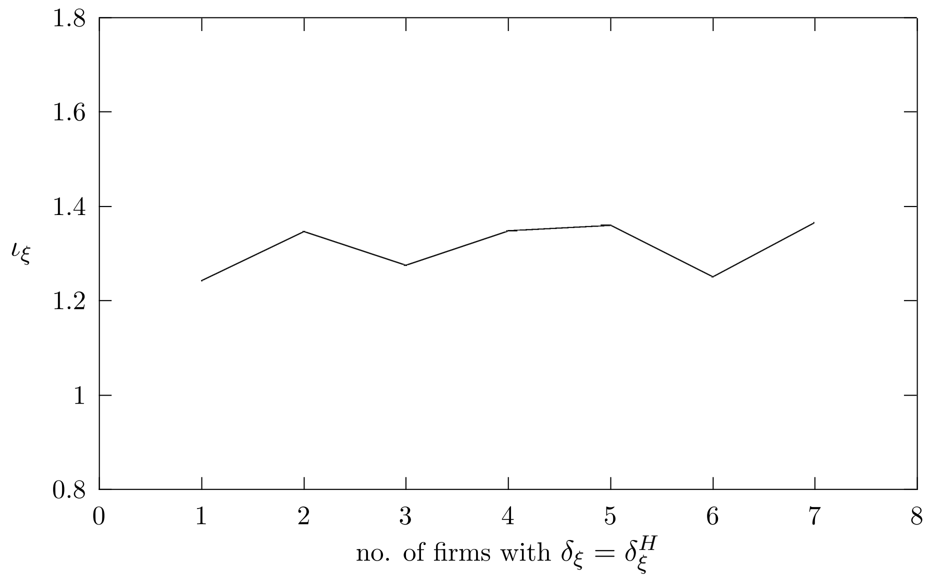


7
6.5
6
5.5
$|\bar{M}|$
5
4.5
4
3.5
3
0
1
2
3
4
5
6
7
8
no. of firms with $\delta_\xi = \delta_\xi^H$

Figure 4


175
170
165
$\bar{\pi}_{ind}$160
155
150
145
0 1 2 3 4 5 6 7 8
no. of firms with $\delta_\xi = \delta_\xi^H$

(a)


1.8
1.6
1.4
ι_ξ
1.2
1
0.8
0 1 2 3 4 5 6 7 8
no. of firms with $\delta_\xi = \delta_\xi^H$

(b)

Figure 5

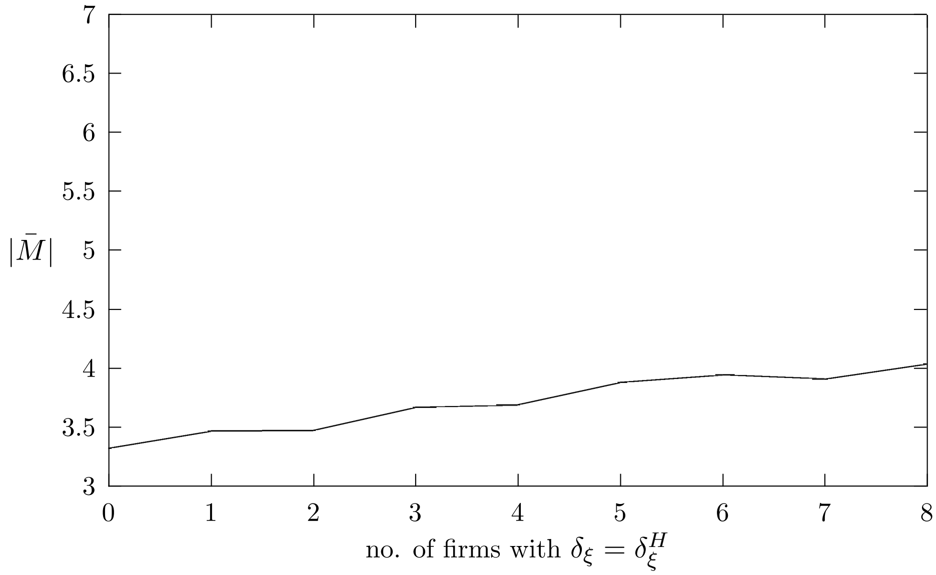
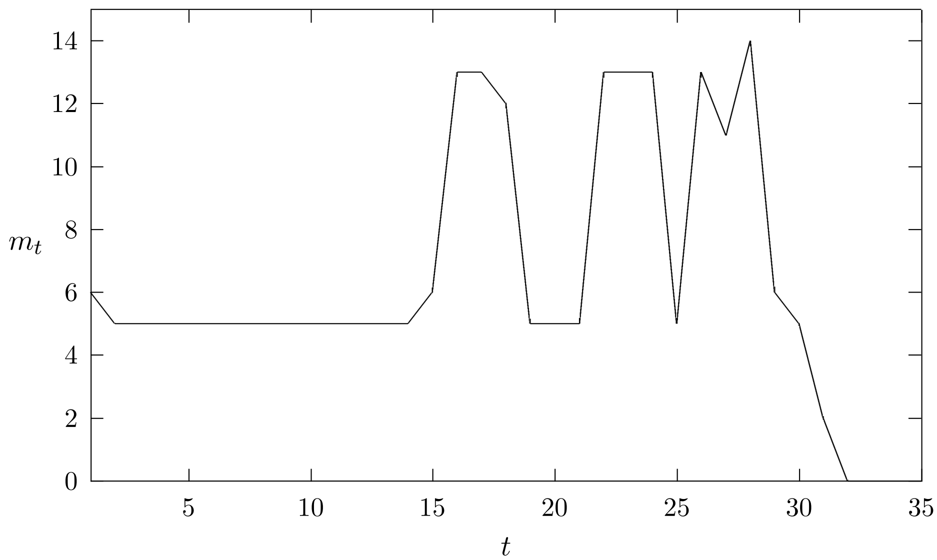
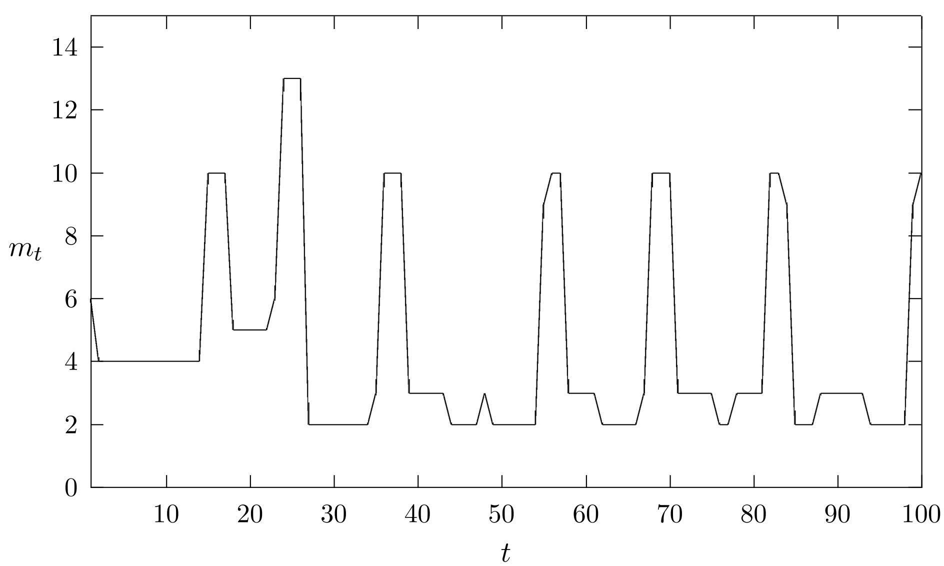

7
6.5
6
5.5
$|\bar{M}|$
5
4.5
4
3.5
3
0
1
2
3
4
5
6
7
8
no. of firms with $\delta_\xi = \delta_\xi^H$

Figure 6



14
12
10
8
6
4
2
0
m_t
5
10
15
20
25
30
35
t

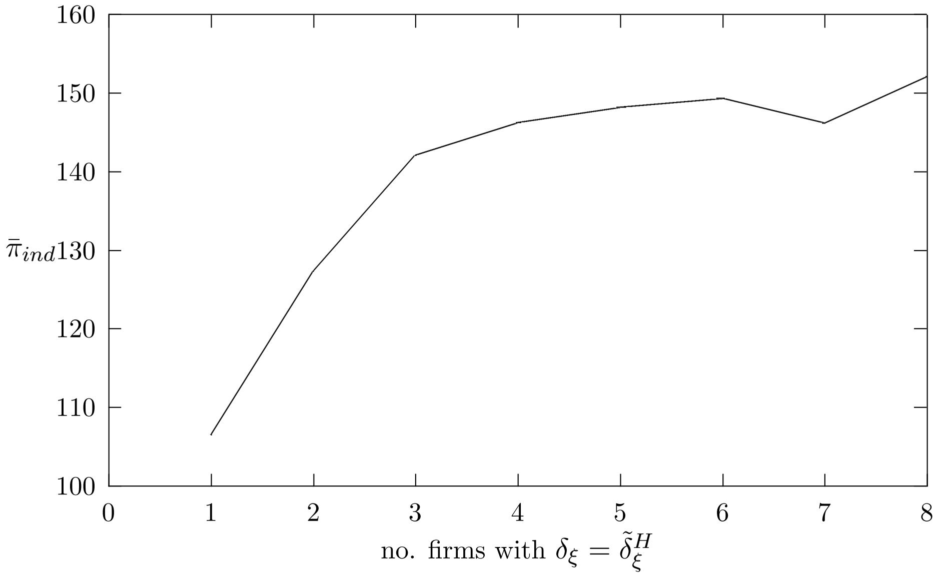
(a)



14
12
10
8
6
4
2
0
m_t
10
20
30
40
50
60
70
80
90
100
t

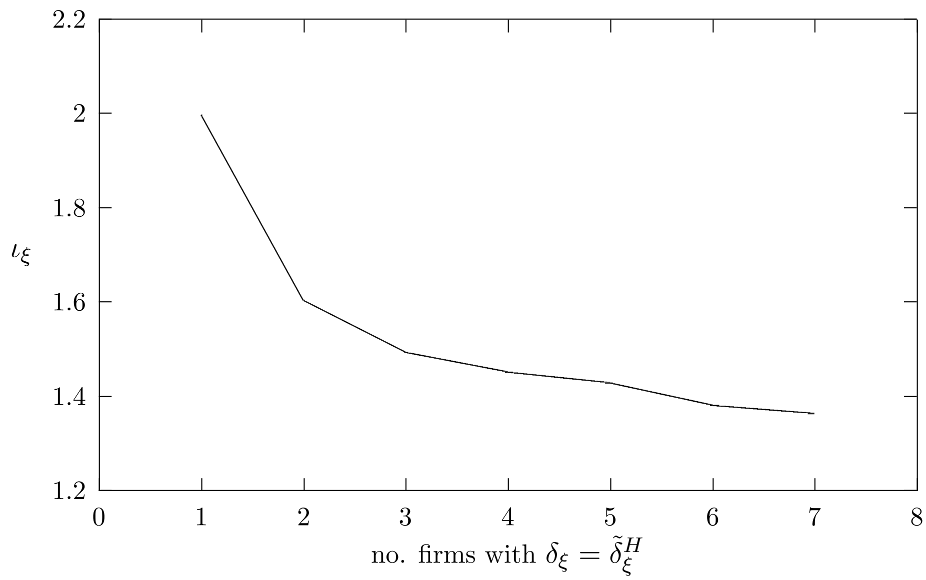
(b)

Figure 7



160
150
140
$\bar{\pi}_{ind}$
130
120
110
100
0
1
2
3
4
5
6
7
8
no. firms with $\delta_\xi = \tilde{\delta}_\xi^H$

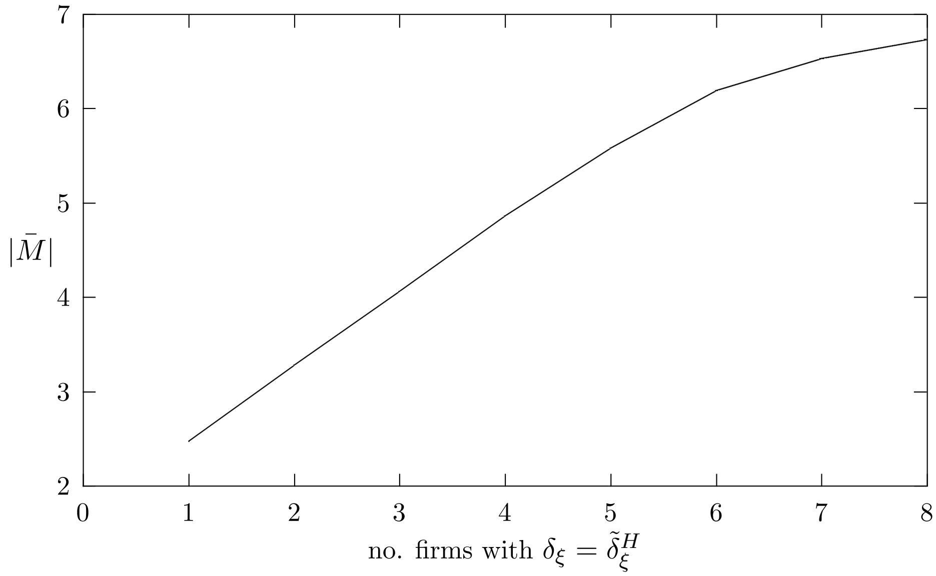
(a)



2.2
2
1.8
ι_ξ
1.6
1.4
1.2
0
1
2
3
4
5
6
7
8
no. firms with $\delta_\xi = \tilde{\delta}_\xi^H$

(b)

Figure 8



7
6
5
$|\bar{M}|$
4
3
2
0 1 2 3 4 5 6 7 8
no. firms with $\delta_\xi = \tilde{\delta}_\xi^H$

Figure 9