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ERIM REPORT SERIES *RESEARCH IN MANAGEMENT*	
ERIM Report Series reference number	ERS-2007-055-ORG
Publication	August 2007
Number of pages	32
Persistent paper URL	
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ABSTRACT AND KEYWORDS	
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Free Keywords	Concentric diversification, product lifetime, cooperatives, agent-based analysis
Availability	The ERIM Report Series is distributed through the following platforms: Academic Repository at Erasmus University (DEAR), DEAR ERIM Series Portal Social Science Research Network (SSRN), SSRN ERIM Series Webpage Research Papers in Economics (REPEC), REPEC ERIM Series Webpage
Classifications	The electronic versions of the papers in the ERIM report Series contain bibliographic metadata by the following classification systems: Library of Congress Classification, (LCC) LCC Webpage Journal of Economic Literature, (JEL), JEL Webpage ACM Computing Classification System CCS Webpage Inspec Classification scheme (ICS), ICS Webpage

On the Evolution of Product Portfolio Coherence of Cooperatives versus Corporations: An Agent-Based Analysis of the Single Origin Constraint

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Key words: Concentric diversification, product lifetime, cooperatives, agent-based analysis.
Version: August 28, 2007.

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1. Introduction

One of the fascinating aspects of enterprises is the evolution and composition of their product portfolios. Product portfolios evolve due to enterprises expanding current product lines, adding new products, divesting products, mergers, and so on. An important feature of the evolution and composition of product portfolios is coherence. It entails that products are related in terms of markets or processes. Relatedness be-

tween products in the portfolio of enterprises is established and summarized in a number of stylized facts by Teece et al. (1994, p3–4) [1]:

the sequence is generally for firms to begin as single product and subsequently become multi-product, rather than the other way around;

firms maintain a constant level of coherence between neighboring activities;

firms not only add businesses, they also commonly divest.

These general observations can be developed in more detailed directions, empirical as well as theoretical. Coherent product portfolios may follow different paths of evolution. For example, coherent product portfolios of different enterprises may develop in different directions, or the product portfolio may develop in clusters of related products. Theoretical accounts of the stylized facts entail clarifying the mechanisms driving the composition and evolution of the product portfolio. This article provides an explanation for the impact of governance structure on the evolution of corporate coherence, while incorporating the above stylized facts.[2]

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[1] Tanriverdi & Venkatraman (2005) in a recent study stressed the importance of relatedness.

[2] A standard way of delineating a governance structure is to distinguish income and decision rights (Hansmann 1996). Income rights address the question 'How are benefits and costs allocated?', i.e. they specify the rights to receive the benefits, and obligations to pay the costs, that are associated with the use of an asset. Other important themes regarding income rights are financing, cost allocation schemes, and the effects of horizontal as well as vertical competition. Decision rights in the form of authority and responsibility address the question 'Who has authority or control?', i.e. they concern all rights and rules regarding the deployment and use of assets. For example, a franchise chain has to decide how many outlets will be company-owned. Important themes regarding authority are its allocation ('make-or-buy' decision), formal versus real authority, relational contracts, access, decision control (ratification, monitoring),

Teece et al. (1994) pose that explaining corporate coherence requires that various corporate forms have to be taken into consideration. This position is supported by empirical evidence indicating that there is a relationship between governance structure and diversification policy, but it seems to depend on the governance structures being compared. For example, Kamshad (1994) did not find a statistically significant difference between the diversification policy of investor owned firms and labor managed firms. Similarly, Demsetz and Villalonga (2001) find no statistically significant relation between ownership structure and firm performance. However, Van Oijen and Hendrikse (2002) establish a statistical significant difference between investor owned firms and agricultural cooperatives regarding their diversification profiles. Investor owned firms diversify in related products, while cooperatives have a tendency to diversify in unrelated products. Van der Krogt et al. (2007) show that (dairy) cooperatives and investor owned firms have quite different expansion strategies. These studies are illustrations of the now widely accepted view that institutions matter (Rodrik et al. 2004). The debate is therefore progressing from the question of whether governance matters to the analysis of how specific governance structures matter and under what circumstances.

This article investigates the product portfolio consequences of cooperatives versus corporations. A cooperative is an association of many independent growers who jointly own a downstream processor / retailer (Sexton 1986). The providers of input own the enterprise in a cooperative, while the providers of capital own the enterprise in an investor owned firm (Hansmann 1996). This difference is reflected in various aspects, like different worldviews / orientations of owners, different ways of financing the enterprise, and different ways of decision making. The governance structure differences between cooperatives and corporations may have therefore a number of product portfolio implications. The reason is that a cooperative is supposed to serve member interests and to generate maximum value in processing. It is de-

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decision management (initiation, implementation), task design, conflict resolution, and enforcement mechanisms.

signed for the former task, and because the organizational structure required for the two tasks is different, it is expected to have an impact on the latter task.

One of the distinct aspects of a cooperative is the single origin constraint. Cook (1997: 87) observes that '… cooperatives … are 'single origin' in that their objective is to optimize the utilization of their member owners output, not to originate products in another area or country. Being single origin for a co-operative is rational because of the member owners' high degree of physical, site, dedicated assets and temporal asset specificity. This asset specificity comes in the form of investments, land, machinery, perishable output, and location whereby their value in the next best use is often significantly lower.' The single origin constraint of cooperatives entails that they will never divest products requiring the inputs of members. It determines to a certain extent which new product will be selected.

The relationship between the single origin constraint and the evolution of product portfolio is highlighted in our model, while capturing the stylized facts formulated by Teece et al. (1994). The methodology of agent-based modeling is adopted to analyze the implications for the evolution of product portfolio. It highlights social dynamics and is geared to study '… macro effects [as] dynamic consequences of decisions and mechanisms operating only at the micro level.' (Hegselmann and Flache 1998). Two important features are locality, i.e. agents basing their decisions on their own state and the local environment, and emergence of macrostructures, i.e. the evolution of the system as the outcome of the interactions between the agents. In an agent based model the unit of analysis is represented as an agent that possesses some properties, a repertoire of actions, and ways of interacting with other agents and with its environment. Each agent is characterized by a state, while decisions of agents are captured by transition rules. These transition rules produce a new state for each agent as a function of the current state of the agent and the state of its environment including agents in this agent's neighborhood.

Locality will be captured by incorporating a result from the diversification literature. Studies regarding diversification report many failures and there are many prescriptions for successful diversification (Gruca et al 1997; Johnson and Thomas 1987; Palepu 1985; Rumelt 1982). Lowes et al. (1994) formulate the so-called concentric diversification strategy as the main general prescription coming out of this literature. It

entails to diversify only into activities related to current products, markets, or processes. The transition rule in our model randomly produces a new product / activity in the local neighborhood of the current product portfolio in each period. Cooperatives and corporations are distinguished by assigning a different lifetime to the first product in the product portfolio. The first product of a corporation will be divested after a finite number of years, while a cooperative will never divest its first product due to the single origin constraint, i.e. the lifetime of the first product of a cooperative is infinite. All other products have the same finite lifetime in both governance structures. The locality of an agent's decision rules will therefore serve to capture the feature of concentric diversification, while the transition rules will drive the evolution of the product portfolio. This simple model, consisting of concentric diversification and the single origin constraint, is able to address the question: How does the evolution of the product portfolio coherence of a corporation and a cooperative differ?

The article is organized as follows. Section 2 formulates various differences between cooperatives and investor owned firms and identifies diversification implications. Section 3 presents the model. Section 4 formulates the results regarding the impact of the single origin constraint on the evolution of the coherence of the multi-product firm. Section 5 concludes and formulates directions for future research.

2. Cooperatives and diversification

Hansmann (1996) states that governance structures are usually characterized by ownership of one group of stakeholders. Stock-listed enterprises are owned by investors, cooperatives are owned by buyers or suppliers, labor managed enterprises are owned by employees, and so on. Different stakeholders are usually characterized by different objectives, like shareholders of an investor owned firm are interested in total profits, whereas a member of a cooperative is oriented towards bringing his/her portfolio of assets to value (rather than bringing the assets at the up- or downstream stage of production to value). A major rea-

son for the dominance of one group of stakeholders is that different owners having different objectives will result more often in conflicts.[3]

The implications of governance structure variety for product portfolio evolution will be made specific by comparing agricultural cooperatives with investor owned firms. The core of an agricultural cooperative is member control over the infrastructure at the downstream stage of production. In other words, formal ownership by the input suppliers over the downstream assets is the essential feature of a cooperative. It provides the members with market power and access to input/output markets.[4] A cooperative is supposed to serve member interests and to generate maximum value in processing. It is designed for the former task, and because the organizational structure required for the two tasks is different, it is expected to have an impact on the latter task.

Members take the entire portfolio of farm activities into account when they exercise their ownership rights in a particular cooperative regarding a particular investment / divestment proposal (Cook 1995). Diversification decisions of a cooperative are therefore guided by the portfolio of farm activities of individual members rather than the portfolio of activities of the cooperative, because the owners of an agricultural cooperative have chain specific assets. The governance structure differences between cooperatives and corporations may have a number of product portfolio implications. Prominent examples are the portfolio problem, the horizon problem, and the single origin constraint.

The portfolio problem entails that an important consideration in the diversification decision of members in cooperatives may be spreading of risks of their individual farm portfolio. It may result in members '… will pressure cooperative decision makers to rearrange the cooperative's investment portfolio, even if the reduced risk portfolio means lower expected returns.' (Cook 1995: 1157). It results in the hypothesis that

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[3] How these conflicts play out depends on how control is allocated, but it seems clear that it will most likely have adverse consequences when different types of stakeholders are in control.

[4] An important aspect of a cooperative is that members have usually a delivery right / obligation.

a cooperative diversifies in a different way than an investor owned enterprise. To be more specific, a cooperative diversifies more in unrelated products than an investor owned enterprise.

The horizon problem is due to the heterogeneity in the composition of the membership of a cooperative. It is heterogeneous in various ways, like the extent of patronage, location of the farm of members, and the age of the members. The age distribution of the membership, together with the limited transferability, liquidity, and appreciation mechanisms for exchange of residual claims, may result in the horizon problem (Cook 1995: 1156). It entails that a member has a disincentive to contribute to growth opportunities when the productive life of an asset is longer than the remaining membership period.

The single origin constraint entails that a cooperative will never divest the activity of processing the produce of the members. The single origin constraint may account for a number of properties of the diversification portfolio of cooperatives, like an input orientation, a tendency to avoid new businesses, less flexibility in their procurement of inputs, less flexibility in their product portfolio, active in fewer industries than corporations, and a higher ratio of unrelated to total diversification than corporations due to spreading risks of the farm portfolio of activities.

Various explanations for corporate diversification have been advanced in the strategy literature (e.g. Hoskisson and Hitt 1990, Montgomery 1994, Ramanujam and Varadarajan 1989).[5] We will address briefly institutional theory and agency theory because they are most relevant for the model of this paper. Institutional theory (Davis et al. 1994, Kogut et al. 2002) investigates the influence of institutional factors on diversification behavior. Various institutional factors are mentioned, such as government regulation, interfirm networks, and ownership (e.g. Kogut et al. 2002, Teece et al. 1994). For our purposes, the institutional factor that D'Aunno et al. (2000) refer to as norms about property rights seems particularly relevant, since it differs between investor owned firms and cooperatives. The owners of an investor owned

[5] These perspectives are rooted in different theories or paradigms, notably agency theory (Jensen 1986), industrial organization (Palepu 1985), the resource-based view of the firm (Penrose 1959), and transaction cost economics (Williamson 1975).

firm have the right to use the assets in a way that maximizes the value of the firm. They are less concerned about meeting the corporation's original mission than they are about generating profits. Faced with market pressures, they are likely to abandon traditional goals and commitments and exercise their right to use assets for other business opportunities (D'Aunno et al. 2000). In contrast, cooperatives are primarily founded in a specific industry to protect the interests of many small members against a monopolistic supplier or customer (Milgrom and Roberts 1992). The members are less likely to abandon the original mission and use the assets to seize business opportunities in industries they are not active in. As a consequence, diversification into new industries is more probable for investor owned firms than it is for cooperatives.

Agency theory suggests that firms diversify because their managers have personal motives to do so. Managers do not return free cash flows to shareholders, but spend them on diversification projects due to motives like empire building, pay increases, and reduction of employment risk (Ahimud and Lev 1981, Jensen 1986). This is not in the interest of the shareholders, for instance because they can diversify risks themselves by building an efficient stock portfolio. However, in an investor owned firm, the interests of shareholders and managers can be aligned, for instance by granting stock options to managers, which could help to eliminate diversification projects that destroy value. This instrument is not available in a cooperative. This may be even in the interests of the members because it reduces the emphasis on profits, and therefore favors broader interests of members. In addition, risk reduction through product diversification might actually be in the interest of the members of the cooperative, since a large portion of their wealth is often tied to the cooperative (Hendrikse and Veerman 2001)

3. The Model

In this section we will develop an agent-based model. Our aim is to investigate the dynamics of agents developing their product portfolio in a competitive environment with other agents. However, before we can hope to be able to interpret the complexities that will emanate from such a simulation, we need to

know how the behavior of an individual agent evolves independent of the behavior of other agents. The focus will therefore be on one agent.

An agent-based model consists of the definition of the states the agent can be in, and the transition rule that governs the evolution of its state. An agent is characterized by its product portfolio and a transition rule determining how it will diversify in the next period. A *product portfolio* consists of a set of products. Each product is represented as a cell in a two-dimensional grid. The distance between cells represents the similarity between products. A product is characterized by the number of activities (or production units) and its lifetime. Divestment is captured by removing a product, and its associated activities, from the product portfolio when it has reached its lifetime. A product's lifetime starts at the period when it is added to the portfolio. The state of an agent is defined as its product portfolio.[6]

A *transition rule* produces a new state for each agent as a function of the agent's current state and the state of its local environment. The new state consists of the portfolio of products in the previous period plus an additional product activity. Agents diversify their product portfolio by picking one of the cells within their local neighborhood. The local neighborhood is the set of product cells that have a chance greater than zero of being chosen in the next period. These chances are calculated based on the content of the current product portfolio.

[6] There are two major differences between the classic model of Schelling T.C. Schelling. 1978. *Micro Motives and Macro Behavior*. Norton. and this paper. First, his model has a fixed number of agents of various types, the type of an agent does not change, and the state of each agent is modeled as a location. Our model has one agent, being one of many possible types / orientations. Second, Schelling studies population dynamics, i.e. the interaction between agents, by having agents move to different locations when the number of foreigners in the local environment is above a certain threshold. We study the evolution of the diversification portfolio of an enterprise, i.e. the agent.

Figure 1 illustrates two periods of a simulation with one agent. The grids on the left hand side depict the development of the product portfolio. The grids on the right hand side show the local neighborhood represented by the weighed probability distribution determining the chance that a product is chosen in the next period. At the start of a simulation the portfolio of an enterprise consists of one product activity. The local neighborhood in this case consists of all the product's neighboring product cells (the Moore neighborhood). Each product cell within the local neighborhood has an equal probability of 1/9 of being chosen.[7] Note that the product cell in the current portfolio is also part of the local neighborhood and thus may be chosen in the next period. The meaning of choosing a product that is already in the portfolio is that the production capacity for that product will be augmented by one unit. Each unit of a product is called an activity.

[7] Choosing the next product in the Moore neighborhood of the current product portfolio seems to be a natural way to capture a concentric diversification strategy.

Figure 1 An example of the evolution of a firm's product portfolio during two periods.

Start:

0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	1	1	1	0
0	1	1	1	0
0	1	1	1	0
0	0	0	0	0

Period 1:

0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	1	0	0
0	0	0	0	0

0	0	0	0	0
0	1	1	1	0
0	2	2	2	0
0	2	2	2	0
0	1	1	1	0

Period 2:

0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	2	0	0
0	0	0	0	0

0	0	0	0	0
0	1	1	1	0
0	3	3	3	0
0	3	3	3	0
0	2	2	2	0

Suppose that the product south of the product in the starting portfolio is chosen at the beginning of the first period. The right hand side of the row in the middle illustrates that the local neighborhood now contains 12 products. Six of these products are within the Moore neighborhood of both products in the current portfolio. Therefore their chance to be chosen is twice the chance of the other products. Suppose that in the second period the same product is chosen as in the first period. The bottom row shows the portfolio and the weighed probability distribution at the end of the second period.

4. Results

This section formulates the results regarding the relationship between the lifetime of products and the evolution of the product portfolio. The evolution of the coherence of a product portfolio will be described by three measures: product portfolio's diversity index, product dispersion index, and activity dispersion index. A product portfolio's diversity index in a period is defined as the ratio of the actual number of products in the product portfolio to the maximum number of products possible in this period. To capture

the relatedness of products and activities in the evolving portfolio two measures are defined: the products dispersion index (D_P) and the activities dispersion index (D_A). D_P is defined as the average distance between products in the product portfolio, while D_A is the weighted average distance between products in the product portfolio. (D_P assigns the same weight to all products, while D_A weights according to the number of activities associated with the product.) Distance is measured to the centre of gravity of the portfolio, where the centre of gravity is the mean position of all product cells when D_P is determined and the mean position of all activities when D_A is determined.

Three cases are distinguished. The case consisting of all products having infinite lifetime is considered first. Subsequently the case consisting of all products having the same finite lifetime is addressed. Finally, the single origin constraint case is evaluated. It consists of an intermediate case of one product having infinite lifetime and all other products having the same finite lifetime.

4.1 Infinite Product Lifetime

If products have an infinite lifetime, then activities once started will never be stopped. An immediate implication is that the number of activities distributed over all products in the portfolio is equal to the number of periods passed, i.e. there is never divestment. The number of products in the portfolio at any period may range from 1 (in case at each previous period the same product was chosen) to the number of periods passed (in case at each previous period a new product was chosen). The agent-based simulation toolkit Repast (North et al. 2006) is used to investigate how the number of products in the portfolio changes with the number of periods. We executed 25 runs of 20,000 periods. Figure 2 shows that the number of products increases with the number of periods while the rate of this increase decreases with the number of periods. Thus, the probability of choosing a new product decreases at a decreasing rate with time.

Figure 2 The number of products in the portfolio per period when the product lifetime is set to infinity.

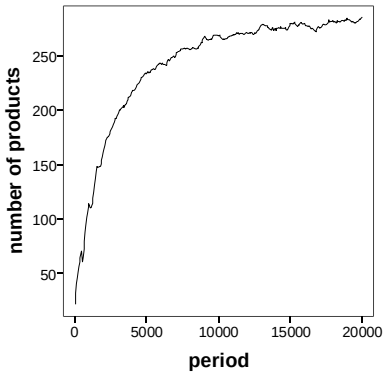
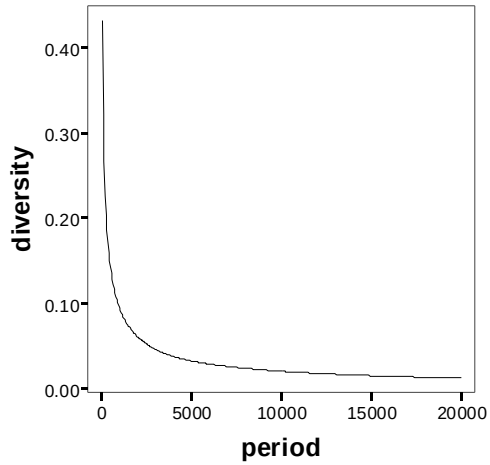


Figure 3 shows a decline of the diversity index over time at a decreasing rate. The implication for the product portfolio's composition is that with the passing of time the activities in the product portfolio will be concentrated on a few product cells.

Figure 3 The development of the product portfolio's diversity index with infinite product lifetime.

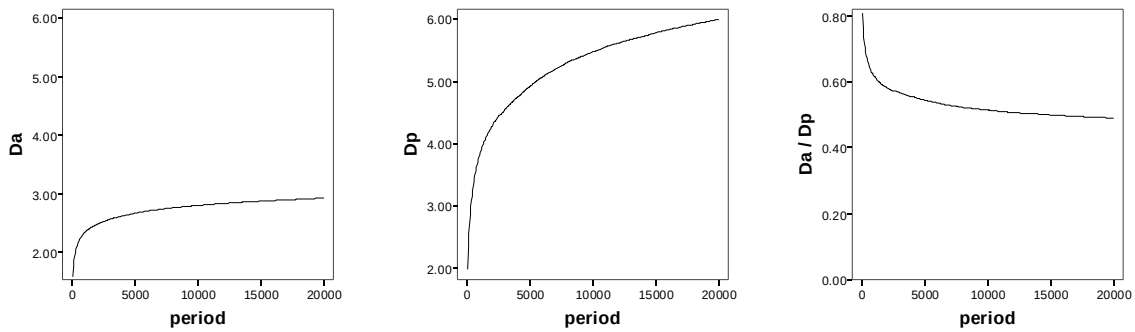


While we have determined that the product portfolio's diversity index decreases with time, it still remains an open question how the shape of the product portfolio will develop over time. At the start of the

diversification process, the portfolio will expand. This can easily be inferred from Figure 1. At the first period the probability of choosing a different product cell than the starting position is 8/9; so on average the process starts with an increase in both the activities dispersion index (D_A) and the products dispersion index (D_P). However, during a run, the activities and products added to the portfolio will tend to be centered on the area near the first product, due to the fact that the product cells in the centre get more and more weight relative to the cells near the edge of the portfolio.

The development of the ratio of D_A to D_P provides a characterization of the product portfolio's shape. It turns out that both D_A and D_P increase at a decreasing rate during a simulation run. The decrease in the rate at which D_A increases is larger than the decrease in the rate at which D_P increases (Figure 4). Thus, there seem to be two trends working on a portfolio's dispersion: an expansion effect resulting in a spreading of activities over more and more products, and a concentration effect resulting in an increasing concentration of activities within the centre of the portfolio. Figure 4(c) shows that the ratio of D_A to D_P decreases over time, but at a decreasing rate. In conclusion, the expansion effect (D_P) of the diversification strategy is declining slower than its concentration effect (D_A) such that the base of the mountain will always keep on expanding, while the shape of the mountain becomes steeper and steeper.

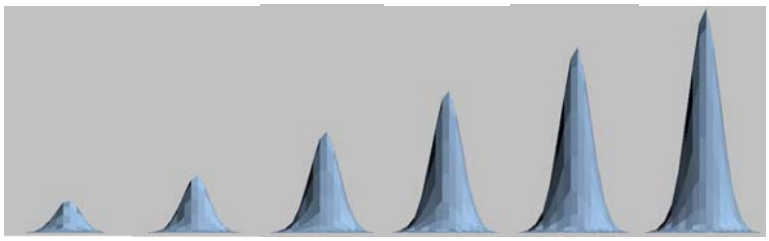
Figure 4 The development of (a) the Activities Dispersion (D_A) and (b) the Products Dispersion (D_P) of a product portfolio and (c) the ratio of D_A and D_P during 20000 periods. All products have infinite lifetime.



(a) (b) (c)

Figure 5 visualizes the developments described in figure 4.

Figure 5 Development of the portfolio's shape when all product have infinite lifetime. Snapsots taken at period 500, 1000, 2000, 3000, 4000, and 5000.



4.2. Finite product lifetime

To test how the product portfolio will develop when the firm does divest, we limit the lifetime of (all) products.[8] Before presenting the results of the simulations in terms of the three indices we give a general

[8] Another way to incorporate divestiture is that existing products may die due to either too much competition or being too isolated. Too much competition entails that a bound is introduced on the number of

characterization of what will happen. Assigning a finite lifetime to products limits the number of products and its activities. Suppose a product's lifetime is set at 50. Up until the 50th period the number of activities increases linearly with the number of periods. The maximum number of products possible during these periods is also equal to the number of periods. This situation occurs if a new product is chosen at each period. After the 50th period the limited product lifetime starts to have a divestment effect. At period 51 the first product in the portfolio will be removed. Removing a product entails removing all activities associated with that product. Consequently, the total number of activities in the product portfolio will decrease. How much the total number of activities decreases depends on the number of activities associated with the product removed (this may range from 50, in case at each period the same product (i.e. the first product in the portfolio) was chosen, to 1, in case this first product was never chosen again during the previous 49 periods). From period 52 onwards, at each period there may be a product that reaches its maximum age. For example, in case at period 2 a different product was chosen than the first product, this product, and its associated activities, will be removed from the portfolio. However, in case at period 2 the diversification algorithm has chosen the first product (the chance of this is 1/9, see Figure 1) then at period 52 no product would be removed from the portfolio.

The result of this process is that the mountain that has developed during the first 50 periods, at which no products are removed from the portfolio, suddenly collapses in the centre, giving it the appearance of a crater. Figure 6 presents the result of a simulation run where the product lifetime was set at 1000. The left hand part of the figure shows the shape of the mountain just before the diversification effect of finite product lifetime starts. The right hand part of the figure shows the effect of the product lifetime fifty periods after the start of the diversification effect.

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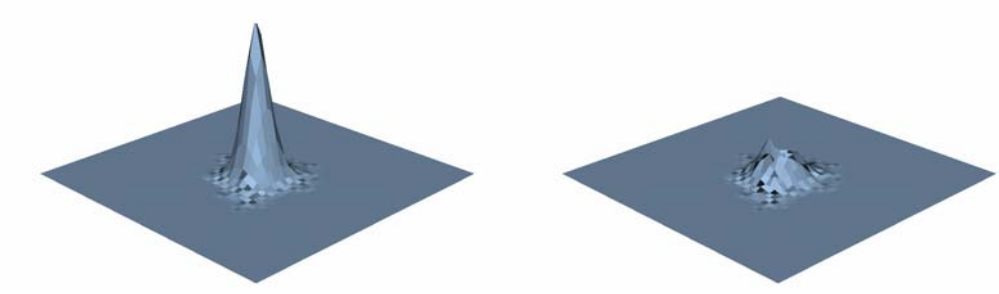
activities, whereas being too isolated from the majority of products in the diversification portfolio may be captured along the lines of Schelling T.C. Schelling. 1978. *Micro Motives and Macro Behavior*. Norton..

Figure 6 The impact of product lifetime 1000 on the development of the product portfolio. Maximum height of mountain is 40, i.e. the maximum number of activities in one product cell is 40 (at period 1000).



(a) Period = 1000 (b) Period = 1050

The collapse entails that the probability weights on all remaining products regarding the selection of a new activity increases. This has four effects. First, the mountain resurrects by having more activities on the edges of the crater, but does not reach its original height anymore. Second, there remains a hole in the centre. Third, the base of the mountain widens due to the more equal distribution of probability weights. Finally, the pattern of collapse and resurrection fades away after a number of periods. At each period number equal to a manifold of the product lifetime, the mountain starts to collapse, and at a period half-way in between these periods, the mountain starts to resurrect. After roughly 5 times the product lifetime (5000 periods) the recurrent phenomenon of collapse and resurrection has faded away (Figure 7).

Figure 7 Recurrent collapse and resurrection of the product portfolio with product lifetime set at 1000. Maximum height of the mountain is 11, i.e. the maximum number of activities in one product cell is 11 (at period 2000).

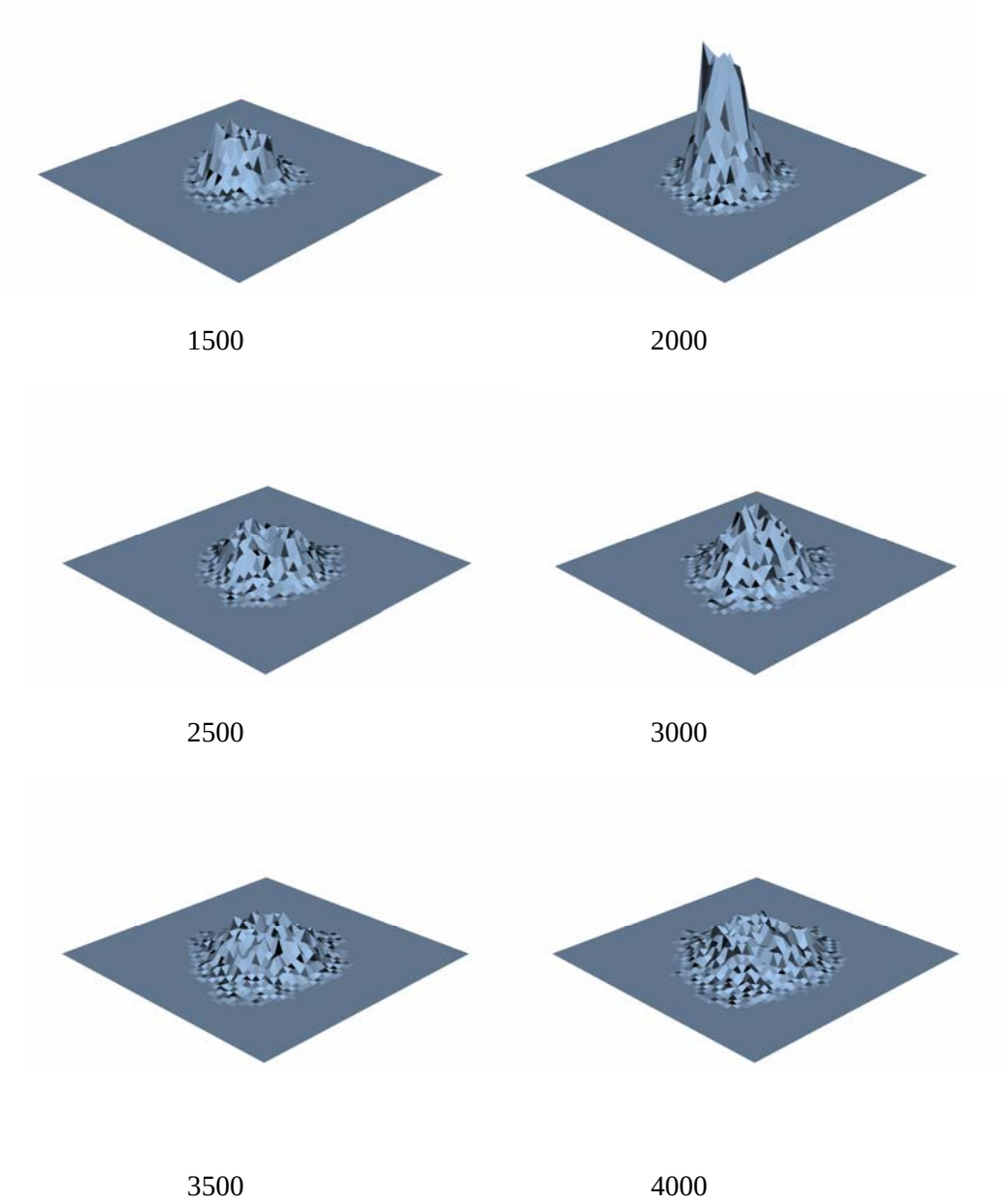


Figure 8 shows the development of the product portfolio diversity index by the mean outcome of 25 runs, where the product lifetime is 500. During the first 500 periods the result is the same as in the first case with infinite product lifetime. The pattern regarding the number of products in Figure 8 is similar to

the pattern in Figure 2. However, the increase in the number of products after period 500 is initially much larger. The increase in the number of products will be faster after period 500 because removing the first product entails spreading the probability weight associated with the first product over all other products. This increases the likelihood that a new product is chosen.

Figure 8 The number of products in the portfolio per period when the product lifetime is 500

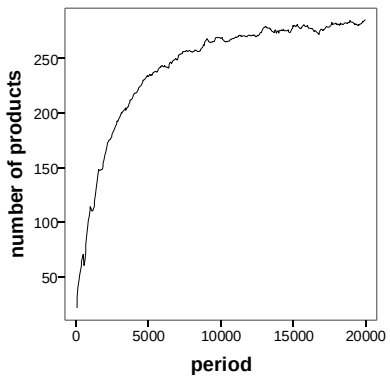


Figure 9 presents the results regarding the product portfolio diversity index. The pattern differs substantially from the pattern in Figure 3. During the first 500 periods the result is the same as in the first case with infinite product lifetime. From period 501 the product portfolio diversity index starts to increase again and stabilizes after some time. This is due to two effects. First, the denominator stays at 500 once period 500 is reached. Second, the first product was a large contributor to the concentration effect, i.e. increasing the probability of choosing a product near the portfolio's centre instead of a new product. If the first product is removed, then this increases the likelihood that a new product is chosen.

Figure 9 Development of the portfolio's product diversity index with product lifetime 500.

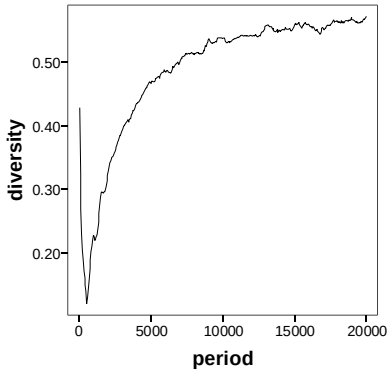


Figure 10 presents the results in terms of the portfolio's dispersion indices. The similarity with Figure 4 is that both D_A and D_P increase with time, indicating that the area covered by the portfolio widens in the course of time. However, the rate of increase of D_A and D_P differs substantially between Figure 4 and Figure 10. The major impact of introducing finite lifetime is on D_A. It becomes more similar to D_P because finite lifetime eliminates the mechanism of adding more and more probability weight on products close to the centre. The ratio of D_A and D_P approaches unity, implying that there is no concentation effect, i.e. a restricted area in the product cells grid that attracts more and more activities. So, in contrast with the first case when all products had an infinite lifetime, the portfolio becomes less coherent as soon as divestment takes effect.

Figure 10 Development of the portfolio's Activities Dispersion (D_A), Products Dispersion (D_P) and the ratio of D_A and D_P per period. The product lifetime is set at 500.

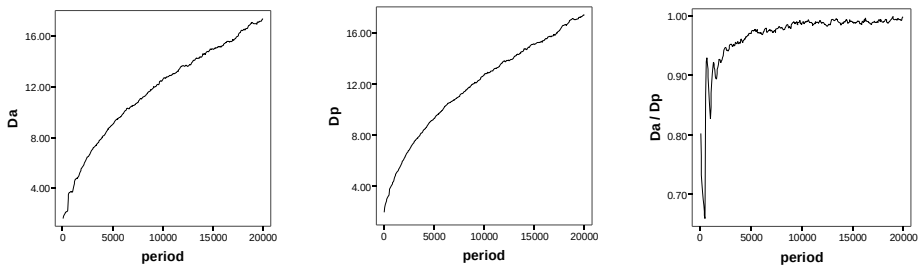
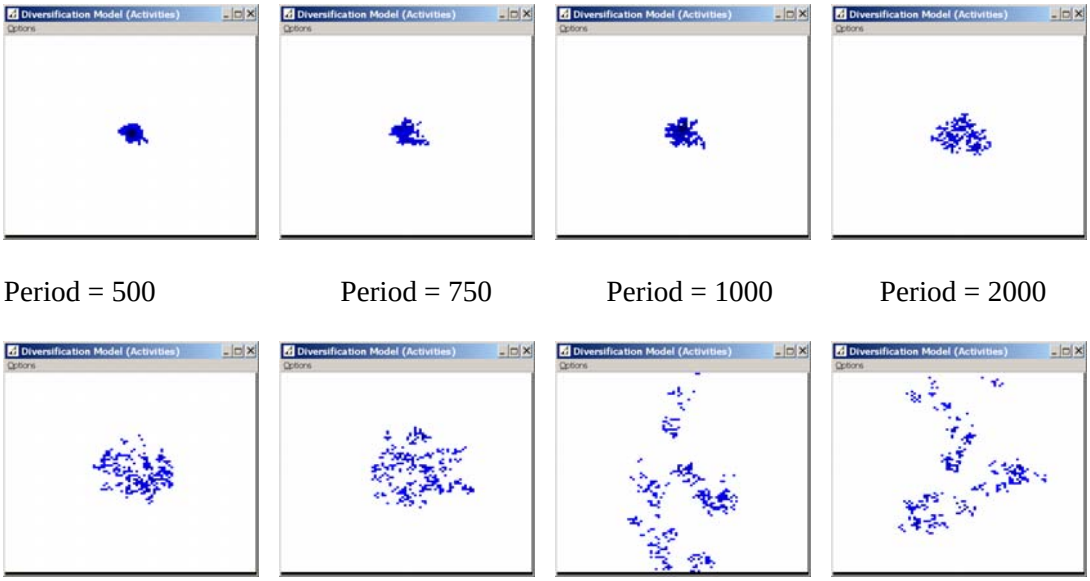


Figure 11 visualizes the evolution of the product portfolio when products have a finite lifetime. The portfolio becomes more and more dispersed, but it still consists of small clusters. These clusters tend to drift apart very slowly. The snapshots taken from a single run illustrate this process.

Figure 11 The development of the product portfolio with product lifetime 500, starting from a single product.



Period = 500 Period = 750 Period = 1000 Period = 2000

Period = 5000 Period = 10000 Period = 50000 Period =150000

A number of robustness checks have been carried out regarding the above results. The results are presented with respect to a product lifetime of 500. The same results emerge with shorter or longer lifetimes. Another aspect of our model is that simulations start with one product. This is motivated by the stylized fact of Teece et al. that ‘the sequence is generally for firms to begin as single product and subsequently become multi-product, rather than the other way around’. Another way of demonstrating the effect of product lifetime on the portfolio is to start from a portfolio consisting of a set of randomly distributed

products.[9] We used a randomly distributed set consisting of 500 products, aged 1 through 500, each with one activity attached to it, and a product lifetime of 500. The results after 1000 periods:

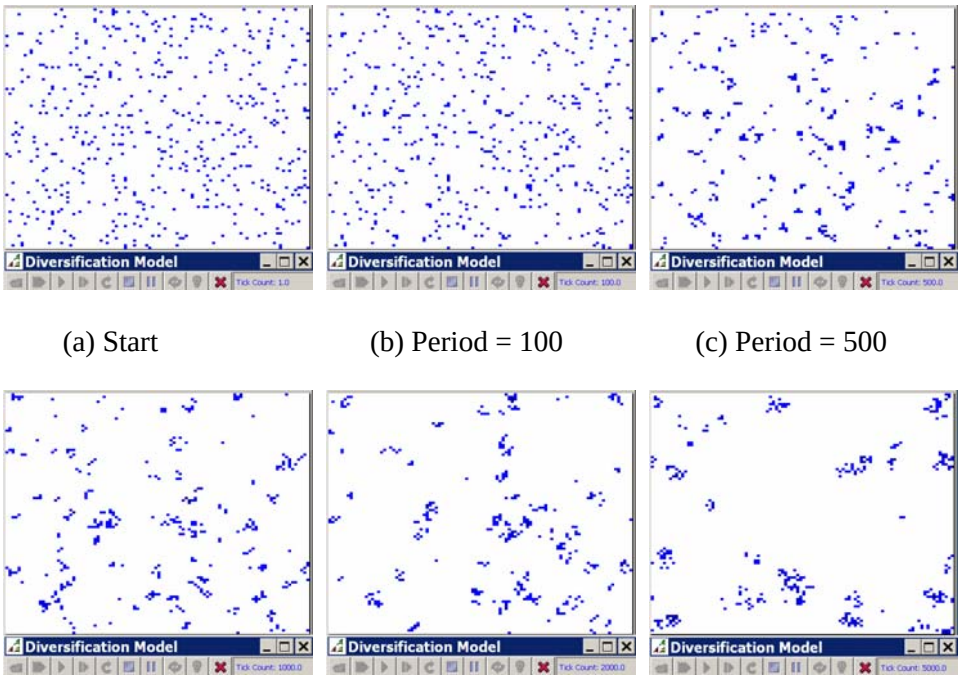
the number of products is reduced from 500 to around 280, resulting in a product diversity index of 280/500 = 0.56;

the random pattern is changed to a pattern of clusters of products; (see Figure 12)

We may conclude that after a sufficient number of periods (a few thousand) it is impossible to tell from which starting condition the divestment took effect, whether it was from the coherent set of products as depicted in Figure 6(a) or from the randomly distributed set of products as depicted in Figure 12(a). So, the results seem to be robust with respect to the starting position.

[9] The edges of the grid have been "pasted together" in the simulation, resulting in a three-dimensional solid called a torus.

Figure 12 The development of the product portfolio with poduct lifetime 500; starting from a randomly distributed set of 500 products aged 1 through 500.



(a) Start (b) Period = 100 (c) Period = 500

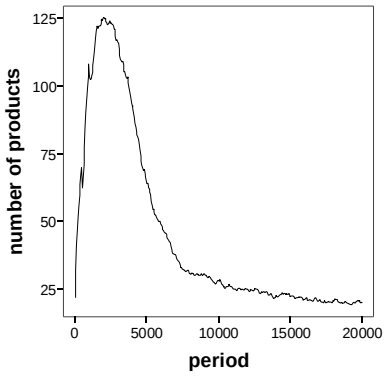
(d) Period = 1000 (e) Period = 2000 (f) Period = 5000

4.3. Mixed product lifetime: Single origin constraint

In the previous section all products were assigned the same finite lifetime. The effect on the portfolio's evolution was that the products and associated activities generally were not centered on the portfolio's first product, as in the first model when all products had an infinite lifetime. This result of the second model may be in correspondence with the way investor owned firms develop their portfolio, but it is certainly not characteristic of cooperatives. Cooperatives are founded by parties who seek to secure an outlet for their produce. Divesting activities related to products in the portfolio at the cooperative's formation is therefore highly unlikely, i.e. cooperatives are characterized by *the single origin constraint*. We model the single origin constraint by assigning an infinite lifetime to the first product in the portfolio, while assigning the same finite lifetime to all other products.

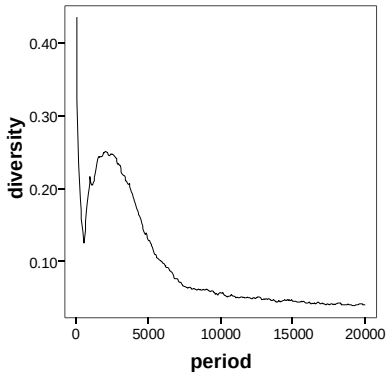
First we look at the number of products in the portfolio. Figure 13 depicts a pattern quite distinct from Figure 2 and Figure 8. During the first 2000 periods (which in this case equals to four times the product lifetime) the number of products increases. However, from then on the number of products starts to decrease. The number of activities associated with the first product will never decrease in the course of time, while all other products will be eliminated in the next 500 periods. This will have an increasing effect on the probability of choosing the first product in the course of time, and therefore decreases the probability of choosing new products.

Figure 13 The number of products in the portfolio per period with single origin constraint and product lifetime 500.



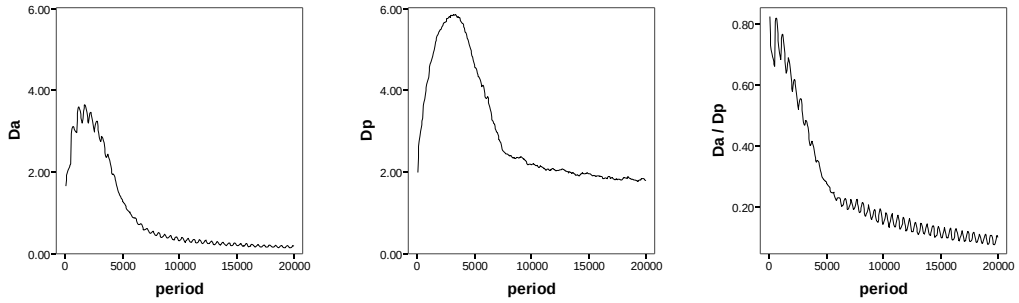
The development of the product diversity index of course is directly linked to the number of products. Figure 14 shows that the product diversity decreases during the periods before divestment starts and from then on starts to increase, just like what happened in the previous model (see Figure 9). Finally, when the concentration effect of the single origin constraint has built up enough strength to counterbalance the expansion effect, the product diversity starts to decrease. Figure 14 reflects therefore roughly the left hand side of Figure 9 and the right hand side of Figure 3.

Figure 14 Development of the portfolio's product diversity index with single origin constraint and product lifetime 500.



The portfolio's dispersion indices show the same pattern (Figure 15). At first the dispersion, both of the product and the activities, increases until finally the single origin constraint takes effect. When this happens, initially both D_A and D_P sharply decrease, and after some time (around period 8000) the rate of the decrease becomes weaker. The decline in the ratio of D_A to D_P is in the single origin constraint case due to the decrease in D_A, whereas this decline is due to an increase in D_P in the previous two cases.

Figure 15 Development of the portfolio's Activities Dispersion (D_A), Products Dispersion (D_P) and the ratio of D_A and D_P per period with single origin constraint and product lifetime 500.



5. Conclusion

This article has formulated a number of results regarding the impact of governance structure on the evolution of product portfolio coherence by using agent-based methodology. More specifically, the impact of

the single origin constraint of cooperatives is investigated when enterprises adopt a concentric diversification strategy. Concentric diversification is made operational by selecting new activities in the Moore environment of the current portfolio of activities, while the single origin constraint is modeled by assigning an infinite lifetime only to the first activity of a cooperative.

Three models have been investigated: infinite product lifetime, finite product lifetime, and a mixed mode of infinite and finite product lifetime. The outcome of the infinite lifetime model is that the concentric diversification strategy results in a coherent portfolio that grows both in height and width, with the founding product at the centre. The outcome of the model with all products having finite lifetime is very much different. The product portfolio of a corporation desintegrates into a random pattern of diverging small clusters in the course of time. Also, the clusters themselves come and go. The reason is that the core of a cluster is eliminated after the first products in the core of a cluster reach their limited lifetime. The outcome of the single origin constraint model, where the founding product had infinite lifetime and all other products a finite lifetime, is that the portfolio starts to expand as in the second model, but the portfolio becomes more and more centered around the location of the founding product. This is due to the increasing number of activities associated with the founding product. A result is therefore that the distribution of product lifetime of products is an important factor in determining the coherence of the product portfolio of enterprises. To be more specific, our model indicates that product portfolios evolve into many clusters of related products only when all products have finite lifetime. The centripetal effect on portfolio composition of one product with infinite lifetime dominates the centrifugal effect of products with final lifetime, regardless the number of products with finite lifetime.

Various avenues for future research are possible. First, competition between agents can be modeled in various ways. Competition entails that there are at least two agents, and that there is somehow an interaction effect. One way of modeling interaction is that the lifetime of a product is affected by the number of activities of the same product of the rival portfolio. Another way of modeling interaction is to introduce

profits/payoffs as a third characteristic of a product, next to its number of activities (or production units) and its lifetime. The transition rules will again govern the investment and divestment process.

Second, the composition and evolution of product portfolios has been addressed, but this does not determine the direction of the growth activities. Modeling the portfolio problem and the horizon problem along the lines of this article may generate some directionality in the product portfolio. For example, a focus in the Moore neighborhood may account for the difference between related and unrelated diversification, while the lifetime parameter is a natural ingredient of the model for capturing the difference between short and long run projects.[10] A recent study by Ang et al. (2005) shows the background of CEOs has an impact on their divestiture decisions.

Third, various other aspects of governance structure can be taken into account explicitly by the agent-based methodology. A line of inquiry may start with the observation that a cooperative is often characterized as a society of members and a downstream economic entity. The impact of the organization and representation of the society of members in a cooperative may have an impact on the pace of product portfolio decision making. Members in cooperatives vote regarding various policy proposals. These decisions are usually first evaluated in regional membership meetings, and subsequently in the annual general as-

[10] Hendrikse, Smit, & de la Vieter (2007) focus on the relationship between the orientation of decision makers and the directionality of corporate coherence It entails in terms of the grid on the right hand side of the first row that certain 1s are changed in 0s. For example, an agent with a vertical orientation has a 0 in the middle row at the left and right hand side. A vertical orientation may have the interpretation of unrelated diversification, whereas a horizontal orientation, with 0 in the middle column at the top and at the bottom, may be interpreted as related diversification. Hendrikse & Muijen (1998) present a model where the orientation of the agent is to a certain extent determined by the agents in the local neighborhood of the agent.

sembly meeting.[11] The general view is that this democratic decision making process regarding important policy changes is slow. Another aspect of the society of members is that collective ownership requires a method for collective decision-making. Most commonly a democratic decision-making procedure of some sort is employed.[12] A problem with collective decision-making procedures is that they may yield decisions that are (collectively) inefficient in the sense that they do not maximize aggregate surplus because voting power is to a certain extent allocated independent of quantity and / or quality (Hart and Moore 1996). The members of a cooperative want to keep the average member profitability, i.e. profit per member, high, while a corporation makes decisions with the intention to maximize total profits. More specifically, members are mainly concerned about the return on investment of their own farm enterprise, not in the return on investment of the cooperative per se. It results again in the hypothesis that a cooperative diversifies in a different way than an investor owned enterprise. This may have negative implications for the profitability of a cooperative.

Finally, firms can have excess capacity in resources according to the resource-based view (Penrose 1959). The resources can be redeployed in new businesses, i.e. product diversification. Several types of resources can be used for diversification (Chatterjee and Wernerfelt 1991). A priori, no differences with respect to physical and intangible assets can be expected, but, in general, cooperatives have less financial resources than corporations. Specifically, cooperatives can only generate additional equity by retaining earnings and obtaining extra funds from the limited pool of members. In contrast, corporations can retain earnings and raise additional equity in the stock market from any investor who is willing to take the risk. Consequently, cooperatives may have fewer means to diversify than corporations. This results in the hypothesis that the frequency of product portfolio changes is lower for a cooperative than an investor owned

[11] The production nature of the relationship between the member and the cooperative entails that there are also frequent (informal) interactions.

[12] Votes in cooperatives are usually aggregated by a one-member-one-vote scheme, although some cooperatives adhere to weighted votes by the volume of patronage.

firm. We intend to investigate the implications of some of these observations in future research using agent-based methodology.

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