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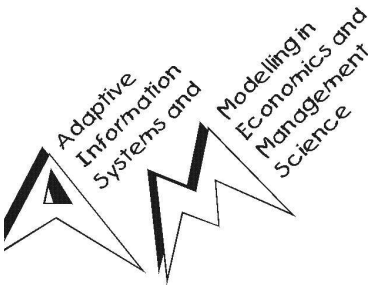

Product Diversification in an Artificial Strategy Environment

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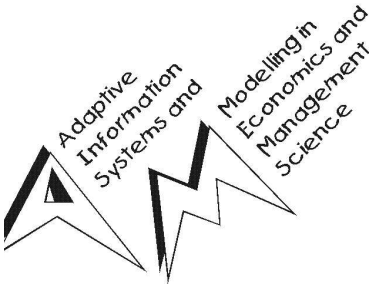

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Abstract

The paper studies the impact of a diversification vs. a core-competence oriented strategy using an agent-based simulation model. The aim of the paper is twofold: first, we analyze whether agent-based models are a viable tool for analyzing questions related to corporate strategy. We show that standard results from the strategy literature can indeed be reproduced and refined by using this type of models. Second, the agent-based model allows us to formulate more precise hypotheses and more precisely delineate the scope of situations in which standard results from the strategy literature apply. For the problem of diversification analyzed in this paper, the results from the agent-based simulation lead to the conclusion that in addition to environmental dynamics, overall market size is also an important factor, which was not considered in the previous literature.

1 Introduction

Strategic decisions are, almost by definition, among the most important decisions to be made in a firm. However, the field of strategy is characterized by a variety of approaches, which differ not only in their recommendations but also in their conceptualization of strategy (Hax & Majluf, 1988) and the strategy variables analyzed. Furthermore, many approaches to strategy rely on a broad, qualitative analysis and do not employ analytical methods.

One possible reason for this lack of analytical approaches to strategy research is the complexity of the subject, which defies most analytical solution methods currently available. However, while it is not possible to derive analytical results and closed form solutions to strategic questions, it is still possible to use quantitative methods for research on strategy.

Several quantitative methods are available to model the behavior of complex, dynamic systems. System dynamics models have been used for decades to represent the behavior of such systems at an aggregate level and derive mostly qualitative insights into the relationships governing them. They are therefore an useful tool for answering strategic questions (Fowler, 2003). More recently, agent-based simulation models have been successfully applied in areas such as economics (Holland & Miller, 1991; Judd, 1997; Tesfatsion, 2000) or organization theory (Carley, 1995), which obviously share many common traits with problems in corporate strategy.

In the present paper, we use an agent-based simulation model to study one central question of strategy research, the impact of diversification on corporate performance under different conditions of the competitive environment. The research goals of this paper are therefore twofold:

- From a *methodological* point of view, the aim of this paper is to study the applicability of agent-based modeling approaches to strategy research. We want to study if agent-based models can replicate common results of strategy research, which were obtained using other methods, and possibly improve upon them.
- This potential improvement of existing results can lead to *substantive* results. Specifically, we expect that agent-based models, which require a precise and formal specification of the concepts involved, will allow us to more precisely delineate the conditions under which results are actually applicable.

The remaining part of this paper is structured as follows: in section two, we introduce the concept of diversification and review empirical evidence which leads us to the research hypotheses studied in this paper. Section three introduces the Artificial Strategy Environment used for the simulation experiments reported here. Section four gives an overview of the experimental setup and presents the results obtained. Section fives concludes the paper by summarizing the main results.

2 Diversification Strategies

Strategies can be formulated at several levels including the corporate, business, and functional levels (Wheelwright, 1984; Varadarajan & Clark, 1994). Corporate strategy deals with the management of a portfolio of individual business units, its composition and the allocation of resources to business units.

Business strategy describes how a single business unit tries to achieve competitive advantage versus its competitors, and functional strategies refer to single functional areas within one business unit.

Our main research question is located at the corporate level. While there has been some discussion about the importance of strategy at this level, there is convincing evidence that economic results cannot be explained by taking into account just data at the business unit level, and that strategy at the corporate level is indeed an important factor (Bowman & Helfat, 2001).

The composition of the portfolio of business units is one of the most important strategic questions at the corporate level. There has been a long debate in the strategy literature on the benefits of diversification into a broad range of different businesses vs. following a more focussed, core-competence oriented (Gorman & Thomas, 1997) strategy. While some authors (Keats & Hitt, 1988; Wiggins & Ruefli, 2002) found only weak empirical evidence for benefits of diversification, others argued that diversification is indeed beneficial provided that a firm diversifies into products that react differently to business cycles (Amit & Livnat, 1989), or products that use similar resources (Markides & Williamson, 1996) and when possible synergies are adequately managed (Hill, 1995). Others argued that rather than following a pure diversification or pure core competence strategy, firms should aim for a modest amount of diversification to find an optimum balance between reducing competition by differentiating and maintaining legitimacy by similarity to other firms (Deephouse, 1999).

The dichotomy between diversification and focused strategies was extended by (Miles, Snow, Meyer, & Coleman, 1978), who added the frequency of new product introductions as an additional parameter and thus distinguished four basic strategies:

- The *prospector* strategy has a strong focus on diversification and innovation. Firms following this strategy are characterized by high rates of innovation and introduce highly diversified products.
- The *analyzer* strategy is also characterized by high innovation rates, but unlike in the prospector strategy, new products are more similar and build on common core competencies.
- The *defender* strategy combines a core competence focus with low innovation rates. Firms using this strategy focus on continuous development and refinement of existing core products.
- The fourth strategy combines low innovation rates with a high degree of diversification between products. It was labelled *reactor* by Miles and Snow, who attributed the wide diversification to a lack of clear focus rather than a conscious strategic choice.

Miles and Snow further argued that these strategies would fit to different environments. A prospector strategy should be most appropriate in a dynamic, growing environment, while a defender strategy would be more suitable in a stable environment and the analyzer strategy takes a middle position.

This typology and the proposed match between strategy types and environmental conditions forms the starting point for our research. By considering the strategy type and its fit to the environment which a firm faces as the main factors influencing a firm's performance, we make two important assumptions:

Firstly, following the typology of Miles and Snow, we consider "diversification" as a one-dimensional concept which can be measured using the dispersion of a firm‘s products in feature space. In the empirical literature, a distinction is often made between the degree (extent) and the type of diversification (related vs. unrelated). The distinction between related and unrelated diversification is based on the similarity of resources needed to manufacture the different products. However, there is strong empirical evidence that these concepts are highly related to each other (Palich, Cardinal, & Chet, 2000; Hoskisson, Hitt, Johnson, & Moesel, 1993; Keats & Hitt, 1988) and thus we consider the degree of diversification as measured by product similarity as an adequate indicator of diversification.

Secondly, by focusing on diversification and thus on current strategy, we deliberately ignore historical facts, which might also influence a firm's performance. One central argument of the resource based view of strategy (Wernerfelt, 1984; Amit & Livnat, 1989) is that the initial endowment of a firm with resources and the way these resources are managed and developed over time have a considerable impact on a firm's performance. In order to isolate the impact of current diversification strategy from other factors, we consider only firms with identical initial resource endowments in our experiments.

There is already considerable empirical evidence on the relationship between strategy, environment and performance, on which we can base our hypotheses.

On the one hand there are some studies which directly address the relationship between diversification and performance (Chatterjee, 1991; Bettis, 1981; Pandya & Rao, 1998; Varadarajan, 1986; Amit & Livnat, 1989; Dubofsky & Varadarajan, 1987; Hall, 1995; Grant, Jammine, & Thomas, 1988). On the other hand, there is empirical research on configurational theories that often refers to the typology of Miles and Snow (Miles et al., 1978) and therefore focusses on the match between firm strategy and its external environment (Lengnick-Hall & Wolff, 1999; Doty & Glick, 1993; Burnes, 1997; Hambrick, 1983; Slater & Narver, 1993; Segev, 1989; Shortell & Zajac, 1990).

Studies in the former area are often said to produce inconclusive results (Palich et al., 2000; Hill, 1995) due to inconsistent data, different time frames, performance measures and moderator variables. Figure 1, which is based on (Palich et al., 2000), summarizes the main hypotheses tested in empirical studies on the relationship between diversification and performance:

- In the *linear* model, an increase in diversification is assumed to (unconditionally) increase performance.
- In the *u-shaped* model, it is assumed that there exists an optimal level of diversification. As long as this level is not reached, increasing diversification will also improve performance, but once the optimum level is reached, further diversification will reduce performance. This optimum level of diversification is often associated with the maximum of related diversification, and further diversification into unrelated areas is seen as counterproductive.
- In the *bounded* model, diversification ceases to have a positive impact on performance after a certain extent, but does not have a negative impact.

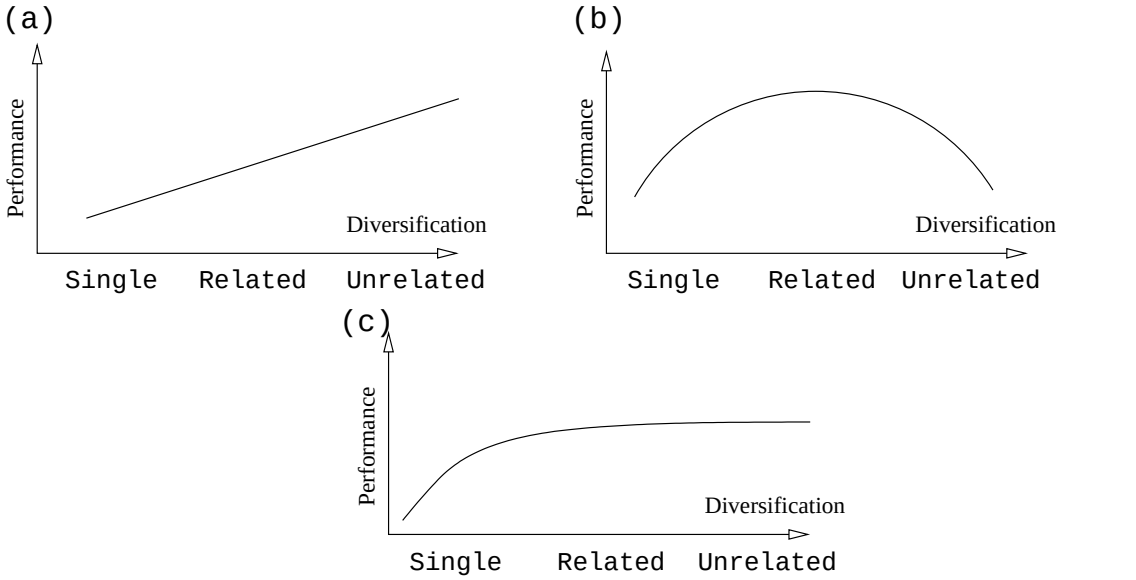

Figure 1: Diversification Models

Similar problems exist with empirical research based on configurational theories. Doty and Glick (1993) criticize the lack of systematic empirical research on Mintzbergs (1979) theory of five ideal types of organization which is the most prominent instance in the field of configurational theories. In contrast the typology of Miles and Snow seems to be moderately supported by empirical research (Doty & Glick, 1993); for a review see (Zahra & Pearce, 1990). Additionally (Segev, 1989) suggests a wide congruence of Miles and Snow‘s strategy types with Porters Cost Leadership and Differentiation strategy.

Therefore, we base our analysis mainly on the typology of Miles and Snow. However, to more precisely operationalize the strategy parameters which underlie this typology, we use a somewhat different typology. Since Miles and Snow do not assign the reactor strategy to any type of environment and because empirical

findings show that this strategy is of little relevance in practice (Slater & Olson, 2001), we only consider three distinct types of strategies:

- diversifier,
- variator and
- core competence firm.

Diversifying firms, which are similar to the prospector strategy of Miles and Snow, have a very high probability for developing new products and they try to launch very different products to ensure the coverage of the complete feature space as far as possible. Variators correspond to the analyzer strategy of Miles and Snow. They have the same rate of innovation, but their products are less dispersed in feature space. Core competence focused firms are exactly the opposite of diversifiers. They focus only on a small sector of the feature space and hardly ever launch a new product.

Core competence firms are the only strategy considered with a low innovation rate. The fourth possible combination, a low innovation rate combined with a high degree of diversification, can hardly be considered as a relevant strategy and therefore is not analyzed.

Comparing the core competence strategy to the high innovation strategies, its likely advantages are lower costs for production and product development. On the other hand, a core competence focus causes firms to compete in few closely related markets and therefore they have a higher operating risk (Amit & Livnat, 1989) as markets may break away instantly due to disruption or a change in consumer preferences (D'Aveni, 1999). Thus, like in the typology of Miles and Snow, core competence firms should perform better in a stable environment, while the other two types should fit better into a more dynamic environment.

To test the "fit" between strategies and environments, a performance measure is needed. Since the beginning of research on the strategy-performance-relationship, there is an intense discussion on the suitability of performance measures for varying research questions. Most researchers use measures based on accounting data such as ROI, ROE, ROC, or ROS (Varadarajan, 1986; Amit & Livnat, 1989; Chatterjee, 1991; Simmonds, 1990; Bettis, 1981; Markides & Williamson, 1996; Pandya & Rao, 1998). The most commonly used measure is the ROA (Hawawini & Verdin, 2003; Pandya & Rao, 1998). Due to differing cost calculations for inventory or depreciation, the use of accounting data does not seem to be a reliable basis for measuring strategy impacts. Therefore often market returns, operating profit or discounted cash flows are used (Pandya & Rao, 1998; Hawawini & Verdin, 2003).

As these problems in performance measuring are often caused by limited access to firm data, they are not relevant for our simulation experiments. Since the asset base of our firms is identical, it is also not necessary to correct for different amounts of capital employed. Therefore we have chosen the average operating cash flow of firms as performance measure.

As we have already explained, the types considered in our study are similar to those developed by Miles and Snow. Given the empirical support for their typology, we therefore formulate :

Hypothesis 1: Firms following the diversifier strategy will have a higher aggregated cash flow than firms that follow a variator or a core competence strategy. Firms that follow a variator strategy will have a higher aggregated cash flow than firms following a core competence strategy.

However, Miles and Snow and similar configurational theories also suggest an impact of the environment on outcome, which makes a diversification strategy less attractive under some circumstances. We therefore also analyze the following alternative to hypothesis 1:

Hypothesis 2: In a more dynamic environment, firms following a diversification strategy will have a higher aggregated cash flow than firms following a core competence strategy. In a more static environment, firms following a core competence strategy will have a higher aggregate cash flow than firms following a diversification strategy. Firms that follow a variator strategy will perform in between the two other types for both types of environment.

The main advantage of a core competence strategy in a stable environment is the possibility to obtain lower costs, which can be passed on to the consumers by following a cost leadership approach. We therefore expect:

Hypothesis 3: Firms following a core competence strategy will have lower unit costs and charge lower prices than firms following a variator or core competence strategy. Firms following a variator strategy will have lower costs and charge lower prices than firms following a diversification strategy.

It should be noted that hypothesis 3 is formulated without referring to different types of environment. However, lower costs will be of advantage only in stable environments, while in more rapidly changing environments, the greater flexibility of diversifiers should pay off. Their broader product portfolio should enable them to stabilize profits even in turbulent environments. Therefore, we formulate:

Hypothesis 4: In a more dynamic environment, firms following a diversifier strategy will have a lower variation of their cash flows over time than firms following a core competence strategy, firms following a variator strategy will take a middle position.

3 The Artificial Strategy Environment

In this section, we provide only a short overview to the simulation environment which was developed to test these hypotheses. For a more extensive description, the reader is referred to (Bauer, Schwingenschlögl, & Vetschera, 2002).

Since we are interested in the effects of diversification, the range and diversity of a firm's product portfolio is of particular interest. Following earlier research (Natter, Mild, Feurstein, Dorffner, & Taudes, 2001; Krishnan & Ulrich, 2001), we characterize products by n-dimensional feature vectors. The similarity of products can thus be measured by their distance in feature space. This distance can be considered as a measure of product diversification similar to the spread in industry classification codes that is often used in the empirical literature (Amit & Livnat, 1989). While other approaches to measure diversification like discrete classifications (Keats & Hitt, 1988), concentric indices (Davis & Thomas, 1993) or entropy (Kim, 1989; Hoskisson et al., 1993) are also used in the empirical literature, this measure is directly linked to the representation of product characteristics used in our simulation and thus most consistent with our approach.

Different forms of diversification are often discussed in the literature with respect to the costs which they induce. A core-competence based strategy with a narrow product focus can be seen as advantageous because it enables learning and thus a better cost position can be obtained than with a broad diversification (Kekre & Srinivasan, 1990). Similarly, the advantages of diversification into related products (vs. unrelated diversification) are often seen in a better cost position due to easier coordination of related activities and the exploitation of synergy effects between related products.

Therefore the cost function used in the model must take into account the similarity of products and its effects on costs as well as the possibility to improve the cost situation over time by learning and specific investments.

We denote a firm's product portfolio at time t by S_t. Each product $k \in S_t$ is characterized by its feature vector $f_k = (f_{k,1}, f_{k,2}, \ldots, f_{k,N})$, where N is a constant throughout the simulation. The number of units of product k produced in period t is $x_{k,t}$.

To model advantages of specialization, we introduce the firm's current "focus of knowledge" E_t. E_t is a point in the feature space, which is a weighted sum of the features of both the current production program and the firm's past knowledge. Unit costs of the different products increase with the distance of the product in feature space from the firm's current focus of knowledge.

The cost function of a firm is modeled similarly to (Karnani, 1984) and is defined as :

$$K_t = \beta_t \left(\sum_{k \in S_t} x_{k,t} \cdot c_{k,t} \right)^{\alpha} \tag{1}$$

where β_t is a parameter denoting the overall efficiency of the firm in period t. $x_{k,t}$ is the amount of product k manufactured in period t. $c_{k,t}$ are the unit costs (which depend on the product's distance to the focus of knowledge) and α is a parameter indicating increasing or decreasing costs of scale. The parameter β_t will change over time due to learning effects, but can also be influenced by the firm by making productivity-enhancing investments.

It should be noted that for $\alpha \neq 1$, cost function (1) makes it impossible to allocate costs correctly to products. Thus any production decision which the agent makes will necessarily be based on approximate unit costs and estimates about the consequences of production decisions will only be approximations of the true changes.

In addition to these variable costs, we also consider fixed costs at two levels: fixed costs of individual products Kp_k are incurred whenever product k is manufactured at all, and corporate fixed costs Kc are always incurred. The value of Kp_k is determined as a random number when product k is introduced and remains constant over time. Kc is generated at the beginning of the simulation and is also constant.

Apart from the cost structure of a firm, its competitive position is affected by external factors related to the market(s) in which the firm operates. Research on corporate strategy has always been aware of the fact that markets are not static, but evolve over time (Amit & Schoemaker, 1993). Consequently, the concept of product life-cycles has always played a prominent role in the strategy literature (Onkvisit & Shaw, 1989; Porter, 1998). More recent research has stressed that the development of markets does not necessarily follow such a clear-cut pattern, but rather might be characterized by unexpected disruptions like the emergence of new technologies, which make existing product obsolete and thus cut short their life cycle (D'Aveni, 1999).

Firms do not offer their products on specific markets, but rather manufacture products with specific features and offer them to all consumers. Consumers from various markets may demand a firm's products, but the firm only observes cumulated demand for its products. During the simulation, new markets are created, while existing markets may decline and eventually vanish.

A market follows a product lifecycle, which is generated by a standard diffusion model (Bass, 1969) during its growth phase. At some point in time, the market reaches its maximum size, which has been randomly determined when creating the market, and then starts to decline.

Apart from its current and maximum size, each market is also characterized by an *ideal point* in feature space. Customers prefer products close to their ideal point over more distant products and are willing to pay higher prices for them. This ideal point may change over time. Both the probability and maximum distance of a movement are exogenously given parameters of the simulation. By changing these parameters, we can expose firms to different environmental scenarios and observe the impact of their strategies under various conditions.

In order to provide a realistic environment, in which firms can offer products with different features at different prices, the market model simulates imperfect markets. Consumers are assumed to perform only a limited search among the products being offered. Thus even a firms which offers inferior products at comparatively high prices will be able to attract some customers, although it will face smaller demand than firms offering their customers a better value. For each market there is also a limiting price above which customers will not buy any product.

Whenever a new market is created, it can be of two types:

- An *independent market*, which consist of entirely new customers and does not directly effect the size or structure of existing markets.
- A *disruptive market*, which reduces the customer base of existing markets.

Of course, over time in the simulation, an independent market might also have some effect on sales on other markets, for example, when competitors start to focus on the new market and thus competition in the other markets decreases.

A disruptive market will divert a fraction of an existing market's potential size towards itself. Whenever a new market is created, it is randomly designated to be either an independent or a disruptive market according to a prespecified probability. By increasing the probability of disruptive markets, the experimenter can create a more turbulent environment for the firms.

Both costs and revenues of a firm are influenced by the firm's short run decisions on the amount to be manufactured of each product and the price to be asked for each product. Products can not be stored between periods, so no inventory decisions need to be made.

In its planning process, the agent takes the following information into account:

- the plan of the previous period,
- a demand forecast for the next period,
- cost information,
- the total production capacity.

Frequency of new product introduction	Range of new products	
	Wide	Narrow
Often	Diversifier	Variator
Rarely	Core Competence	

Table 1: Strategy types

The plans of the previous period are stored in the agent's memory. The actual amount sold, on which the forecast is based, is determined by the market model. We do not assume that the agent has perfect information about the cost function (1), but uses a standard cost accounting system which allocates the observable total costs to the products. The production capacity at the beginning of the simulation is exogenously given. During the simulation, the agent can increase this capacity by investments.

The production and sales plans of an agent are developed in two stages. At the first stage, the agent considers each product individually and determines a target volume and a target price for each product. Both target volume and target price are dynamically adjusted using data of the previous period, forecasts for the demand of the current period and simple heuristics. At the second stage, all products are considered simultaneously to take into account capacity restrictions. Production capacity is allocated to products based on their relative contribution margins and the target volume of each product.

From a firm's sales revenues and costs, the firm's cash flow can be determined. Free cash flows are used by the firm to implement its strategy. Specifically, they can be used to

- introduce new products,
- extend production capacity, or
- improve the efficiency of production.

The frequency of new product introductions is determined by the strategy of an agent. As we have already mentioned, we consider three types of strategies in our experiments: diversifier, variators and core competence firms. Each firm is exogenously assigned to one strategy type and retains this type throughout the simulation.

The three types can be described according to their rate of introducing new products and the locations in feature space at which they place their new products as indicated in table 1.

The different spread of products across the feature space, which results from applying these strategies throughout a simulation run, is clearly illustrated in figure 2.

Figure 3 shows the movement of the knowledge focus in feature space for the different firm types. The plot indicates that diversifiers can react much better to changing customer requirements than core competence firms.

For the positioning of products in feature space at the beginning of the simulation, we assume that firms have a vague idea about consumer preferences. Core competence focused firms and variators launch their products between the two markets that have the smallest distance in feature space so that they have a chance to compete in at least two markets with their narrow product portfolio. Diversifiers on the opposite determine the most extreme consumer preferences that exist in the markets and try to cover all preferences between these coordinates.

After creating their initial product portfolios, firms adapt them to the market situation according to their strategies. Variators take the past product performance into account each time they develop a new product. They determine the new product features by moving into the direction of the two most successful products currently in their portfolio. This way they can move around in feature space and adopt their products according to consumer preferences without increasing the dispersion of their portfolio.

Core competence focused firms use the same algorithm for launching a new product, but as their innovation rate is per definition much lower, they can hardly react to changing external influences. In contrast, diversifiers try deliberately to increase dispersion and calculate the direction that allows them to move as far as possible away from their knowledge focus. The ideal outcome of this behaviour would be heterogenous products spread all about the feature space with a knowledge focus in the middle of the feature space.

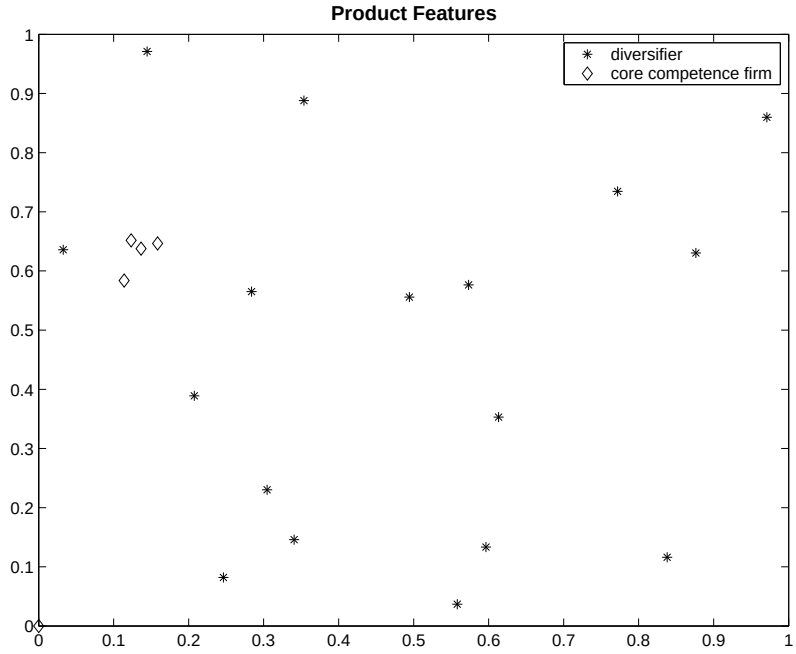

Figure 2: Product features of different firm types

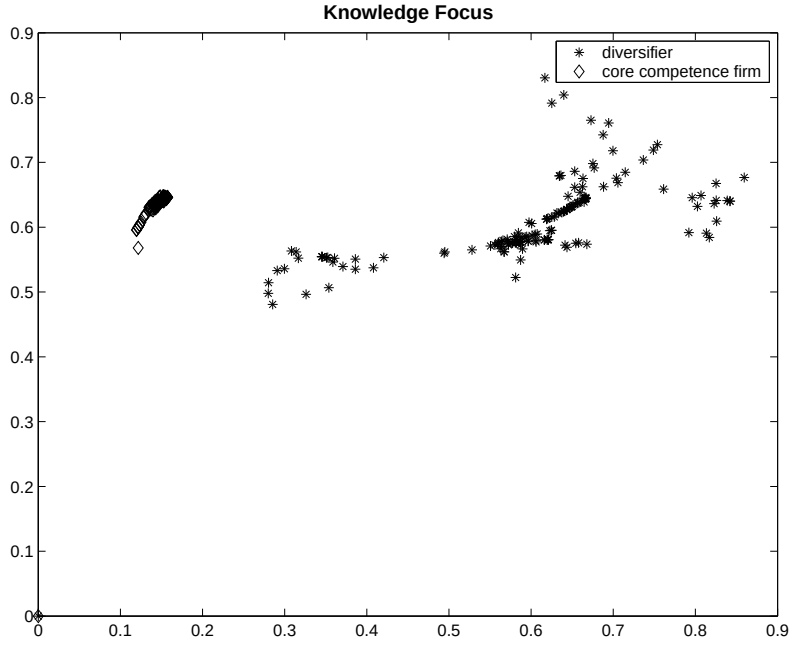

Figure 3: Change of knowledge focus over time

When firms do not develop new products, they can use their free cash flows to invest into additional capacity or productivity improvements. For these investment decisions, firms calculate the impact of their investment alternatives on the total cash flow for the next period and select the investment which will lead to the highest revenues. The decision process involved in making these investment decisions is shown in figure 4.

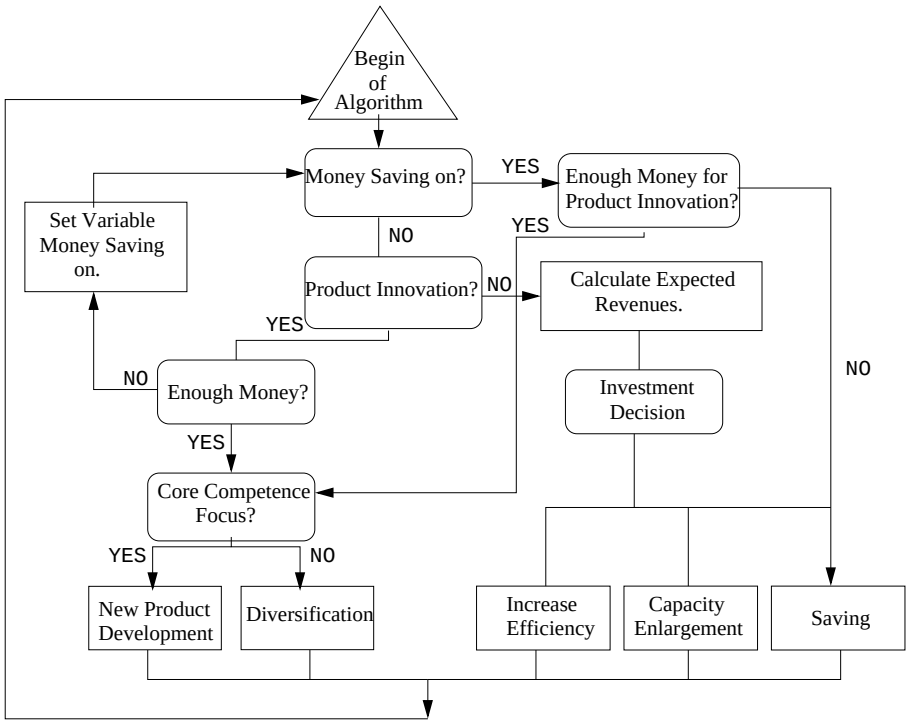

Figure 4: Investment decision

4 Simulation Experiments and Results

To test the hypotheses formulated above, the four environmental settings shown in table 2 were analyzed. In each experiment, 6 firms compete against each other, where two firms each follow the diversifier, variator and core competence strategies. The firms retain their strategies throughout the experiments.

Nr.	*Market Life Cycles*	*Shift in Consumer Preferences*	*Market Size*
1	long	slow	small
2	long	slow	large
3	short	fast	small
4	short	fast	large

Table 2: Experiments

For each of the settings indicated above, 100 experiments were run. Each experiment consisted of a total of 250 time periods. To take into account start-up effects of the model, only results from period 21 onwards were used in the following analyses.

Hypotheses 1 and 2 referred to the performance of the different strategy types. While hypothesis 1 was formulated in general terms, hypotheses 2 proposed that the relative performance of the different types

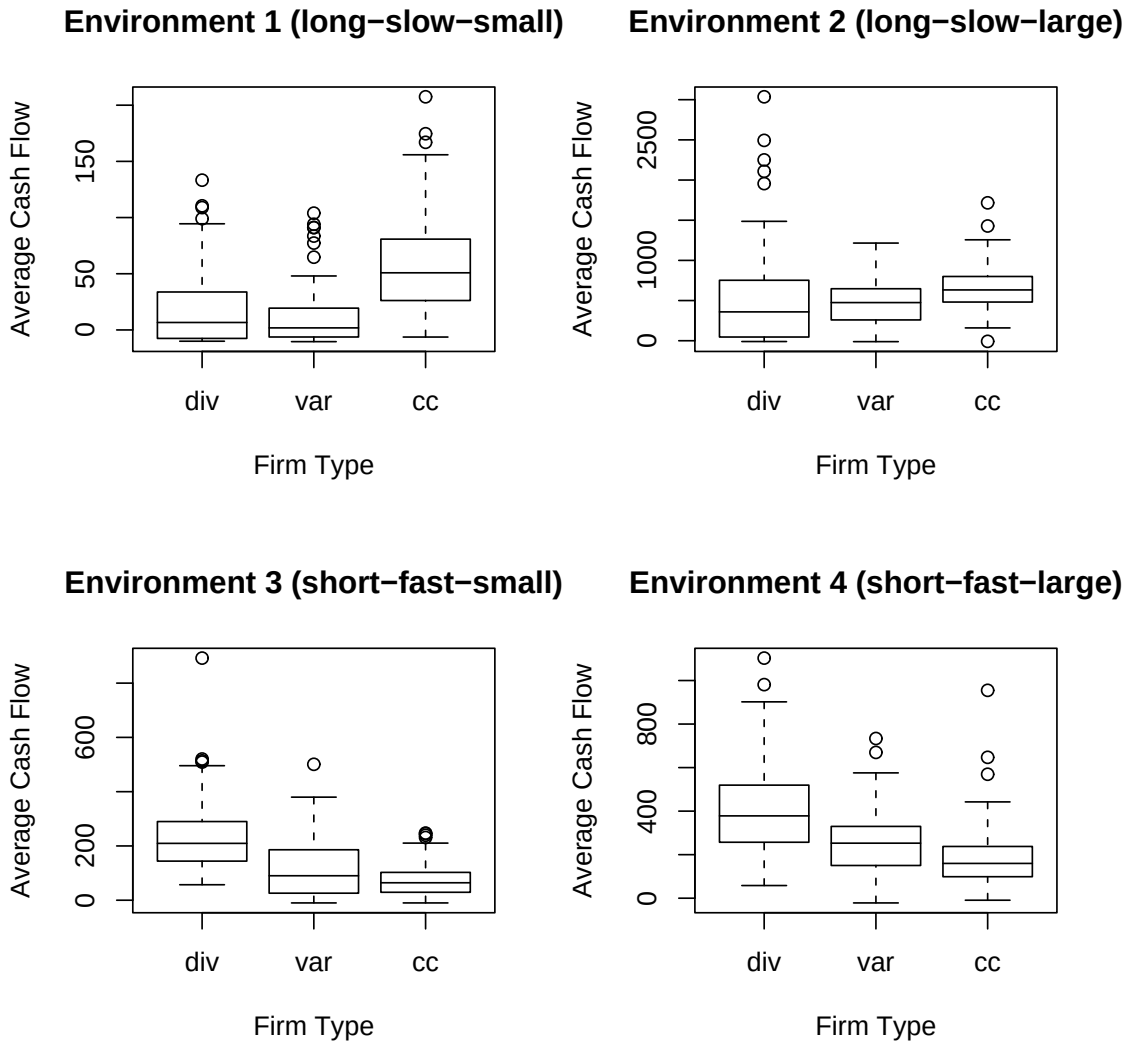

Figure 5: Average Cash Flow of different strategy types in different environments (100 runs, average over periods 21 – 250)

would depend on the environment. Figure 5 represents the cash flows of the different strategy types in the four environments studied. Each data point included in the box plots represents the average cash flow of a firm (from time period 21 to time period 250) for one simulation run.

The figure clearly indicates that there are performance differences between firms, and the ranking of strategy types is dependent on the type of environment. Therefore hypothesis 1, which postulated a general superiority of diversifiers in all types of environment, must be rejected.

The performance differences shown in figure 5 close correspond to those predicted by hypothesis 2. In the more stable environments characterized by long product life-cycles and slow movement of consumer preferences, core competence firms perform better than in the other two environments, where diversifiers are superior. Our results also indicate that this effect is moderated by market size. The performance advantage of core competence firms in stable environments is more accentuated when the total market size is small. On the other hand, market size has less influence on the advantages of diversifiers in dynamic environments.

To test the statistical significance of these results, a nonparametric Wilcoxon signed rank test was used since the observed average cash flows do not fulfill normality assumptions required for standard parametric tests like the t-test. The results shown in table 3 confirm that the observed differences are statistically significant.

Exp	*Div > Var*	*Div > CC*	*Var > CC*	*Median*
1	$V+ = 3010$ $V- = 2040$ $p = 0.048$	$V+ = 743$ $V- = 4307$ $p = 1$	$V+ = 159$ $V- = 4891$ $p = 1$	$m_{div} = 6.626$ $m_{var} = 1.821$ $m_{cc} = 50.829$
2	$V+ = 2407$ $V- = 2643$ $p = 0.658$	$V+ = 1529$ $V- = 3521$ $p = 0.9997$	$V+ = 1102$ $V- = 3948$ $p = 1$	$m_{div} = 359.120$ $m_{var} = 474.856$ $m_{cc} = 632.308$
3	$V+ = 4327$ $V- = 723$ $p < 0.001$	$V+ = 4873$ $V- = 177$ $p < 0.001$	$V+ = 3505$ $V- = 1445$ $p < 0.001$	$m_{div} = 209.4594$ $m_{var} = 90.16545$ $m_{cc} = 64.3703$
4	$V+ = 4275$ $V- = 775$ $p =< 0.001$	$V+ = 4612$ $V- = 438$ $p < 0.001$	$V+ = 3634$ $V- = 1416$ $p < 0.001$	$m_{div} = 378.2$ $m_{var} = 252.773$ $m_{cc} = 159.7932$

Table 3: Wilcoxon tests for cash flow differences

Hypothesis 2 also refers to the variator strategy and predicts that its performance will be in between the diversifier and core competence strategies. This effect is also mostly confirmed by the results except for the stable environments in experiments 1 and 2.

If one compares the competitive situation in this environment setting with the other experiments this outcome is not very surprising. In experiments 3 and 4, the variator clearly outperforms the core competence focused firm as in a dynamic environment the ability to adopt the product portfolio to changing consumer preferences and the greater variety of products can be seen as competitive advantage. In experiments 1 and 2, these advantages do not exist due to stable market conditions. Moreover the variator launches its initial products the same way like the core competence focused firm in between the two markets that have the smallest distance in feature space. This causes the variator to compete against the core competence focused firm in terms of prices and increases the disadvantage of its weak cost position. Therefore especially the small market size in experiment 1 creates a very tough situation for the variator . In contrast, the excess demand in experiment 2 gives the variator the chance to keep up with the diversifiers performance as sales and learning effects can be realized due to capacity restrictions of the core competence focused firm.

Hypothesis 3 predicted that core competence firms would achieve lower costs, leading to lower prices for their products. Figures 6 and 7 clearly confirm this hypothesis. Core competence focused firms have the lowest unit costs followed by variators and diversifiers and at the same time charge lower prices.

This cost leadership strategy of core competence firms seems to be less successful in dynamic environments. But a sensitivity analysis performed on our parameter settings indicates that this is not always

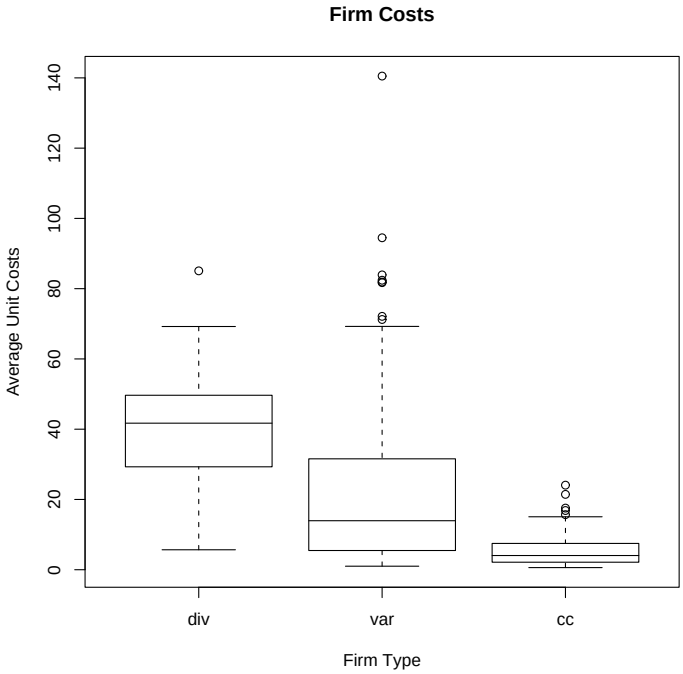

Figure 6: Costs by strategy type

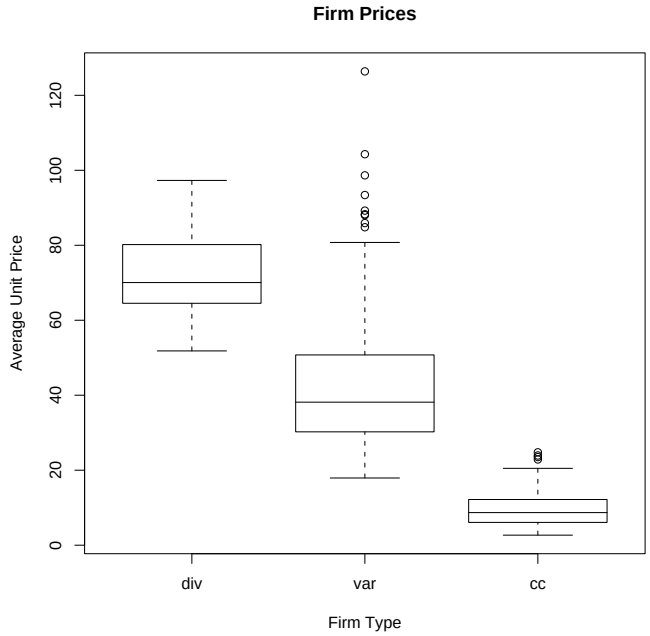

Figure 7: Prices by strategy type

the case. The relative performance of the different strategy types in a dynamic environment is strongly influenced by the reservation prices of consumers.

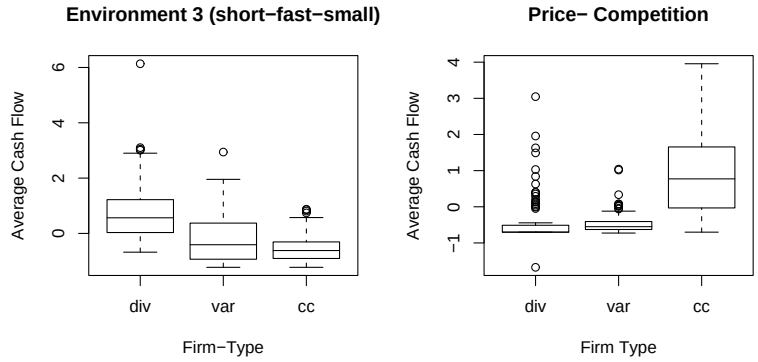

Figure 8: Price Competition (Z-Values of Average Cash Flows)

Figure 8 illustrates the effects of low reservation prices on environment 3, i.e. a small market with rapid innovation cycles and fast movement of consumer preferences. In the standard parameter setting for environment 3, the reservation prices are uniformly distributed between 3 and 100 whereas in the additional experiment they vary only between 3 and 15.

Increasing the price sensitivity of consumers ("Price-Competition" in figure 8) leads to a reversal in the order of firm performance compared to environment 3. This effect can be explained by the higher costs of variators and diversifiers. Only core competence firms in this setting manage to fulfill the demand of consumers for low-cost products.

The relationship between reservation price and performance in this setting is illustrated in Figure 9. In a region of low reservation prices, core competence firms are able to adjust very well to the environment and increase their cash flows rapidly with increasing reservation prices. But after a certain threshold is reached and consumers become less concerned with prices, their performance ceases to improve. On the other hand, diversifiers and variators exhibit a more regular relationship between reservation prices and performance.

Our last hypothesis concerned the volatility of cash flows. In accordance with the standard argument of strategy literature, hypothesis 4 predicted that diversifiers would have more stable cash flows than less diversified firms.

However, figure 10 indicates exactly the opposite situation: diversifiers exhibit the highest variance of cash flows, followed by variators and core competence firms have the most stable cash flows.

But a more detailed analysis of results reveals that it is misleading to consider variations in cash flow as a risk that should be avoided. Figure 11 shows the development over time of the three strategy types for a representative run. While the core competence firms indeed exhibit the lowest variation in cash flow, their cash flows are also very low compared to diversifiers. Core competence firms in this run tend to focus on a small and stable niche market, while diversifiers are able to quickly exploit any new opportunities emerging in the dynamic environment. This leads to more frequent changes in their cash flows, but often these changes are increases, not decreases. Thus, a high variance in this case is an indicator of opportunities, not risks.

5 Conclusions and Further Research

In this paper, we have used an agent-based computational model to study a classical question of strategy research, the impact of diversification strategies on firm performance. Starting from the typology of Miles and Snow, we defined three prototypical diversification strategies and studied their performance in different environments.

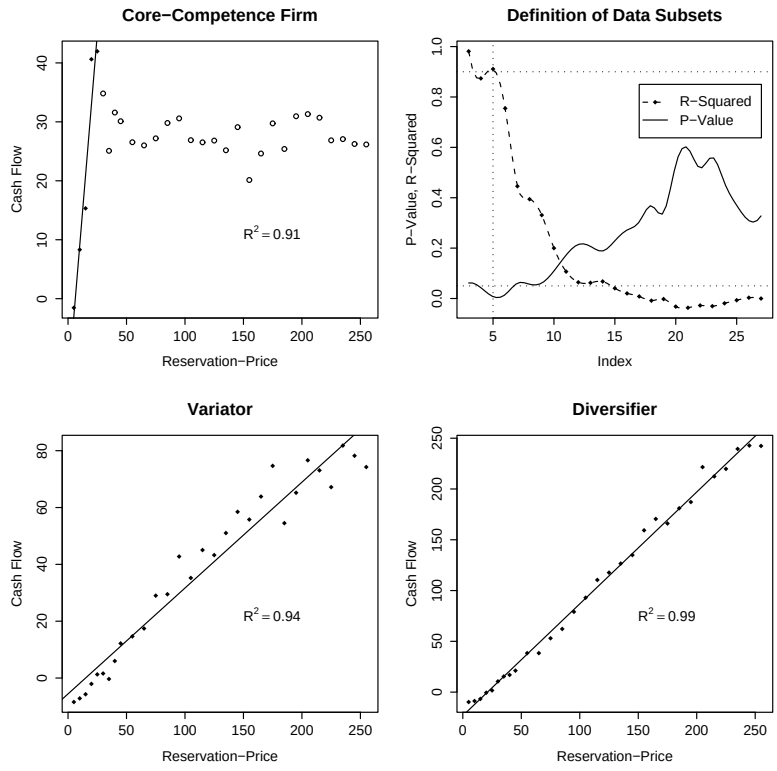

Figure 9: Price-Performance Development

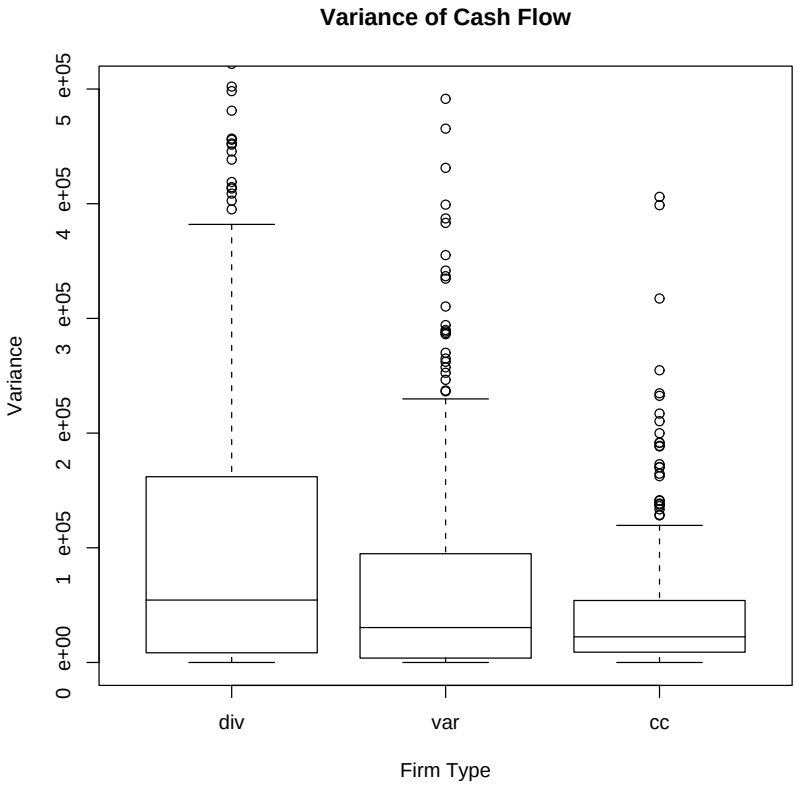

Figure 10: Cash Flow Variances

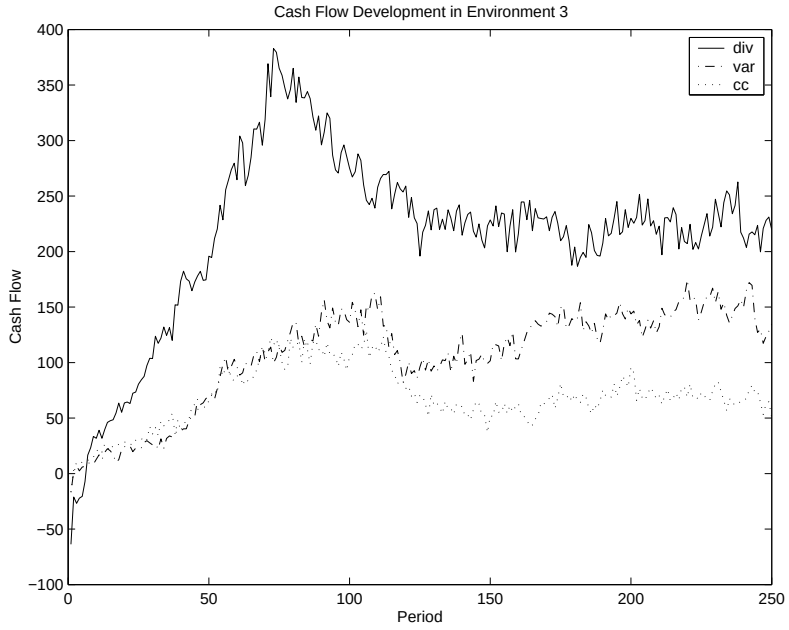

Figure 11: Performance Development in Environment 3

The results from this exercise on one hand show the viability of agent-based models as an instrument of strategy research. Our simulations to a significant extent confirmed existing results of the strategy literature. This correspondence of results can be seen as a validation of our model.

But the results go beyond those of traditional strategic analysis and thus indicate the potential of agent-based models to obtain new results in this field. We have identified market size as a moderating variable, which mitigates the performance advantage of core competence strategies in stable environments. Perhaps even more interesting is the result that the commonly assumed performance advantage of highly diversified firms in dynamic environments might cease to exist if the market is characterized by strong price competition. This effect could explain the current wave of divestitures one can observe in the economy.

The main purpose of this simulation exercise was to serve as a kind of feasiblity study for the use of agent based models in strategy research. Thus, more and richer applications of this methodology can be expected in the future. The present study has identified several promising areas.

It has indicated that results taken for granted in the existing strategy literature are in fact dependent on specific parameter settings and might be weakened or even eradicated in different settings. Thus one important research task is to more precisely delineate parameter ranges for which given results hold. This will require a systematic analysis of parameter space as well as the inclusion of additional dimensions (like the number of competing firms) in the model. These extensions can lead to more substantial contributions of agent-based modeling to research on corporate strategy.

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