Participatory innovation: lessons from breeding cooperatives

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Participatory Innovation: Lessons from breeding cooperatives

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Abstract

Throughout the last decades, breeding in the plant sector, husbandry and aquaculture has come under the ownership control of multinational, investor-owned firms. Breeding in these sectors is risky business, but can be extremely profitable for the involved parties. Against high odds, a few breeding cooperatives have successfully increased their competitiveness in breeding by means of collectively organized innovation, here referred to as "Participatory Innovation". Illustrated by data from two Norwegian breeding cooperatives, we explore conditions for success at intra- and inter-organizational levels. Two factors seem particularly important: (a) Members are leveraged as co-innovators and benefit from a multiplier-effect and (b) The breeding cooperatives have established strategic alliances with external R&D-actors (research institutions, gene banks etc.). These alliances provide inbound knowledge that enable commodification and commercialization of novel scientific insights at the cooperative level. We argue that "Participatory innovation" is a distinct conceptual mode of innovation, differing from more well-known meta-approaches like "Vertically Integrated Innovation", "Open innovation" and "User innovation".

Keywords

Biotechnology, Breeding, Cooperatives, Participatory innovation.

1. Introduction

A radically new bio-technical platform based on DNA-mapping and genomic selection opens novel business opportunities in plants, husbandry and aquaculture (Hope, 2008; Solberg et al., 2008). Availability of high-density marker maps in combination with cost-effective genotyping enable fast and precise exploration of the complex links between actual genes (genotypes) and trait variation (phenotypes) (Cooper, 2008; Solberg et al., 2008; Tvedt et al., 2007). This new approach to breeding is not for everyone (Parry and Dupré, 2010). The development is both capital- and knowledge intensive. Although the surge of recent biotechnological inventions brings down unit costs of the necessary biotechnical analysis, economic efficiency is still a significant driver for the evolution of new organization forms. Breeding is risky business, but successful industrial breeding can be very profitable for actors who control the necessary technical and commercial resources (FAO, 2007; Feindt, 2012; Romstad and Stokstad, 2005; Rosendal et al., 2005; Van Overwalle, 2009). Multinational investor-owned firms can reduce their commercial risk in multiple ways; e.g. through continuous upgrading of breeding material or through bio-patenting (Rosendal et al., 2005; Tvedt et al., 2007). Their new inventions and innovations are based on proprietary science of breeding, where in-house inventions can be patented, and thereafter commercialized. Among the market-dominating oligopolists in breeding of plants, husbandry and aquaculture are vertically integrated global companies such as Hendrix, Monsanto, Dow and EW-group (Feindt, 2012; Gura, 2007; Hope, 2008; Howard, 2009).

In the current global breeding market, two small-scale Norwegian breeding cooperatives (Geno and Norsvin) have against high odds managed to build and retain a strong competitive position. Geno and Norsvin is owned by roughly 9500 cattle farmers and 1500 pig farmers, respectively. Both cooperatives are members of the Federation of the Norwegian Agricultural Cooperatives. Their success can be contrasted to the breeding nucleus of the Norwegian salmon and poultry industries, either of which have disintegrated and been taken over by global conglomerates (regarding salmon, see Aarset and Borgen (2015); regarding poultry, see Kolstad (2002); Skarstad and Borgen (2007)). This is the factual background for the research task to be addressed in this article: What explains the success of Geno and Norsvin with regard to innovation and competitiveness? We find that their success is inseparably related to their distinct mode of innovation; summarized here under the label “Participatory Innovation” (PI). Our article discusses the core characteristics, rationale and dilemmas of “Participatory Innovation” in more detail. In section 2, we present the generic conceptual building blocks of this innovation mode. Our methodological approach follows in section 3. Section 4 is devoted to a presentation of the two breeding cooperatives and the politico-economic institutional context into which they are embedded. This presentation leads us to section 5 where we make sense to our findings by integrating empirical findings with selected insights from cooperative theory and innovation theory. Conclusions are drawn in section 6.

2. Theoretical framework: innovation in cooperatives

How do cooperatives work as producers, possessors and mediators of knowledge that are crucial for innovation? To address such questions with specific reference to the two breeding cooperatives, we present selected theories about cooperatives and innovation respectively. Let’s start with core characteristics of the cooperative form. A cooperative is “a user-owned, user-controlled business that distributes benefits on the basis of use” (Cobia, 1989), and operated by a pool of members working for their own benefit (Hart and Moore, 1996). From the perspective of the individual member, the advantages of cooperative membership relate to the creation of joint investments as well as pooling of risks. The cooperative is set up to overcome the members’ diseconomies of scale by realizing a multiplier-effect to the benefit of all members. To reap this benefit from joint action, farmers must delegate some of their decision power to the cooperative of which they are members. Control is transferred from members to the cooperative without transferring asset ownership (Fama and Jensen, 1983; Grossman and Hart, 1986). Ownership right is separated from control and decision rights. Cooperative members retain property rights over their farms and production resources. One implication hereof is that the cooperative form is characterized by incomplete integration of ownership both horizontally and vertically. To overcome this incompleteness, three dimensions of the vertical relation between the individual member(s) and the cooperative need to be coordinated; i.e. the governance relationship, the transaction relationship, and the investment relationship (van Bekkum, 2001). The *governance* aspect refers to the collection of rules structuring the transactions between different stakeholders. The *transaction* aspect involves delivery of the cooperatives' products in return for a price. The *investment* aspect involves contribution of capital (individually and/or collectively), risk-bearing, and right to residual claims (Cook and Iliopoulos, 1998; Nilsson, 2001). These organizational characteristics allow and invite to active engagement from cooperative members' in decision-making and control. Evidently, the cooperative form does not by necessity provide more and better innovations than other organization forms like e.g. the investor-owned form (IOF). We can easily find examples of inefficient cooperative forms plagued by low or no capability to innovate. Several scholarly students of cooperatives have claimed that inefficiency is caused by ill-defined property rights in the cooperative ownership form, followed by a wide range of ex-ante and ex-post incentive problems (Cook and Iliopoulos, 2000; Nilsson, 2001; Vitaliano, 1993). First, the *common-property problem* is concerned with the disparity between members' contribution to the investments and the distribution of benefits that results from these investments (Cook and Iliopoulos, 1998; Nilsson, 2001). If a disparity exists between a member's contribution of equity and the benefit from the same equity, an incentive to "free ride" will emerge. If the common-property problem is improperly solved, the cooperative will probably not be able to provide sufficient risk-bearing equity. Second, the *horizon*-problem stems from the fact that residual claims of cooperatives are contingent rights to cash flows whose validity expires when a member ceases to patronize the organization. The horizon-problem says that members tend to become preoccupied with myopic perspectives on their cooperative membership. “Here-and-now” actions are assumed to dominate long-term, strategic deliberations on the purpose of the cooperative. Third, the *portfolio*-problem refers to the situation that members may have diverse risk/reward-profiles. As long as cooperative members have unequal time horizons, there will be different evaluations and preferences with respect to the cooperative’s risk/reward-profile. Portfolio problems can give rise to further differences in preferences among subgroups of members, with a general tendency for them to favor decisions with lower levels of risk. These problems may weaken active engagement among members as well as inhibiting the cooperative’s innovative capacity.

The intriguing question is under what conditions cooperatives can ameliorate inherent incentive-problems of various types. The scholarly literature on cooperatives underline that cooperatives are "incompletely integrated" horizontally and vertically (Nilsson, 2001). Subsequently, the vertically integrated innovation mode (VII) (Bogers and West, 2010; Chandler, 1977, 1990) is not as appropriate and efficient for cooperatives as for Investor-owned firms (IOFs). So how do cooperatives actually innovate? The emerging field of distributive innovation research has recently opened the door for several alternatives to the in-house vertical integrated innovation model (West et al., 2014). In particular three antecedents to this renewed interest in innovation theory tend to be emphasized; i.e. the emerging understanding that innovation has its roots outside the firm (e.g. Allen (1977)), the studies by Teece (1986) on how firms profited from their innovations, and the growing interest in business models following the new value chains of the digital industries (see Chesbrough and Rosenbloom (2002)). In this paper, we use elements from particularly three meta-theories of innovation (VII, OI, UI) in order to construct another ideal-type, which we entitle "Participatory Innovation" (PI). None of these provides a realistic account of reality; they are rather constructed to help *structuring* the complex reality of innovation activities. So how can cooperatives innovate efficiently? There's obviously no generic answer to this question. We take as our point of departure that this is an empirical question. More specific knowledge can be gained through empirical studies of cooperatives that have successfully innovated to a significant degree over a long time period. The two breeding cooperatives Geno and Norsvin can contribute with relevant knowledge. We explore the two cases in section 4, but will first (section 3) present our methodological approach.

3. Methodological approach

The two breeding cooperatives – Geno and Norsvin – have been selected by virtue of being unusual or even extreme (Flyvbjerg, 2006). "Unusual" here refers to success against high odds for this particular type of organization. To our knowledge, no other breeding cooperatives have hitherto managed to succeed equally well as Geno and Norsvin. As claimed by Stake (1994), a researcher may have intrinsic or instrumental research interests, or any combination of the two. An *intrinsic* case study is undertaken because one wants to better understand the particular case in question. The study is not undertaken primarily because the case represents other cases or because it illustrates a particular trait or problem, but because, "in all its particularity and ordinariness, this case itself (be it a specific organization, project, person event etc.) is of interest" (Stake, 1994, p. 237). Also according to Stake (1994), the purpose is different in *instrumental* case studies. Stake argues that the case is of secondary interest; it plays a supportive role, facilitating our understanding of something else. In other words, the most interesting issue is not whether the cases are typical or not. Our discussion in this article is predominantly conceptual and instrumental in nature, but first and foremost inspired by the real-life experiences and success of two Norwegian breeding cooperatives. Our purpose is to expand and generalize theory, more than to enumerate frequencies. The basic idea and core concept we expand here is entitled Participatory Innovation. Our empirical study of the two breeding cooperatives are not samples in the strict statistical sense of the word. Rather, our selection of cases is driven by theoretical suppositions (Eisenhardt, 1989) and a wish to contribute to innovation theory. The typology by Bogers and West (2012) distinguish between three ideal-typical modes of innovation: vertically integrated innovation, open innovation and user innovation. Data and lessons from our case-studies are used to extend Bogers and West's typology. We advance a fourth ideal typical mode of innovation, labelled "Participatory Innovation".

Our primary source of data is semi-structured interviews with 15 persons who have first-hand insights about agribusiness in general and breeding cooperatives in particular. Twelve of the informants are in top positions in cooperatives. The last three informants are experts representing other parts of the Norwegian agribusiness and aquaculture industries. Our secondary data source consists of research reports and annual reports, articles in newspapers and magazines, as well as the breeding cooperatives' internal memos and international studies of the status of genetic resources in the agriculture sector.

4. A narrative of success against high odds

In 2007, the FAO (Food and Agriculture Organizations of the United Nations) conducted an independent evaluation of multiple contemporary breeding programs throughout the world. One finding was that breeding over decades had become less and less sustainable (FAO, 2007). FAO credited the Norwegian breeding cooperative Geno for being an important exception to this trend. Geno was accentuated as "one of few European examples of sustainable breeding" (Waterhouse and Solberg, 2009). The FAO-investigation summarized as follows:

> *"In the Nordic countries, specific importance is given to fertility traits, calving and disease resistance, with the Norwegian Red (NRF) and the Swedish Red and White breeds as particular examples. The specific breeding objectives implemented in the NRF (Norsk Rødt Fe) have meant that breeders see semen from this breed as a viable alternative to that produced by the large, international breeding companies." (Cited from FAO (2007:229)).*

Norsvin was commended equally well. The question we address here is: How come? How can this success against high odds be explained? We set particular focus on the mode of innovation of the two breeding cooperatives (section 5), but will first briefly present some core characteristics of their organizational structure as well as their historical context.

The Cattle-Breeding Cooperative 'Geno' is the breeding organization for Norwegian Red Cattle (Norsk Rødt Fe: NRF), the main dairy cattle breed in Norway (Waterhouse and Solberg, 2009). Geno was established in 1935 and is currently owned by 9 500 Norwegian farmers (Geno, 2015). In 2012, the number of dairy cows were just above 230 000 (SSB, 2015b), corresponding to an average of 25 cows per farmer. The Norwegian Pig-Breeding Cooperative 'Norsvin' is a farmer-owned breeding cooperative, established in 1958 (www.norsvin.com). Norsvin is owned by approximately 1 500 Norwegian pig producers and organizes all pig breeding in Norway (Norsvin, 2015b). There are approximately 1.5 million pigs in Norwegian pig farms (SSB, 2015a).

Individual members provide record-data to breeding programs

In the first half of the last century, the Norwegian government was in charge of the cattle-breeding program. Their national program was based on the principle of distinct and endemic races (Hersleth, 2010). However, this approach was not in tune with modern principles of breeding as taught at contemporary schools of agriculture. When the cooperatively owned Geno's predecessor was established in 1935, the preferred breeding goals of the cooperative were therefore in opposition to the principles of the government's program (Hersleth, 2010). The government's power rested on subsidies to holding of bulls and selection of animal for exhibitions. The initiation of artificial insemination and sale of semen empowered the farmers vis a vis the government (Hersleth, 2010). In a private exhibition in the early 1950s, product return and brood stock were added as criteria, on the expense of the exterior. Few years later, the cooperatively controlled NRF-race documented better yields than other races (Hersleth, 2010). Gradually, scholarly breeding experts joined forces with the evolving breeding cooperative and established a relationship that still is the foundation for brood stock improvements. The breeding program of the cooperative was based on continuous research and development in the dairy cattle breeding and genetics, fertility and artificial insemination. Geno gradually developed a mode of innovation where the pool of members (who are also the end-users of the breeding products) actively engaged both in setting breeding goals (Halvorsen, 2016) and in collecting health data for cows. A country-wide health-card system for dairy cows ("Ku-kontrollen") was initiated in 1975. All cows in this system have their own individual health-card where all data about health, fertility and treatments are noted. The health-card system has over decades proved essential for the continuous breeding of Norwegian Red, but also for preventive health measures, planning, and development of statistics (Ruane et al., 1997). In Norway, the system was first applied on a national basis in 1975, with help from the Society of Veterinarians and the Cattle Recording Service. The contribution by the members of Geno to the data recording scheme has been tremendous. The program has also enabled the cooperative and its members to retain control of the breeding targets (Ruane et al., 1997). In their evaluation of Geno's breeding program, Ruane et al. (1997) concluded that the members indeed retain trust in the breeding program, simply because they have experienced that it works over time. The cooperative has remained strong and in charge of the breeding operations on behalf of its members. The members believe in Geno's merit of breeding and co-finance the costs of data recording.

As in the cattle sector, the State previously had great control with the breeding program in the pig sector as well. An illustration of the political and countervailing power aspect of the early organization is the struggle over the exhibition rules emphasizing that the exterior had to yield to other productive traits. The position of the State's pig-breeding facilities was threatened as they made a profit from selling livestock, and the power structures protected these facilities (Jensen, 2008).

The pig farmers learned from the cattle farmers – some were cattle farmers themselves – and molded Norsvin on the experiences from Geno (Jensen, 2008). Norsvin adopted three guiding principles at its initiation; i.e. "Farmer participation in breeding decisions", "Inclusion of new research in breeding practices", and "Progress for all" (Jensen, 2008). The researchers at the Agriculture University of Norway (Now: The Norwegian University of Life Sciences (NMBU)) were a significant part of this structure from day one as the respected breeding specialist professor Harald Skjervold was elected to the breeding council on the Constituent foundation meeting in 1958 (Jensen, 2008).

Norsvin gradually developed programs for pure breeding, crossbreeding and artificial insemination. The aim of Norsvin's genetic program has been to ensure effective, healthy and robust pigs that perform well under different contingencies and production environments. The members of the cooperative agreed that the genetic program must ensure end-products of high quality, and contribute to ethical and sustainable production. The structure and qualities of Norsvin's genetic program is observed and summarized as follows by Committee on Farm Animal Genetic Resources (2003:20):

> *"Pig breeding is organized as a traditional breeding pyramid, in which the breeding herds are at the top. These herds produce and deliver potential breeding males for testing and cross-bred or pure-bred females for the multiplier level. The multiplier level sells females to commercial producers. Contract breeding is used for Durocs, and Duroc-crosses are only available for the members of the meat cooperative"*.

The sustainability of Geno's breeding program is promoted by the fact that both production and function are expressed by multiple traits (FAO, 2007). Many different combinations can result in high total breeding value. As observed by Risan (2003) and Vangen (2007), breeding is based on data from ordinary dairy herds, which ensures that the breeding program produces animals that are well adapted to ordinary production conditions. More specifically, "ordinary production conditions" refer to the varied climatic and geographical conditions that characterize Norwegian agriculture. According to FAO, three features are found to be particularly important with regard to sustainability of Geno's breeding program (FAO, 2007:399):

- *"Both production and function are expressed by many traits, and are strongly weighted in the breeding strategy.*
- *Many different combinations can result in a high total breeding value. This means that animals from different breeding lines can be selected, thus automatically reducing the risk of inbreeding.*
- *The breeding work is based on data from ordinary dairy herds. In connection with the diversity of traits applied, this guarantees that the breeding*

programme produces animals that are well adapted to normal operating conditions."

Data registrations in breeding herds owned by the cooperative members are the basis for the selection of the breeding goal traits (Jensen, 2008). Norsvin's breeding goals consist of a broad spectrum of traits; from production, carcass quality, meat quality, litter size, reproduction and maternal ability onto robustness traits. Breeding goals are revised in line with industrial development, market changes, and scientific advancements. In the post WWII-era, the breeding goals were decided by the State Pig-Breeding Commission, but the cooperative gradually took over. The cooperative's capacity to coordinate the breeding activity was much better, and in 1964 the Commission was dismantled (e.g. Jensen, 2008:58). Results from simulation studies indicate that genomic selection can boost genetic progress with 20-40 % in the maternal line (Grindflek, 2012). Norsvin delivers this genetic progress both to own members and to customers abroad.

Each member of Norsvin participates in innovation by providing a large amount of production data from their breeding herds to the cooperative. On-farm testing of gilts contributes to several new exterior traits since it ensures higher variation in the material (Norsvin, 2010). New tools and methods – such as Computed Axial Tomography (CAT) – enhance breeding for meat and fat quality. Both Norwegian and international herds comprise Norsvin's nucleus populations. Herds from a wide range of different farms are linked together genetically by Artificial Insemination and central testing. The cooperative reports that there were 42 Norwegian nucleus herds in 2015 (Norsvin, 2015a). Their main role is to run the nucleus-breeding program and deliver candidates to the boar test. Registration of data from the nucleus herds serve as an important basis for the calculations of breeding herds. The cooperative invests approximately 30 % of the total company turnover in R&D, and the cooperation with various actors in the Norwegian industry has enabled a broad R&D-front.

The cooperative organization form has streamlined the complex link from invention and new science to innovation and new practice.

From the early start as a countervailing power to the state-controlled national breeding programs, the farmer-owned cooperative has developed sustainable breeding programs of high quality. The members gathered more influence over the breeding programs through active participation by providing information about their animals' health traits, fertility, growth and other production factors. An organized sow control formed the basis for a number of breeding measures, registration of returns and fertility, and studbook registration (Jensen, 2008:50).

The centralistic and hierarchical state-governed programs for cattle as well as pig breeding were gradually suspended. The farmers – the users of livestock – seized control over input to their on-farm production. Members were actively involved in the design and operation of breeding programs, and unique combinations of breeding traits ensured the improvements of the programs. Data was first registered and collected at the level of individual cows and pigs. Thereafter, data was accumulated and analyzed by the cooperative, and the results were shared by all the members of the cooperative. The unique breeding traits were identified by the farmers' voice in the appropriate decision-making bodies. The first seed to the innovation mode "Participatory Innovation" was sown.

The cooperatives benefit from strategic alliances with R&D-institutions

Continuous and effective recording of data is but one important driver behind the success of Geno and Norsvin. To fulfill its mission, the two breeding cooperatives need high quality R&D-capacity. Therefore, the antecedents of Geno and Norsvin integrated tightly with relevant agricultural research institutes, such as the Agricultural University of Norway. Geno and Norsvin have reinforced complementary collaborations with external R&D-partners for decades. The collaborative structure has been reinforced because of the enabling modern biotechnology (e.g. cost-effective genotyping). Public research institutions and scholarly teams from the breeding cooperatives co-produce knowledge that is useful for the refinement of commercialized products and services. Said differently, breeding cooperatives join forces with scholarly organizations in the invention-phase, and thereby come in position to use their newfound knowledge in the commodification and commercialization of products and services for the global market. Geno and Norsvin – in the vocabulary of Etzkowitz and Leydesdorff (2000) – partake in Triple-Helix configurations, consisting of dynamic interrelations between university, industry and government (Figure 1).

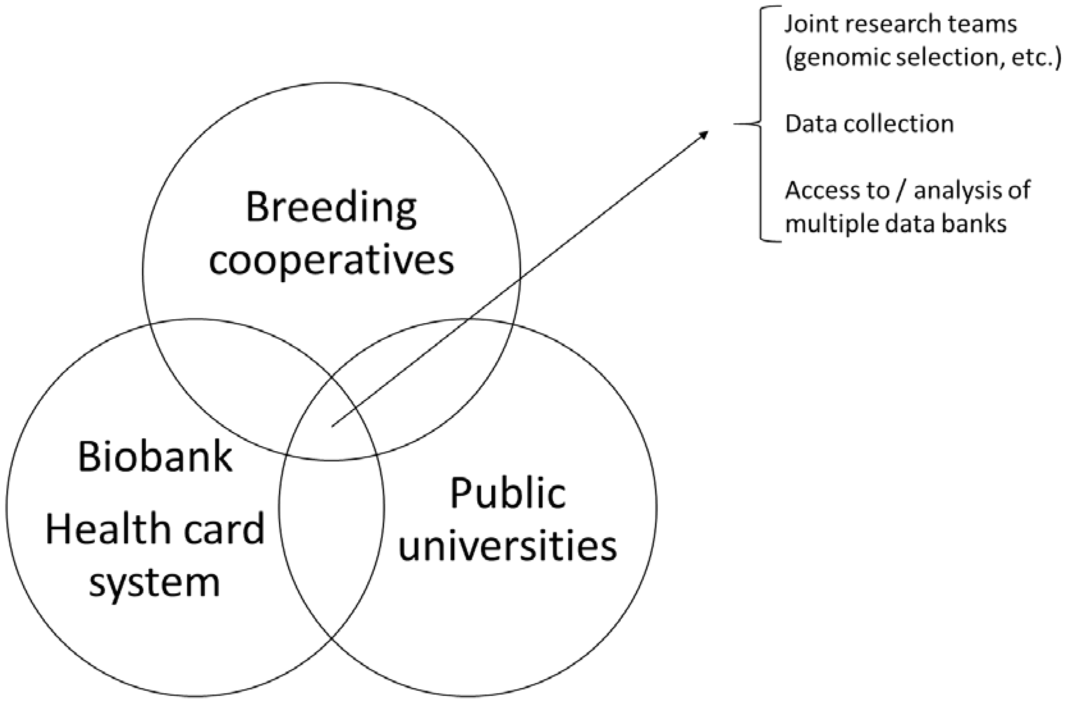

Figure 1: Inter-organizational networks (applied from Etzkowitz and Leydesdorff (2000)).

To wrap up, the individual members of Geno and Norsvin contribute both to data collection and to the overall setting of breeding targets for their respective production system. As will be clarified in the next section, this activity has strong resemblance to “User Innovationshare" in innovation theory (Bogers and West, 2012). Moreover, a significant part of the cumulative inventions takes place and is located outside the organizational boundaries of the cooperatives, in close partnership with their collaborating R&D-institutions. Ultimately, Geno and Norsvin have control of the in-house commodification and commercialization of the products they bring to the market. As will be clarified in the next section, this tight interplay has strong resemblance to "Open Innovation-inbound" in innovation theory (Bogers and West, 2012).

5. Participatory Innovation as composed by UI-share and OI-inbound

The two breeding cooperatives Geno and Norsvin are special-cases of a mode of innovation that we coin "Participatory Innovation" (PI). We substantiate PI by comparing core aspects of this mode of innovation with the more well-known ideal types Vertically integrated innovation (VII), Open Innovation (OI) and User Innovation (UI) , all presented by Bogers and West (2012). VII, OI and UI combine knowledge created at different loci, across multiple stakeholders in various value chains and networks. VII takes into account that the sources of innovation are largely *inside* the boundaries of the firm. Particularly two modes of distributed innovation have so far been described in detail in the scholarly literature; i.e. OI (Chesbrough, 2011; West and Lakhani, 2008) and UI (von Hippel, 1988, 2005). Both OI and UI take as their point of departure that the sources of innovation are largely *outside* the boundaries of the firm. Following Chesbrough (2011) as well as West and Lakhani (2008), OI concentrates on the permeability of organizational boundaries in an effort to understand how internal and external knowledge are used to develop and commercialize valuable innovations. Following von Hippel (1988, 2005), UI assumes that users have the necessary knowledge and motivation to create innovations that solve needs unmet by existing producers. Whereas OI research is ultimately interested in innovation benefits for a producer firm, UI research focuses on the conditions under which users innovate and how users are supported in order to be more innovative.

In contrast, PI pays particular attention to the conditions under which individual members – and/or member communities of users as exemplified by the cooperative – take part and participate in innovation activities. When successful, PI evoke a multiplier-effect that enable each individual user-member to reap benefits that would have been unattainable without collective organization of this type (Cook and Plunkett, 2006; Plunkett et al., 2010). The multiplier effect can be exemplified by each farmer's access to (the output of) universal data. Each farmer invests time and effort in collecting and sharing data from his own farm and receives in return improved breeding material. PI benefits from the inherent self-regulation in a relatively homogenous group, as nicely immortalized by Alexandre Dumas in the Three Musketeers: "One for all, all for one".

In our analysis, we elaborate on "OI-inbound" and "UI-share", which are most relevant for the cases. "OI-inbound" enhance our understanding of the value of the agriculture research community for the breeding cooperatives. "UI-share" serves as a framework for understanding the mechanism among the users of the newfound knowledge produced in collaboration with the research community. Geno and Norsvin have successfully leveraged individual members as co-innovators, and thereby enabled all members to benefit from a multiplier-effect. This situation is captured in the sub-category UI-share . In short, PI draws on well-known elements from both VII, OI, and UI, but is nonetheless a distinct mode of innovation. The core characteristics of the different modes of innovation are presented in table 1.

Table 1: A typology of innovation modes (refined from Bogers and West (2012)).

Attribute	**Vertically integrated innovation**	**Open innovation**	**User innovation**	**Participatory innovation**
Subtypes		**OI-inbound** OI-outbound	UI-input UI-self **UI-share** UI-startup	OI-inbound UI-share
Main propositions	End-to-end innovation	Firms commercialize ideas from network	Users or user-producer dyads innovate	Members leveraged as resources
Representative works	Chandler (1977, 1990)	Chesbrough (2003, 2006)	von Hippel (1988, 2005)	
Key stakeholder	Firm	Firm	User	Member
Other stakeholders	-	Other firms in value network	Producers	External partners in value networks
Locus of innovation / knowledge	Within firm	Outside firm	Among users	Among members
Key success measures	Profit	Profit	Quantity of (significant) innovations	Profit
Level of analysis	Firm	Firm	Innovation	User-controlled firm
Type of innovator	Organizational	Organizational	Individual	Member
Assumed motivations	Pecuniary	Pecuniary	Utility	Pecuniary
Norms	Managerial hierarchy	Market exchange	Cooperation	Long-lasting cooperation based on serial reciprocity
Relationship with other innovators	None	Exchange	Cooperate	Cooperate

In VII, knowledge is possessed, produced and mediated within the organizational borders of one firm, as illustrated by the huge investor-owned breeding companies. PI is distinctively different from the ideal type VII because activities in the latter are integrated horizontally and vertically through ownership whereas PI first and foremost is appropriate for organizations that are incompletely integrated horizontally and vertically. PI is also distinctively different from the ideal type Open Innovation (OI). In fact, PI can be conceived of as open innovation for members of a defined community only (West and Lakhani, 2008). Only eligible members have access to the knowledge; typically farmers that want to buy the products and services that the cooperative can offer. Finally, PI has strong resemblance to UI, but the two ideal types differ in nature since PI-members are ultimately profit-seekers (with pecuniary motivation), whereas users are typically described as non-profit actors (von Hippel, 1988, 2005).

The cooperative is an association of individual members who are self-employed and ultimately responsible for the financial results of their on-farm business. Members` motivation is to run their own farm in a profitable and sustainable manner. But the cooperative members are bound together by the cooperative. Progress for each member is attained by transferring individual autonomy to the collective in the case of resource-demanding tasks like e.g, breeding. Each member co-participate in collective innovation through co-determining the collective breeding goals and provide crucial data from their own farms.

6. Concluding remarks

We started this article by addressing the uncertain future of small-scale breeding cooperatives, given that giant multinational firms increasingly seize control of the novel breeding technologies. As mentioned in the introduction, the in-firm phenomenon VII (Chandler, 1990) is the dominating mode of innovation in breeding of plants, husbandry and aquaculture. Invention as well as innovation are under the hierarchical control of a very limited number of multinational, investor-owned companies. Innovation is organized as a path from new discoveries, through in-firm research and development, to commercialization and distribution to the market. Ideas – generated internally and/or purchased by mergers and acquisitions – are commercialized by vertically integrated resources (Bogers, 2012; Bogers and West, 2010; Chesbrough et al., 2006; Petrusson, 2004; von Hippel, 1988). Intellectual property is protected in order to safeguard company interests and to prevent exploitations from rivals.

Against high odds, the two small-scale Norwegian breeding cooperatives presented in this article have successfully developed and retained a strong position in the market for breeding products for cattle and pigs. The success of Geno and Norsvin was reinforced when international producers began to ask for products from the two breeding programs, because these encompassed qualities that were lost in the other more industrious breeding programs. What lessons can be extracted from the experiences and success of these two breeding cooperatives? To answer this question, we have drawn on the typology of innovation modes that is developed by Bogers and West (2012). We found that the success of Geno and Norsvin is explained by one intra-organizational factor (the way members are leveraged as co-innovators) in combination with one inter-organizational factor (the way strategic alliances with universities and gene banks are leveraged to secure inbound knowledge to the cooperative). The two breeding cooperatives have proved their capacity to commodify and commercialize the co-inventions developed through strategic partnerships with scholarly R&D-institutions. To sum-up in the vocabulary of innovation theory, the two breeding cooperatives have successfully commercialized novel products by combining data from its own members (cf. "UI-share") with the inflow knowledge from R&D-institutions (cf. "OI-inbound"). We have coined this combination "Participatory Innovation". The two cases demonstrate that small-scale breeding cooperatives under certain critical contingencies are capable to select, form and retain an idiosyncratic innovation mode that is tailor-made to the needs of the cooperative members and their customers. Thanks to the distinct mode of innovation that they have successfully developed since the 1950's, the two breeding cooperatives have also successfully ameliorated inherent incentive problems, predominantly because the cooperative members – regardless of farm size, location etc. – are interested in constantly improved breeding material. Neither the "common property", "horizon" nor “portfolio” problems (Borgen, 2004; Nilsson, 2001; Vitaliano, 1993) have unfolded in the two cases.

To wrap up, Geno and Norsvin are two information-rich examples of small-scale organizations with active memberships, i.e. members leveraged as co-innovators through providing data of various types (a special case of UI-share) and strong external alliances (a special case of OI-inbound) that can benefit from optimizing innovation activities on their own terms. Like the other innovation modes (VII, OI and UI) that have hitherto been more investigated among scholars, PI is evidently a useful ideal-type. Our final remark is that all these ideal-types – separately and jointly – help us to identify and create awareness of core aspects of reality, but without being able to describe reality in any full detail. This further means that the Participatory Innovation-mode we have substantiated here can also contribute to understand organizations that are not cooperatively owned, as long as their success depends on distributive features like sharing of data and inbounding of knowledge.

References

Aarset, B., and Borgen, S. O. (2015). The battle of the eyed egg: Critical junctures and the control of genes in Norwegian salmon farming. *Aquaculture* **445**, 70-78.

Allen, T. J. (1977). "Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization," MIT Press, Cambridge, Mass.

Bogers, M. (2012). Knowledge sharing in Open Innovation: An Overview of Theoretical Perspectives on Collaborative Innovation. *In* "Open Innovation at Firms and Public Administrations: Technologies for Value Creation." (C. de Pablos Heredero and D. López, eds.), pp. 1-14. IGI Global, Hershey, PA.

Bogers, M., and West, J. (2010). Contrasting Innovation Creation and Commercialization within Open, User and Cumulative Innovation. *In* "*Academy of Management conference, Technology and Innovation Management division*".

Bogers, M., and West, J. (2012). Managing Distributed Innovation: Strategic Utilization of Open and User Innovation. *Creativity and Innovation Management* **21**, 61-75.

Borgen, S. O. (2004). Rethinking incentive problems in cooperative organizations. *Journal of Socio-Economics* **33**, 383-393.

Chandler, A. D. (1977). "The Visible Hand: The Managerial Revolution in American Business," Belknap Press, Cambridge, Mass.

Chandler, A. D. (1990). "Scale and Scope: The Dynamics of Industrial Capitalism," Belknap Press, Cambridge, Mass.

Chesbrough, H. W. (2003). "Open Innovation: The New Imperative for Creating and Profiting from Technology," Harvard Business School Press, Boston, MA.

Chesbrough, H. W. (2006). Open Innovation: A New Paradigm for Understanding Industrial Innovation. *In* "Open Innovation: Researching a New Paradigm" (H. W. Chesbrough, W. Vanhaverbeke and J. West, eds.), pp. 1-12. Oxford University Press, Oxford.

Chesbrough, H. W. (2011). Bringing Open Innovation to Services. *Mit Sloan Management Review* **52**, 85-+.

Chesbrough, H. W., and Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: Evidence from Xerox Corporation's technology spin-off companies. *Industrial And Corporate Change* **11**, 529-555.

Chesbrough, H. W., Vanhaverbeke, W., and West, J. (2006). "Open Innovation: Researching a New Paradigm," Oxford University Press, Oxford.

Cobia, D. (1989). "Cooperatives in Agriculture," Prentice Hall, Englewood Cliffs.

Committee on Farm Animal Genetic Resources (2003). "Norway country report on farm animal genetic resources, 2002," Ås.

Cook, M. L., and Iliopoulos, C. (1998). Solutions to Property Rights Constraints in Producer-Owned and Controlled Organizations: Prerequisite for Agri-chain Leadership? *In* "Proceedings of the Third International Conference on Chain Management in AgriBusiness and Food Industry" (G. W. Ziggers, J. H. Trinekens and P. J. P. Zuurbrier, eds.). Wageningen Agricultural University, Wageningen, The Netherlands.

Cook, M. L., and Iliopoulos, C. (2000). Ill-defined Property Rights in Collective Action: The Case of US Agricultural Cooperatives. *In* "Institutions, Contracts and Organization. Perspectives from New Institutional Economics" (C. Menard, ed.). Edward Elgar, Cheltenham, UK.

Cook, M. L., and Plunkett, B. (2006). Collective entrepreneurship: An emerging phenomenon in producer-owned organizations. *Journal of Agricultural and Applied Economics* **38**, 421-428.

Cooper, M. (2008). "Life as Surplus: Biotechnology and Capitalism in the Neoliberal Era," University of Washington Press, Seattle.
Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *Academy of Management Review* **14**, 532-550.
Etzkowitz, H., and Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy* **29**, 109-123.
Fama, E. F., and Jensen, M. C. (1983). Separation of ownership and control. *Journal of Law and Economics* **XXVI**, 301-325.
FAO (2007). "The State of the World's Animal Genetic Resources for Food and Agriculture." Commission on Genetic Resources for Food and Agriculture, Food and Agriculture Organization of the United Nations, Rome.
Feindt, P. H. (2012). The politics of biopatents in food and agriculture, 1950-2010: Value conflict, competing paradigms and contested institutionalisation in multi-level governance. *Policy and Society* **31**, 281-293.
Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry* **12**, 219-245.
Geno (2015). Om Geno SA. Vol. 2015.
Grindflek, E. (2012). "Genomics Tools Increase Genetic Gain by 20-40%." Norsvin, Hamar.
Grossman, S. J., and Hart, O. D. (1986). The Costs and benefits of ownership: A theory of vertical and lateral integration. *Journal of Political Economy* **94**, 691-719.
Gura, S. (2007). "Livestock Genetics Companies: Concentration and Proprietary Strategies of an Emerging Power in the Global Food Economy," Ober-Ramstadt, Germany.
Halvorsen, B. E. (2016). Arvegullet. *In* "A-magasinet", pp. 18-28. Aftenposten, Oslo.
Hart, O., and Moore, J. (1996). The governance of exchanges: Members` cooperatives versus outside ownership. *Oxford Review of Economic Policy* **12**, 53-69.
Hersleth, E. (2010). NRF-historien, del 1 [The NRF history, part 1]. *In* "Buskap, Fagbladet for norske storfebønder". Geno, Hamar.
Hope, J. (2008). "Biobazaar: The Open Source Revolution and Biotechnology," Harvard University Press., Cambridge, Mass.
Howard, P. H. (2009). Visualizing consolidation in the global seed industry: 1996-2008. *Sustainability* **1**, 1266-1287.
Jensen, A. (2008). "Et avlsselskap i verdensklasse: Norsvin 1958-2008 [A world class breeding company: Norsvin 1958-2008]," Hamar.
Kolstad, N. (2002). Avl og reproduksjon [Breeding and reproduction]. *In* "Fjørfeboks". Landbruksforlaget, Oslo.
Nilsson, J. (2001). Organisational principles for co-operative firms. *Scandinavian Journal of Management* **17**, 329-356.
Norsvin (2010). In 2010 the Norsvin on-farm test underwent a significant upgrade. The new model ensures more accurate ranking of animals and thus improved selection., Vol. 2016. Norsvin.
Norsvin (2015a). Godkjente avlsbesetninger [Approved nucleus herds].
Norsvin (2015b). "Norsvin SA Årsberetning [Norsvin Annual report 2014]." Norsvin, Hamar.
Parry, S., and Dupré, J. (2010). "Nature After the Genome," Wiley-Blackwell.
Petrusson, U. (2004). "Intellectual Property and Entrepreneurship: Creating Wealth in an Intellectual Value Chain," Center for Intellectual property studies, Göteborg.
Plunkett, B., Chaddad, F. R., and Cook, M. L. (2010). Ownership structure and incentives to invest: dual-structured irrigation cooperatives in Australia. *Journal of Institutional Economics* **6**, 261-280.

Risan, L. C. (2003). "Hva er ei ku? Norsk Rødt Fe som teknovitenskap og naturkultur [What is a Cow? Norwegian Red as Techno-Science and Nature-Culture]." Faculty of Arts, University of Oslo, Oslo.

Romstad, E., and Stokstad, G. (2005). "Valuation of Genetic Resources." Department of Economics and Resource Management, Norwegian University of Life Sciences, Ås.

Rosendal, G. K., Olesen, I., Bentsen, H. B., Tvedt, M. W., and Bryde, M. (2005). "Strategies and Regulations Pertaining to Access to and Legal Protection of Aquaculture Genetic Resources," Rep. No. 7. Fridtjof Nansen Institute, Lysaker.

Ruane, J., Klemetsdal, G., and Heringstad, B. (1997). Health traits data for dairy cattle in Norway: An overview and new opportunities. *In* "Int. Workshop on Genetic Improvement of Functional Traits in Cattle-Health Traits", pp. 19-24 Int. Bull. Eval. Serv., Uppsala, Sweden.

Skarstad, G. Å., and Borgen, S. O. (2007). "Norwegian Poultry Farmers' View on Animal Welfare," Rep. No. 4. Norwegian Agricultural Economics Research Institute, Oslo.

Solberg, T. R., Sonessen, A. K., Woolliams, J. A., and Meuwissen, T. H. E. (2008). Genomic selection using different marker types and densities. *Journal of Animal Science* **86**, 2447-2454.

SSB (2015a). "Husdyrhald, 1. januar 2015, førebelse tal [Livestock, 1 January 2015, preliminary figures]." Statistics Norway.

SSB (2015b). Tabell: 03710: Husdyr per 1. januar, etter husdyrslag [Table: 03710: Fram animals per January 1st, by livestock species]. Statisics Norway.

Stake, R. E. (1994). Case Studies. *In* "Handbook of Qualitative Reserach" (N. K. Denzin and S. L. Yvonna, eds.). Thousand Oaks, Sage.

Teece, D. J. (1986). Profiting from technological innovation. *Research Policy* **15**, 285-306.

Tvedt, M. W., Hiemstra, S. J., Drucker, A. G., Louwaars, N., and Oldenbroek, K. (2007). "Legal Aspects of Exchange, Use and Conservation of Farm Animal Genetic Resources," Rep. No. 1. Fridtjof Nansen Institute, Lysaker.

van Bekkum, O.-F. (2001). "Cooperative Models and Farm Policy Reform. Exploring Patterns in Structure-Strategy Matches of Dairy Cooperatives in Protected Versus Liberalized Markets," Koninklijke Van Gorcum, Assen, The Netherlands.

Van Overwalle, G. (2009). "Gene Patents and Collaborative Licensing Models: Patent Pools, Clearinghouses, Open Source Models and Liability Regimes," Cambridge University Press, Cambridge.

Vangen, O. (2007). "Beitende husdyr i Norge [Grazing Livestock in Norway]," Tun Forlag, Oslo.

Vitaliano, P. (1993). Cooperative enterprise: An alternative conceptual basis for analyzing a complex institution. *American Journal of Agricultural Economics* **65**, 1078-1083.

von Hippel, E. (1988). "The Sources of Innovation," Oxford University Press, New York.

von Hippel, E. (2005). "Democratizing Innovation," MIT Press, Cambridge, Mass.

Waterhouse, K., and Solberg, T. R. (2009). Fruktbar og frisk, det er Norsk Rødt Fe! [Fertile and Fresh, it is Norwegian Red!]. *In* "Genialt".

West, J., and Lakhani, K. R. (2008). Getting clear about communities in open innovation. *Industry and Innovation* **15**, 223-231.

West, J., Salter, A., Vanhaverbeke, W., and Chesbrough, H. W. (2014). Open innovation: The next decade Introduction. *Research Policy* **43**, 805-811.