# Land Ownership and Distribution: The relationship with property law in the Norwegian case

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**Abstract**

Issues of land distribution and ownership matter in an industrialized and post-industrial world. In rural areas, land is still the livelihood of a large portion of the people and thus central to the viability of local communities. Land ownership is also central to national politics through issues of self-sufficiency, food sovereignty and recourse management. This study applies a historical approach combined with system dynamics modeling to the case of Norwegian odelsrett between 1814 and 2014. The odelsrett is a familial right of redemption regarding landed, agricultural property, which has roots going back more than a millennium in Norway. The aim of this study is to identify the impact of the odelsrett on the distribution of land ownership in Norway as a case. The results indicate that the odelsrett in Norway helped to increase wider distribution of land amongst the agricultural population only with the help of external historical events. We furthermore demonstrate how land ownership is an exclusive right, and how the legal system of which the odelsrett is part is designed to and operates to reproduce this right.

## 1.0 Introduction: why land distribution and the odelsrett matters

This paper presents a historical and systemic land use analysis with the Norwegian case of the odelsrett through the past 200 years. The odelsrett is, in essence, a familial right of redemption in regards to agricultural property. The odelsrett thus ensures the oldest child of the owner of agricultural property the first right of purchase to the property within a set timeframe, when the property has been owned by the current owner for a set amount of years and when the property is of a certain minimum size (acres). Up until 1974, male children had the right before female children even if the female child was older. This changed after 1974 when the genders were put on equal footing in the matter (Skeie, 1950; Gjerdåker, 2001; Falkanger, 1996; Robberstad, 1948). There have later been various changes to the odelsrett regarding the size of the property to which it applies, and to whom the right is bestowed, but its essence is still the same. Today, Norwegian agriculture is heavily regulated, including several measures regulating land use in addition to the odelsrett, but in this paper we seek to isolate the odelsrett and to understand its effects on land distribution. The contribution of this article lies in providing a systemic perspective in understanding how the odelsrett affected distribution of landed property over time.

Andrew Gunnoe wrote that “the social relations of landownership are fundamental components of all modes of production” (Gunnoe, 2014). As Western Europe made the first global transition to industrial capitalism, land was one of the first resources to become commodified and subjected to capitalist market

relations (Wood, 1991; Gunnoe, 2014; Polanyi, 1944). This is no less so today with the emergence of neoliberal and neo-productivist agricultural regimes (Almås and Campbell, 2012; Clapp, 2015; Havro and Dybvik, 2017; Hodge and Adams, 2014; Mangan, 2015). In general, distribution and ownership of land has been acknowledged as having a central role in modern societies because it provides the basis of production for the most basic needs of society (Clapp, 2015). The relatively recent emergence of the concept of food sovereignty also underlines this (McMichael, 2014). Furthermore, when, in 2013, Thomas Piketty released his book *Capital in the twenty-first century*, it gained immediate and massive attention. The book touched on fundamental issues of distribution of wealth and capital, and one of the book's main theses was that ownership of real property and inherited capital would become the principal source of accumulation of wealth in the 21st century (Piketty, 2014). Although most real property today is not agricultural land, Piketty`s thesis might be an indicator that, although agriculture constitutes only a small part of most industrial economies – ownership of land may become a central issue of modern politics and policy in the future.

To be more specific on how land ownership matters: Morini (2018) has recently pointed to five ways in which ownership of land becomes a central topic of politics across the globe today. First is the issue of transition to private property and market-based regimes in former communist states. Second is the problem of formalization of land rights in developing countries; third is the so called "land grabbing" in developing countries. Forth is the trend of rapid privatization and concentration of land in many western countries. Fifth, there are issues related to the emergence of commons, which lead to friction in the understanding of private ownership.

The odelsrett fits into this framework. In the case of Norway and the odelsrett, debates have tended to focus on establishing rights for small land owners vis-a-vis state power, on various forms of land grabbing and on the fear of concentration of land in a few private hands. Some of the main arguments for keeping the odelsrett is that it is supposed to have kept land secure for small landowners either from encroachments from state power or from powerful private buyers. It has been common through the past 200 years to attribute the widespread ownership structure of land amongst the agricultural population to the odelsrett (Evju, 2015; Gjerdåker, 2001). Going back to the mid-18th century, the odelsrett started to be discussed as part of enlightenment-inspired land and agricultural reforms and improvements. Many reformers at the time saw the odelsrett as backwards, while others saw it as key to keeping an independent class of small landowners, and thus keeping a productive modern, sustainable agricultural production (Gjerdåker, 2001; Skeie; 1950; Storsveen, 1997). These two main positions run through the debates about the odelsrett up until the present. In addition, although critique of the odelsrett has sometimes been very strong, the right has maintained a dominant position in Norwegian agriculture up until the present. It has wide support amongst the Norwegian agricultural population today (Thanem and Heggem, 2016), as well as amongst major political parties. This is clear in the parliamentary debates about the odelsrett, where, although the odelsrett has been challenged, the majority of political parties

has supported it. The odelsrett as a supposed mechanism of egalitarian land distribution seems to be the main argument amongst the supporters. Thus, Martin Kolberg of the Labor Party states the odelsrett:

> Has to a large extent contributed to making Norway into the country it is today. With a population spread over most of the country and a family-based agricultural sector that has helped in sustaining a viable rural area, and which has provided the basis for a just society all over our country (Stortinget, 2016).

Similarly, Bård Vegar Solhjell from the socialist party stated that the odelsrett:

> Has led to a more equal distribution of land, and thus a more equal distribution of the power that follows it. More so than other alternative solutions, which for the most, are market-based. This has made Norway a more egalitarian country than it would otherwise have been. It has made the agricultural sector one with less division and difference in class relations than would have otherwise been the case (Stortinget, 2016).

The claim is that the odelsrett has been central in creating an egalitarian, social democratic Norway by keeping landed property equally distributed amongst the agricultural population. In our analysis, we discuss what effects the odelsrett actually may have had on the distribution of land in Norway over the past 200 years, and we make several key points about what we may learn from this on a general level when it comes to land distribution and property law. In the following section, we start by describing the historical developments of agriculture and landownership in Norway and its connections with the odelsrett.

**The odelsrett and landownership in Norway 1800-2014**

At the beginning of the period, in 1814, Norway was an overwhelmingly agricultural society. In total, there lived about 888 000 people in Norway, and more than 80 percent of this population lived off agriculture in various ways (Gjerdåker, 2002; Pryser, 1999). Since the mid-18$^{th}$ century, there has been a trend towards a higher degree of land ownership by the agricultural population leading to the emergence of a group of what we shall refer to as independent farmers in this paper. This means an agricultural worker who has full ownership of the land that they are farming and sustains themselves there, normally with a family. After a series of wars in the late 17$^{th}$ century, the absolutist monarchy of the Dano-Norwegian state initiated a series of land sales of aristocratic and church land. In Norway, at first, the land was bought in large chunks by relatively rich individuals, but later the land was often sold to Norwegian agricultural workers (mostly tenants); simultaneously with, and a bit before the land sales, landowners had also started consolidating their ownership to their farms by buying out other 'shareholders' in the farm – such as the church, city merchants or other small or large farmers with land. This meant the gradual dissolution of a peculiar Norwegian land-owing system that had developed in the late medieval period (skyldsystemet), where the worth of a farm was measured in a certain value of goods (Holmsen, 1980), and where several people could own parts of a farm. Instead, after the sale of crown land, there emerged a system where landowners gained more exclusive user rights of their land,

and more land was sold directly to the people who were farming the land. This lead to the emergence of a gradually larger group of agricultural workers who were owners of the land that they farmed, what we call here: independent farmers. Many people went from being tenants to becoming land owners. By 1720, one third of the land was farmed by agricultural workers who also owned the land that they farmed and were thus independent farmers. In the northeastern valleys of eastern Norway, the percentage was as high as 60-70 percent, while the southwest had a self-owning percentage between 15- and 30 percent. In the farm areas around Trondheim in central Norway (Trøndelag), the percentage varied from 5 to 20 percent. During the 18th century, there were further public sales of land to private persons: there was one wave of land sales during the 1720s and one during the 1750s. By 1800, the percentage of land that was farmed by independent farmers was as high as 80 percent in some areas in the eastern parts of Norway, while the percentage had risen to about 60 percent in the southwest and to 50 percent in Trøndelag. For the country as a whole, almost 60 percent of the land was farmed by small and large independent farmers who owned the land that they were farming in 1801 (Pryser, 1999; Sevatdal, 2017). A total of 78 000 farms were worked by either tenants (40 percent) or independent farmers (60 percent) in 1814. The agricultural labor force was however considerably larger than this – there were about 80 000 crofters called "husmen", and about 100 000 household servants (Pryser, 1999).

As the 19th century progressed and approached its closure, the Norwegian population more than doubled, with almost two million people living in the country by the end of the century (Nerbøvik, 1999). Most people still lived in rural areas, and farming remained a dominant livelihood. In this period, the number of small hold farms increased. This was, on the one hand, due to sales of church goods initiated by the Norwegian state, first from 1821 and with more force from 1828. On the other hand, the establishment of new farms also contributed to the rise in the number of farmers owning land. This happened through cultivation of new land in commons, first and foremost in the north of Norway – but also through crofters buying the land that they farmed and through sub-division of farms (Gjerdåker, 2002, Sevatdal, 2017). In 1830, the percentage of land that was owned by agricultural workers, which thus were independent farmers, had increased to 66 percent, while it reached 80 percent in the late 1850s (Sevatdal, 2017). There was however also an increasing group of landless tenants, functionaries and industrial and skilled workers that set a firm mark on relations of property and appropriation by the closing of the century. During the 1840s, large factories started emerging, especially around Oslo, but also in the other big cities such as Bergen and Trondheim. In 1850, there were still no more than 12 000 industrial workers in Norway, but by 1875 the number had risen to 44 000 while the number of skilled artisans and functionaries had reached 35 000. In 1870, there were also 53 000 husmen (crofters) with land, and 69 000 husmen without land (Pryser, 1999) There were furthermore 123 000 household servants. The number of people living in cities was also growing; by 1875, 25% of the population lived in cities, and there was an especially intense period of industrialization from 1860-1875 in which the number of industrial workers quadrupled (Nerbøvik, 1999). The key development in terms of ownership in this

period was the increase in the number of farms and independent farmers as the group of tenants disappeared. Simultaneously, there was an increase of husmen (crofters). In other words, the percentage of independent farmers was high, while the group of crofters became larger. It should also be noted that a large number of "surplus" workers was taken out of the economic system by emigration – the number of people that emigrated from Norway in the course of the century was almost equal to the number of people living in the country in 1801 (Pryser, 1999).

The trend of more agricultural workers owning land (becoming independent farmers) continued as the 20th century unfolded, and the group of husmen (crofters) declined fast. By the late 1920s, more than 90 percent of farms belonged to independent farmers – and the large group of husmen had been significantly reduced to only a few thousand (Almås, 2002). The primary reasons for this decline in crofters was that more attractive opportunities opened up for potential crofters in the new industries and through emigration, and that farmers found it more profitable to hire other forms of labor on their farms (Sevatdal, 2017). The new land law (Jordlova) of 1928 – which granted tenants, crofters and land pioneers more secure rights in their land – was also a factor in play. This involved making it easier for them to achieve odelsrett on their farms (Almås, 2002, Gjerdåker, 2001). Finally, an increasing mechanization of agriculture made large labor forces on the farms gradually redundant. This did not mean, however, that the number of farms did not continue to grow. There was a strong wave of new land clearances in the early 20th century, in addition to an increase in sub-dividing of farms (Gjerdåker, 2002; Sevatdal, 2017), and the number of farms continued to increase until it peaked in 1950 with about 200 000 active farms, almost all of which were owned by independent farmers. From 1950 onwards, there was a rapid decline in agricultural workers and farms, so that today, the number of people employed in agriculture constitutes no more than 2 percent of the labor force, and the number of people engaged in the agricultural labor force has become almost identical to the number of active, independent farms (SSB, 2018). An important change to note, however, is that while there are about 40 000 active farms today, there are 184 000 agricultural properties. Average farm size today is about 25 hectares (SSB, 2018). As a result of this, many active farmers are leasing much of the land that they are farming from owners of agricultural property with no production, thus creating a farm structure where one sees the emergence of a new form of tenant (Forbord et al., 2014).

The general trend in ownership of land from 1814 up until today is the decline in tenancy and the emergence of a system based almost solely on individual, independent farmers owning land. The group of crofters did increase during the first half of the 19th century, but then declined fast in the latter half of the century. To what extent did the odelsrett contribute to this general trend where more farmers became owners of their land? It is clear that a lot of the impetus towards self-ownership in the 18th and 19th centuries came because land became available to buy and because the previous owners were either not interested in owning the land, or more or less forced to sell it. As the new owners acquired odelsrett to their property, it is reasonable to assume that this had the effect of keeping the farm in the hands of the

family, thus thwarting the possibility for external buyers to buy farms, and keeping farm properties split into relatively small family owned units. An "external" buyer is a one that is not already a landowner or agricultural worker.

In the following analysis, we use a systems approach and apply system dynamics modeling to the historical developments described above to suggest the effects that the odelsrett might have had on land distribution. Although system dynamics modeling is established in investigating land use and evaluating policy (e.g. Xie et al., 2018; Corral-Quintana et al., 2016; Antunes et al., 2006; Chang and Ko, 2014; Zheng et al., 2017; BenDor et al., 2013), this is to our knowledge the first study using system dynamics to evaluate the relationship between property law and equality over a long time horizon.

In the following analysis, we discuss system dynamics modeling as a method and how the odelsrett model was built (2.0). The model structure is illustrated with a simplified stock and flow diagram (SFD) and explained by individual model sections (2.1). Section 2.1 highlights the logic used to build the model, while section 3.0 provides the results of the structural analysis (system feedback analysis) and the results of the simulation (system behavior graphs). This section also discusses these results in the context of the debate surrounding the odelsrett. Finally, the conclusion (4.0) provides the limitations of this study and outlines future research. The full model, including documentation of validation and testing, is given in Appendix A following the reference list.

**2.0 Methods and Model Building**

As a methodological frame, we use a systems perspective, utilizing system dynamics modeling for the analysis. System dynamics modeling is a type of simulation modeling with strengths in quantifying structural feedback and in understanding how emergent historical behavior is generated from structural mechanisms (Sterman, 2000); these include many social and cultural structures – structures in a systems approach refers to mathematical relationships. Though an established method for analyzing land use and policy (Xie et al., 2018; Corral-Quintana et al., 2016; Antunes et al., 2006; Chang and Ko, 2014; Zheng et al., 2017; BenDor et al., 2013), historical land use analysis is a new domain for system dynamics modeling. System dynamics modeling is similar to structural equation modeling, though with a specific focus on quantifying system feedback (Hovmand, 2003). Essentially, a system dynamics model is a set of ordinary differential equations (ODEs) that seeks to replicate historical system behavior in order to predict future system behavior. This study does not extend the time horizon of the model and predict future behavior, as this model is meant to aid historical analysis. Historical analysis involving the odelsrett has tended to focus on its evolving legal meaning over time (Falkanger, 1996; Robberstad, 1948; Skeie, 1950), or on the centrality of the right for nation building and nationalist discourse (Fuglestad, 2018; Evju, 2015; Glenthøj, 2012; Sørensen, 2001). While studies discussing land distribution have sometimes investigated the social importance of the odelsrett and the actual existence of a relatively widespread ownership structure (Lunden, 1992), others studies have sought to explain

and display the economic and social conditions leading to the emergence of widespread ownership (Sevatdal, 2017; Dyrvik, 1999). Such historical analyses are interesting in pointing out processes and forces in the making, but they do not give a clear indication of the systemic role of the odelsrett in these processes. A systems approach to the historical analysis allows us to identify clear trends and presents them in easily accessible models. This is another reason a systems approach using system dynamics modeling is used in this study. This new perspective will complement studies using more traditional methods on how odelsrett works over time.

Before we detail the logic of the 'Odelsrett System Dynamics Model' in 2.1, there are several key aspects of system dynamics modeling in general that need to be explained given that historical analysis in rural studies is a new domain for system dynamics modeling. System dynamics models are engineered tools used to aid scientific analysis (Olaya, 2014). They are not comprehensive representations of an entire system. These models are built to analyze specific relationships (in this case, feedback mechanisms in land distribution in odelsrett); and only that which is necessary for the analysis is built into the model because increasing structural complexity in a model decreases behavioral comprehension (Davidsen, 1992). It is important to note that system dynamics models are not data dependent, and it has methods for addressing data gaps (Sterman, 2000). In addition, system dynamics modeling is able to operationalize qualitative data, which is another reason that this method was chosen for this topic. Operationalizing qualitative data in system dynamics models means taking narrative text from analysis based on, for example, interview data, literature review data and document analysis data and translating this into equations that is the mathematical structure of the system of interest. This does not mean the entire model is built from qualitative data sources. To initialize the model simulation, parameter values are estimated or taken from historical sources (specified in A.1). In addition, exogenous variables (external to the model boundaries) use quantitative data - such as annual data on the number of agricultural workers used in this study. Qualitative data from historical analysis is the primary data source used to build the Odelsrett System Dynamics Model. The variables and relationships analyzed qualitatively (empirical, but not countable) in the literature and given in the previous section are operationalized by translating them into the set of equations and estimated parameter values given in Appendix A (see A.1). Data gaps that must be filled in order to make the model run a simulation can make model building difficult, and graphical functions are used to estimate possible values, which are tested using sensitivity analysis (see A.2). Given the literature presented in the previous section, the following section provides the logic of operationalizing the qualitative data as equations in the system dynamics model.

### 2.1 The Odelsrett System Dynamics Model

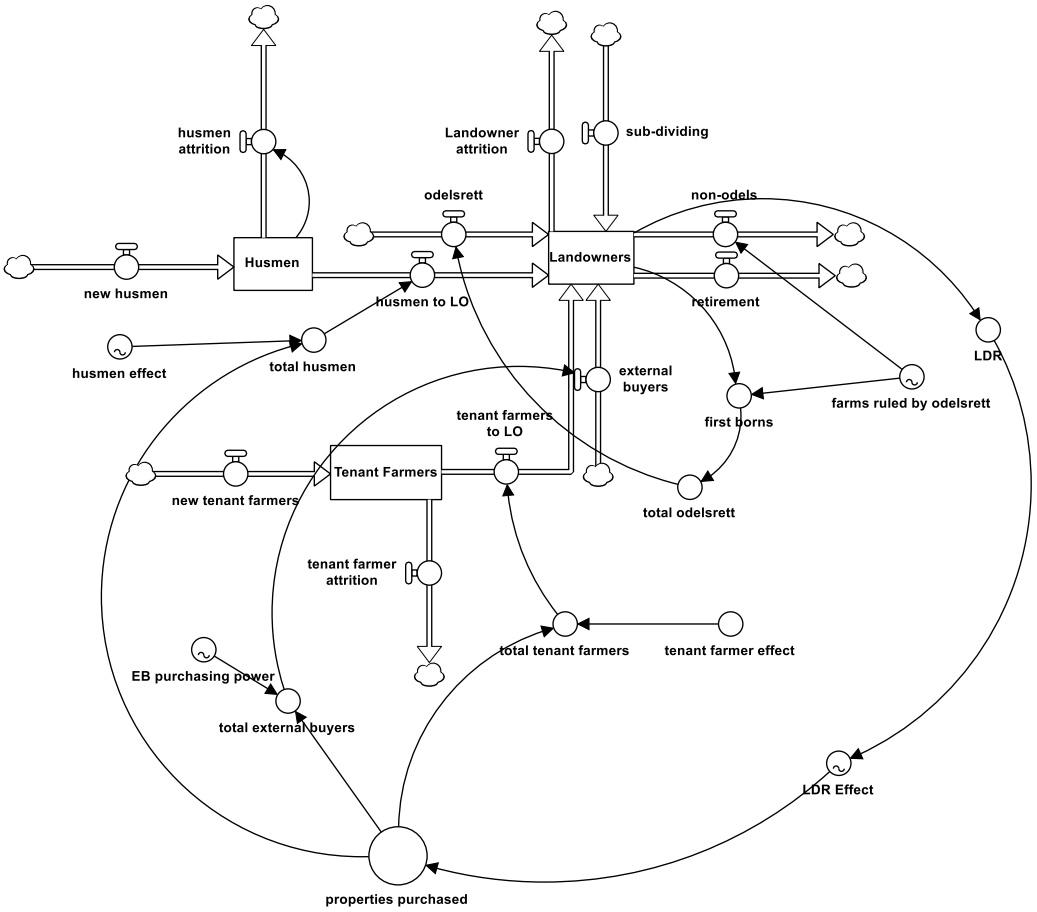


*Figure 1: SFD of the Odelsrett System Dynamics Model (EB=External Buyer; LO=Land Owner; LDR=Land Distribution Ratio). Clouds=source/sink; Boxes=stocks; arrows with valves=flows that in/decrease stocks over time; circles=variables; black arrows=indicate mathematical relationships.*

The general trend in ownership of land from 1814 up until today is the decline in tenancy and crofting (husmen), and the emergence of a system based almost solely on independent farmers. To what extent did the odelsrett contribute to this? It is clear that a lot of the impetus towards freeholding in the 17$^{th}$ and the 19$^{th}$ centuries developed because land became available to buy and because the previous owners were either not interested in owning the land, or more or less forced to sell it. As new owners acquired odelsrett to their property, is it reasonable that this had an effect on keeping the farm in the hands of the family, thus thwarting the possibility for external buyers to buy farms and keeping farm properties split into relatively small family owned units? And how strong was the effect of the odelsrett in this regard?

We built a system dynamic model to understand this effect and its strength. The full model is given Appendix A and is graphically illustrated with the simplified SFD in Figure 1. Figures 2-5 are snapshots of Figure 1, each followed by a partial model description. The SFD does not include many relationships that the full model includes and is meant to explain how the model was built for those not familiar with system dynamics modeling. As parts of the model are explained with Figures 2-5, variables that the text is referring to are given in parentheses. The time horizon for the model is 1814-2014. Throughout the model description and analysis, landowners are independent farmers as described earlier. There are four types of people that can become landowners: husmen, tenant farmers, external buyers and the first-born

children of current landowners. Each of these except external buyers (because they are considered outside the agricultural laborer system) are stocks (the boxes in Figure 1).

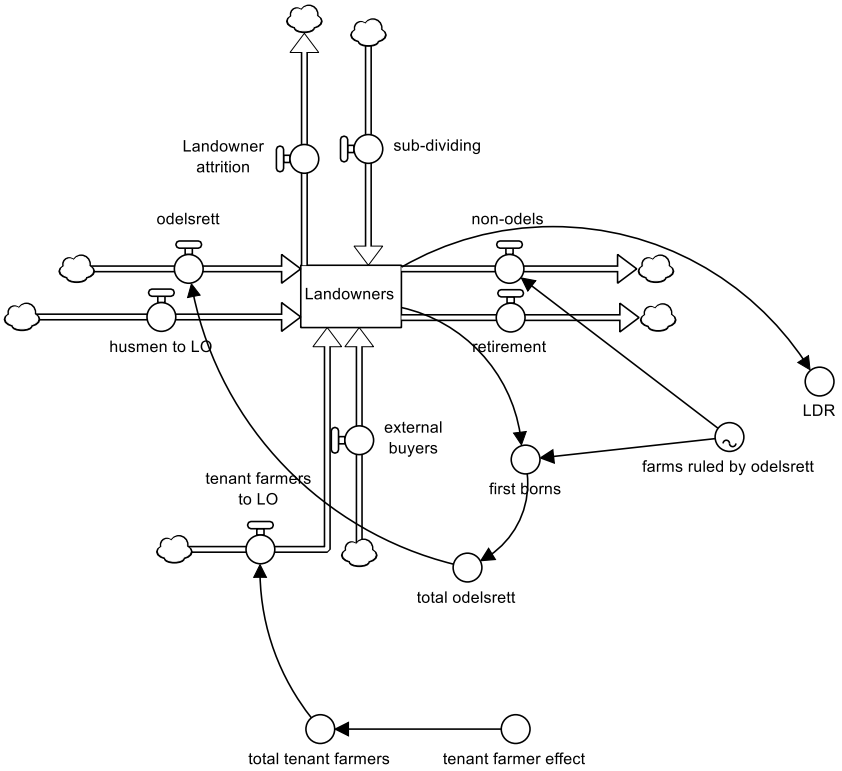


*Figure 2: Landowner stock, flows and main variables (LO=Land Owner; LDR=Land Distribution Ratio)*

Figure 2 shows that landowners (Landowners stock) can increase in number from inflows from the husmen (husmen to LO inflow), tenant farmers (tenant farmers to LO inflow), external buyers (external buyers inflow) and from first-born children of landowners (odelsrett inflow), which is a portion of the landowner stock (first-borns variable and total odelsrett variable). The landowner stock is affected by sub-dividing (sub-dividing inflow), where a portion of the farms are sub-divided into new farms. This creates more landowners by creating more properties for sale. Not all farms are ruled by odelsrett (farms ruled by odelsrett variable and non-odels outflow), and this creates properties for sale (see Figure 3). Some landowners sell off their land for non-agricultural purposes, and this is represented with landowner attrition (landowners attrition outflow). The first-born children enter the landowners stock through odelsrett. External buyers, the first-born children of landowners, husmen and tenant farmers each have a built-in effect that represents their ability to buy farmland, which changes over time due to societal changes (explained further with Figure 5). The number of landowners determines the LDR (Land Distribution Ratio = Landowners/Total Agricultural Workers). Total agricultural workers is provided by external data. LDR is a metric used to evaluate land distribution equality (discussed in section 3.0).

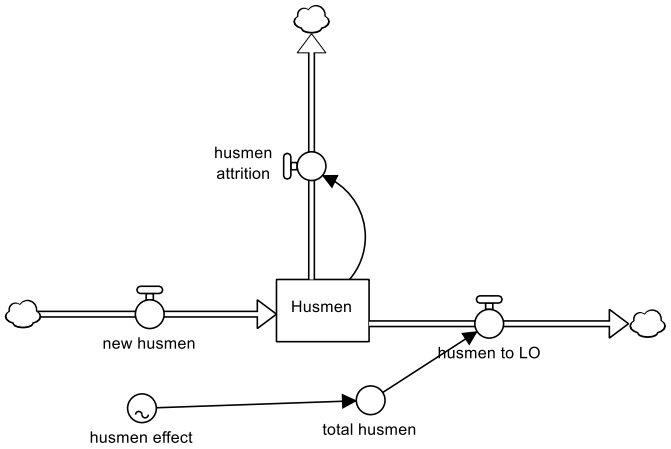


*Figure 3: Husmen stock, flows and main variables (LO=Land Owner)*

Figure 3 shows the husmen (Husmen stock). Husmen are crofters who have a limited ability to become landowners (husmen to LO outflow) because of their limited purchasing power (husmen effect variable). Some did however, and their position in the agricultural labor market changed over time, which is important for the overall historical behavior of odelsrett (explained in section 3.0). New husmen came into the system as new plots became available (new husmen inflow). In addition to becoming landowners, the husmen left this stock if they left agriculture (husmen attrition outflow). If they did not become landowners then children are assumed to have inherited the plots and continued as husmen.

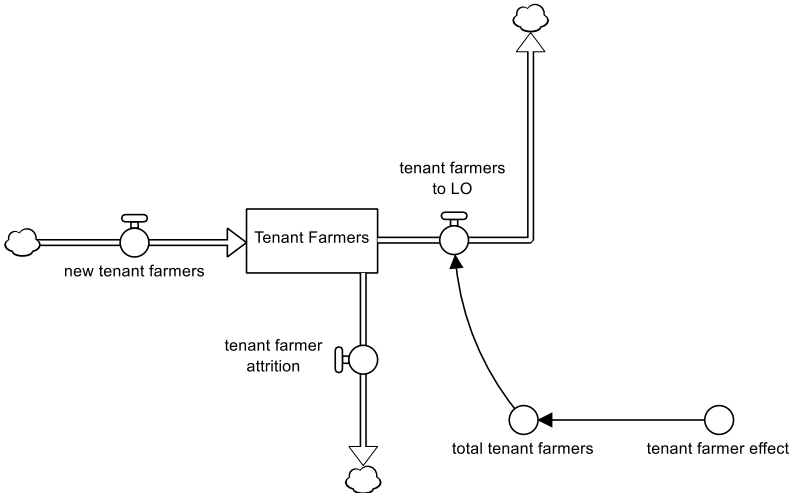


*Figure 4: Tenant farmers stock, flows and main variables*

Figure 4 shows the tenant farmers (Tenant Farmers stock). They had an increased ability (more than husmen) to purchase property (tenant farmer effect variable). This pushed tenant farmers into the landowners stock (tenant farmers to LO outflow). Figure 4 also shows that new tenant farmers could enter if tenancies became available (new tenant farmers inflow), and tenant farmers could leave the tenant farmer stock if they left agriculture (tenant farmer outflow). If they did not become landowners and stayed in agriculture, the children of tenant farmers are assumed to have inherited the tenancy and continued as tenant farmers.

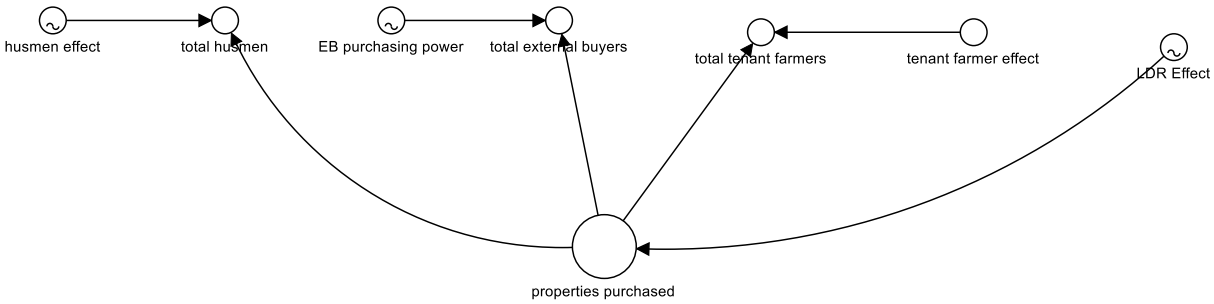


*Figure 5: Properties available to purchase and effects for husmen, tenant farmers and external buyers (EB=External Buyers).*

No one can buy property without properties to purchase. Figure 5 shows this part of the system. Properties become available to purchase, and husmen, tenant farmers and external buyers are able to purchase these properties (properties purchased variable). Each of these groups has a purchasing power that is based on their ability to buy the property. These are built-in effects (EB purchasing power variable, tenant farmer effect variable and husmen effect variable) that push external buyers (total external buyers variable), husmen (total husmen variable) and tenant farmers (total tenant farmers variable) into the landowner stock. Properties purchased is affected by the LDR (LDR effect variable). LDR represents the effect current inequality levels has on the ability of diverse groups to purchase property and become landowners. The more unequal the LDR, the more difficult it is for tenant farmers, external buyers and husmen to purchase property.

This total system structure, which includes several significant feedback loops, reproduces the historical behavior. The feedback loops and system behavior are discussed in the next section.

**3.0 Results and Discussion**

The results of the simulation are shown in the behavior graphs in Figures 6-8. They are discussed below in terms of the feedback structures that were identified. The system structure feedback is illustrated graphically with the causal loop diagram (CLD) presented in Figure 9. In Figures 6-7, we provide model simulations (blue) compared to historical data (red) to show the validation of the model structure (see Appendix A for more information on model validation.)

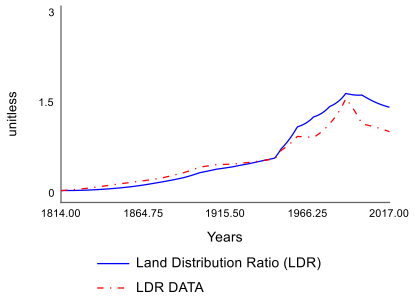


*Figure 6: Land Distribution Ratio (LDR); Simulation in blue and historical data in red*

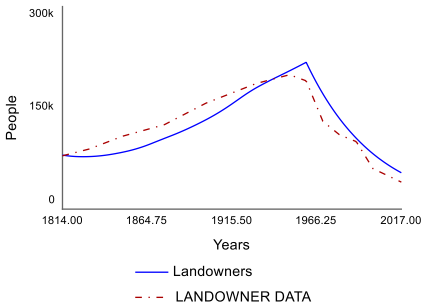


*Figure 7: Number of Landowners; Simulation in blue and historical data in red*

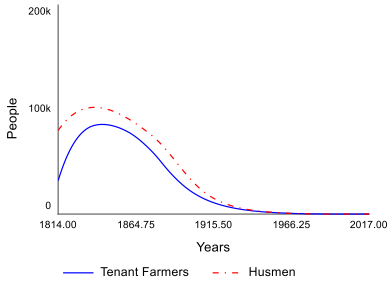


*Figure 8: Simulation of number of tenant Farmers (blue) and husmen (red)*

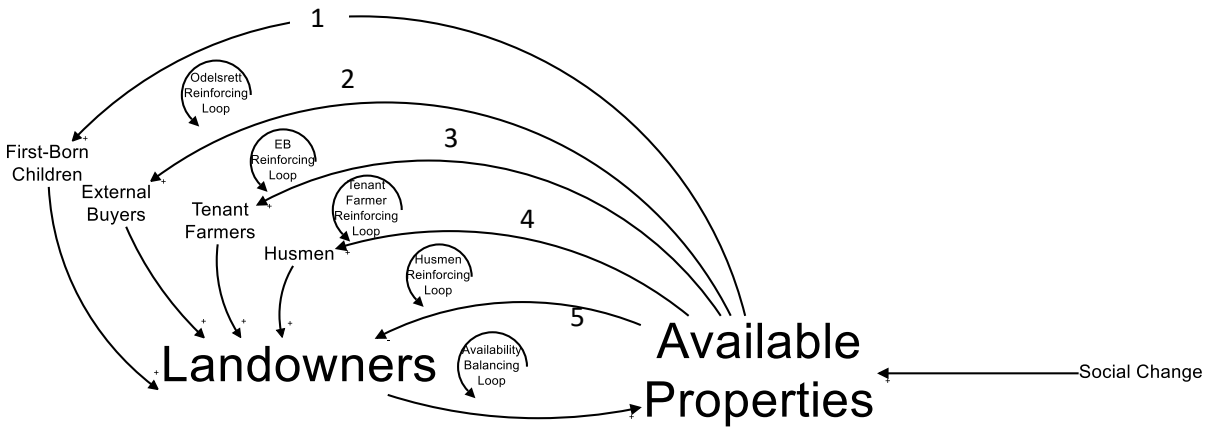


*Figure 9: CLD of the model structure showing five feedback loops leading to the system behavior shown in Figures 6-8*

We identified four reinforcing feedback loops (loops 1-4) and one balancing loop (loop 5) interacting with each other, which leads to the behavior shown in the behavior graphs in Figures 6-8. Reinforcing feedback loops found in the system structure lead to exponential behavior, either growth or decay. Balancing loops stabilize behavior at an equilibrium.

The four reinforcing feedback loops in Figure 9:

1) Odelsrett Reinforcing Loop

As the number of available properties increases, the higher the likelihood that first-born children can become landowners. This is a strong feedback loop because of odelsrett. Odelsrett keeps this loop dominant (explained below) for most of the time horizon.

2) External buyers (EB) Reinforcing Loop

As the number of available properties increases, the higher the likelihood that external buyers can become landowners. This is dominant in certain periods in the time horizon (explained below).

3) Tenant Farmer Reinforcing Loop

As the number of available properties increases, the higher the likelihood that tenant farmers can become landowners. This loop is dominant in certain periods in the time horizon (explained below).

4) Husmen Reinforcing Loop

As the number of available properties increases, the higher the likelihood that husmen can become landowners. However, this is weak because of the husmen's limited ability to purchase property.

These reinforcing loops 1-4 are balanced by the:

5) Availability Balancing Loop

The amount of available properties to purchase is limited, which stabilizes the exponential behavior of these four reinforcing loops. When landowners sell their farms, properties are available to buy.

Husmen, tenant farmers, external buyers and first-born children are the pool of people that can purchase farms and become landowners. The larger this pool, the more potential landowners. These reinforcing feedback loops are not of equal strength. The odelsrett reinforcing loop dominates the others, but it is always kept stable (not increasing exponentially) by the availability balancing loop. First-born children of landowners have much more power because odelsrett helps them purchase property and become landowners. External buyers, tenant farmers and husmen have limited purchasing power and in ultimately becoming landowners.

In this way, it would seem that the odelsrett keeps farmland in the hands of the few, making landownership unattainable for anyone else. The odelsrett reinforcing loop is dominant at many points over the course of the time horizon. However, these feedback structures are not working in isolation and are influenced by societal change – this includes public land sales and population growth during the 19$^{th}$ century, as well as urbanization and industrialization in the latter half of the century and in the 20$^{th}$ century (Sevatdal, 2017, Nerbøvik, 1999, Pryser, 1999). In the 1820's, the church and state began to sell off land, which increased the amount of available properties that were not under odelsrett. This means that the purchasing power of external buyers, tenant farms and husmen increased. These were largely purchased by external buyers and tenant farmers (which is one reason we see the number of

tenant farmers is decreasing in the mid-19th century in Figure 8). The external buyer and tenant farmer reinforcing loops gained strength, and this increased the number of landowners and properties governed by the odelsrett, as shown in Figure 7 with the number of landowners increasing over the 19th century. Over the course of the 19th century, there is also an increase in the number of farms that are sub-divided, with larger farms breaking up into smaller farms. This was primarily because of the increase in population and the lack of new available land. It was also important that alternative livelihoods either in industry or in America did not emerge as significant alternative livelihoods until the late 19th century (Pryser, 1999). Due to a change in social conditions, the tenant farmer reinforcing loop became dominant, leading to exponential decay, with the tenant farmers becoming landowners (tenant farmers disappearing in Figure 8). The main reason for this was the selling of public lands during the early 19th century (Sevatdal, 2017). The number of husmen also disappeared by the early 20th century (Figure 8), but relatively few of these became landowners. Many of them emigrated to America or left agriculture for other industries (Nerbøvik, 1999).

Figure 6 shows the land distribution ratio (LDR); this ratio is a metric used to evaluate land distribution equality. This is not a performance indicator; i.e. a higher/lower value does not necessarily correspond to a more/less equal land distribution. This ratio is the number of landowners over the number of agricultural workers. Although a low value can indicate a more unequal landownership distribution than a higher value (as with pre-WWII), an evaluation of the LDR is not always so straightforward (as seen in recent decades). In 1814, the LDR is very low, but it begins to increase over the course of the 19th century. Once someone became a landowner, it was a stable place to be, as the odelsrett reinforcing loop kept the property within the hands of the family, balanced by the available property for sale. It was difficult to get into this structure, but once someone was a landowner, they stayed a landowner as long as they wanted to be. Because of this, we see the LDR increasing slowly over the 19th century, with more farms being owned by those who farm them. The two main reasons for this increase was the selling of public land, tilling of new land and sub-division of farms (Gjerdåker, 2002). The LDR increases slowly because when more land becomes available to purchase outside of the odelsrett (as discussed above), more agricultural workers become landowners (Gjerdåker, 2002)

Post-war Norway created interesting conditions for this system. Many people left agriculture, and agricultural workers currently comprise only 2 percent of the Norwegian labor force. This can be attributed to the general modernization of Norwegian agriculture since 1945: labor became increasingly mechanized, production more efficient and output higher and integrated into a national and international market. Many small and medium-small farmers could not successfully adapt to this situation, nor could the national agricultural market and the political system sustain them all (Almås, 2002). The number of landowners shown in Figure 7 decreases sharply after WWII. When workers leave agriculture, this also increases the LDR. Fewer workers are now needed to run a farm, and in recent decades, it is common to lease land to other farmers if you are a landowner and have another job. Again, increasing

mechanization on the farms was an important factor for why less labor was needed. The reason for the increase of land leasing is the need for farmers to keep up production on their farms, and the odelsrett may be an important factor keeping active farmers from buying land instead of leasing it (Almås, 2002; Forbord, 2014). This is why we are seeing an LDR value greater than one in recent decades – there are more owners than there are workers. Here the odelsrett reinforcing loop is very strong with only the external buyer reinforcing loop still active (though very weak). The odelsrett reinforcing loop is so strong that even if the owner wants to leave agriculture, they lease their land instead of selling to external buyers.

## 4.0 Conclusion

Land distribution in Norway over the past 200 years is partly the result of odelsrett working in tandem with external policies and events that made more properties available to purchase and societal change (changing labor force and emigration). "External" policies in this context means forces acting on the odelsrett system structure but not generated by the odelsrett system itself. At the start of our period of analysis, there were 78 000 farm properties, of which 60 percent were owned by independent farmers, many of them with odelsrett. When the state started selling church goods from the early 1820s, the number of farmers with land increased as they bought land to which they could acquire odelsrett. New farms were also stablished through new cultivation and through crofters buying free their land. When Norway became industrialized, the odelsrett, according to our model, continued to keep farmland within closed loops. This, on the one hand, insured that land became secure for those already using it vis-a-vis external buyers, but it also made it difficult for active farmers to buy new land and add to their farms. This has resulted in a situation where the vast majority of the about 40 000 active farms are owned by the farmers themselves. However, there are currently around 180 000 farm properties in Norway, and this means much of the land belonging to these holdings is leased to the remaining active farms. For societies seeking to secure long-term wide distribution of land as a way of increasing societal development, measures such as the odelsrett have strong effects of keeping land widely distributed (once a wide distribution has been established). The debate on whether odelsrett helps or hurts land distribution equality cannot solely focus on the law itself, but instead, it should focus on the law as part of a social system constantly adapting to changes in various parts of the system. Viewed with this lens, the odelsrett has a much more checkered past that is helpful in understanding similar laws in other contexts and useful for developing policy.

As a final observation, we acknowledge that system dynamics modeling has limitations. Any mathematical modeling is an objectification of reality, and as it is secondary analysis, the model is only as useful as the primary research on which it is built. The model presented in this paper, in particular, should not be taken as comprehensive because it is a first generation model. This means that the model was built from the ground-up and was not based on a previously published model. There are several

areas of the model that need to be developed in the next model generation. Specific to our model design versus mathematical modeling in general, the model currently treats the disaggregation of external buyers as an exogenous force on the system, which could in the future be built endogenously into the model. In addition, the husmen and the tenant farmers are simply represented in this model generation, and this should be expanded. Lastly, a valuable modeling approach to strengthen the landowner section of the model would be to develop it into an aging chain, to include variables affecting generations of landowners (children, adults and retired farmers) all living on the same property.

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## Appendix A

Appendix A provides the full system dynamics model used for the analysis in this article, including the equations, variables and values. The time horizon for the model is 1814-2017. The model contains three stocks, 12 flows and 25 variables, including 35 equations, two constants and 13 graphicals.

Model validation included reproducing historical behavior with simulation. The results of which were shown in Figures 6 and 7 in section 3.0. Unit consistency and shock tests were performed, as well as a sensitivity analysis. The results of the sensitivity analysis are given in section A.2

### A.1 The Odelsrett System Dynamics Model

*Stock equations with flows, where t=time:*

(1) Husmen(t) = Husmen(t - Δt) + (change in husmen – husmen to landowners – husmen attrition) * Δt

Initial value Husmen = 80 000 (Sevatdal, 2017)

Inflows:

(a) change in husmen = ((agricultural worker data*new_husmen_rate)-Husmen)/generation_time

Outflows:

(a) husmen to landowners = total husmen/generation time

(b) husmen attrition = (Husmen*husmen attrition rate)/generation time

(2) Landowners(t) = Landowners(t - Δt) + (odelsrett + tenant farmers to landowners + husmen to landowners + external buyers + "sub-dividing" - "non-odelsrett" - retirement - attrition) * Δt

Initial value Landowners = 50 000 (Sevatdal, 2017)

Inflows:

(a) odelsrett = ((total odelsrett)/generation time)

(b) tenant farmers to landowners = total tenant farmers/generation time

(c) husmen to landowners = total husmen/generation time

(d) external buyers = total external buyers/generation time

(e) "sub-dividing" = (Landowners*"sub-dividing rate")/generation time

Outflows:

(a) "non-odelsrett" = ((1-farms ruled by odelsrett)*Landowners)/generation time
(b) retirement = Landowners/ownership time
(c) attrition = (Landowners*landowner attrition rate)/generation time

(3) Tenant farmers(t) = Tenant farmers(t - Δt) + (new tenant farmers – tenant farmers to landowners – tenant farmer attrition) * Δt

Initial value Tenant farmers = 32 000 (Pryser, 1999)

Inflows:

(a) new tenant farmers = ((agricultural worker data*new tenant farmer rate)-Tenant farmers)/generation time

Outflows:

(a) tenant farmers to landowners = total tenant farmers/generation time
(b) tenant farmer attrition = (Tenant farmers*tenant farmer attrition rate)/generation time

*Variables*

(1) agricultural worker data = Graph(Time)

(1875.0, 340000), (1890.0, 315990), (1900.0, 290000), (1910.0, 289000), (1920.0, 300700), (1930.0, 304000), (1946.0, 295300), (1950.0, 250450), (1960.0, 188430), (1970.0, 130830), (1980.0, 91400), (1990.0, 63000), (2000.0, 50000), (2017.0, 37000) (SSB, 2019)

(2) average number of farms for sale per year = "non-odelsrett"-attrition

(3) external buyer purchasing power = Graph(Time)

(1814.0, 1.186), (1832.45454545, 1.403), (1850.90909091, 1.520), (1869.36363636, 0.800), (1887.81818182, 0.300), (1906.27272727, 0.200), (1924.72727273, 1.200), (1943.18181818, 0.000), (1961.63636364, 0.000), (1980.09090909, 0.000), (1998.54545455, 0.000), (2017.0, 0.000) (Sevatdal, 2017)

(4) farms ruled by odelsrett = Graph(Time)

(1814.0, 0.6), (1864.75, 0.8), (1915.5, 0.9), (1966.25, 0.9), (2017.0, 0.9) (Gjerdåker, 2002)

(5) first born children = Landowners*farms ruled by odelsrett

(6) generation time = 30

(7) husmen attrition rate = Graph(Time)

(1814.0, 0.000), (1834.3, 0.000), (1854.6, 0.000), (1874.9, 0.000), (1895.2, 0.552), (1915.5, 0.602), (1935.8, 0.638), (1956.1, 0.679), (1976.4, 0.719), (1996.7, 0.760), (2017.0, 0.783) (Almås, 2002)

(8) husmen effect = Graph(Time)

(1814.0, 0.600), (1834.3, 0.600), (1854.6, 0.600), (1874.9, 0.600), (1895.2, 0.000), (1915.5, 0.800), (1935.8, 0.800), (1956.1, 1.000), (1976.4, 1.000), (1996.7, 1.000), (2017.0, 1.000) (Pryser, 1999)

(9) land distribution ratio (LDR) = Landowners/agricultural worker data

(10) land distribution ratio (LDR) effect = Graph(land distribution ratio (LDR)) (see A.2 sensitivity analysis for this variable)

(0.000, 0.000), (0.250, 0.250), (0.500, 0.500), (0.750, 0.750), (1.000, 1.000)

(11) landowner attrition rate = Graph(Time)

(1814.0, 0), (1834.3, 0), (1854.6, 0), (1874.9, 0), (1895.2, 0.00317), (1915.5, 0.00814), (1935.8, 0.01674), (1956.1, 0.02443), (1976.4, 0.03258), (1996.7, 0.03801), (2017.0, 0.04344) (Sevatdal, 2017)

(12) landowner data = Graph(Time)

(1814.0, 79000), (1830.0, 89000), (1850.0, 108000), (1875.0, 125000), (1900.0, 157000), (1930.0, 186000), (1950.0, 199000), (1960.0, 190000), (1970.0, 130000), (1980.0, 110000), (1990.0, 100000), (2000.0, 60000), (2017.0, 40000) (Sevatdal, 2017, SSB, 2018) NB! Due to data availability in the early 19$^{th}$ century, this data time series includes both landowners and tenant farmers. We normalized the model by accounting for this in the calibration of the parameter settings that operationalize the Landowners stock equation used for validation when simulated and in the Tenant Farmer stock equation by comparing simulations to estimated values based on Sevatdal (2017).

(13) land distribution data = landowner data/agricultural worker data

(14) market availability = Graph(Time)

(1814.0, 0), (1823.22727273, 2500), (1832.45454545, 2500), (1841.68181818, 2500), (1850.90909091, 0), (1860.13636364, 0), (1869.36363636, 0), (1878.59090909, 0), (1887.81818182, 0), (1897.04545455, 0), (1906.27272727, 0), (1915.5, 0), (1924.72727273, 0), (1933.95454545, 0), (1943.18181818, 0), (1952.40909091, 0), (1961.63636364, 0), (1970.86363636, 0), (1980.09090909, 0), (1989.31818182, 0), (1998.54545455, 0), (2007.77272727, 0), (2017.0, 0) (Sevatdal, 2017)

(15) new husmen rate = Graph(Time)

(1814.0, 0.100), (1836.55555556, 0.200), (1859.11111111, 0.300), (1881.66666667, 0.400), (1904.22222222, 0.000), (1926.77777778, 0.000), (1949.33333333, 0.000), (1971.88888889, 0.000), (1994.44444444, 0.000), (2017.0, 0.000) (Pryser, 1999)

(16) new tenant farmer rate = Graph(Time)

(1814.0, 0.400), (1836.55555556, 0.250), (1859.11111111, 0.200), (1881.66666667, 0.000), (1904.22222222, 0.000), (1926.77777778, 0.000), (1949.33333333, 0.000), (1971.88888889, 0.000), (1994.44444444, 0.000), (2017.0, 0.000) (Sevatdal, 2917)

(17) ownership time = IF TIME < 1960 THEN 50 ELSE 20 (Almås, 2002)

(18) properties purchased = average number of farms for sale per year*land distribution ratio (LDR) effect

(19) "sub-dividing rate" = Graph(Time)

(1814.0, 0.2443), (1824.68421053, 0.2643), (1835.36842105, 0.2805), (1846.05263158, 0.2932), (1856.73684211, 0.2932), (1867.42105263, 0.2914), (1878.10526316, 0.2118), (1888.78947368, 0.1919), (1899.47368421, 0.1593), (1910.15789474, 0.1466), (1920.84210526, 0.1231), (1931.52631579, 0.0326), (1942.21052632, 0.0000), (1952.89473684, 0.0000), (1963.57894737, 0.0000), (1974.26315789, 0.0000), (1984.94736842, 0.0000), (1995.63157895, 0.0000), (2006.31578947, 0.0000), (2017.0, 0.0000) (Sevatdal, 2017, Gjerdåker, 2002)

(20) tenant farmer attrition rate = Graph(Time)

(1814.0, 0.000), (1834.3, 0.000), (1854.6, 0.000), (1874.9, 0.000), (1895.2, 0.348), (1915.5, 0.398), (1935.8, 0.448), (1956.1, 0.493), (1976.4, 0.538), (1996.7, 0.561), (2017.0, 0.570)

(21) tenant farmer effect = .85 (Sevatdal, 2017)

(22) total external buyers = (properties purchased*external buyer purchasing power) + .25 * market availability

(23) total husmen = properties purchased*husmen effect

(24) total odelsrett = first born children

(25) total tenant farmers = (properties purchased*tenant farmer effect) + .75*market availability

### A.2 Sensitivity Analysis

The variable “land distribution ratio (LDR) effect” is a graphical function built from the assumption that the land distribution is affected by the equality of land distribution itself. This means that the more unequal the land distribution is, the more difficult it is for non-landowners to become landowners. This effect graphical function is shown in Figure A.1 and was subjected to a sensitivity analysis. The sensitivity analysis tested how sensitive the overall LDR was to changes in the LDR effect. Run 1 in Figure A.2 shows the overall LDR as shown in Figure 6 in section 3.0. Run 2 shows the overall LDR behavior when decreasing the LDR effect by 25%. Run 3 shows the overall LDR behavior when increasing the LDR effect by 25%. Figure A.2 shows that the LDR is not sensitive to increasing and decreasing the LDR effect by 25%.

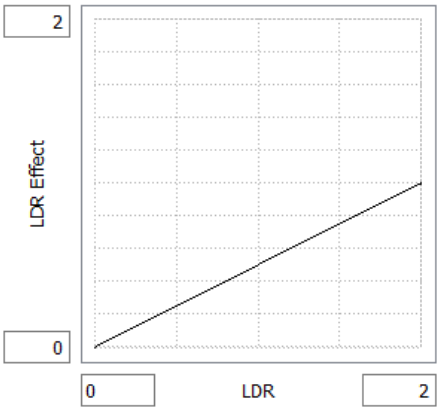


*Figure A.1: Graphical Function: LDR Effect*

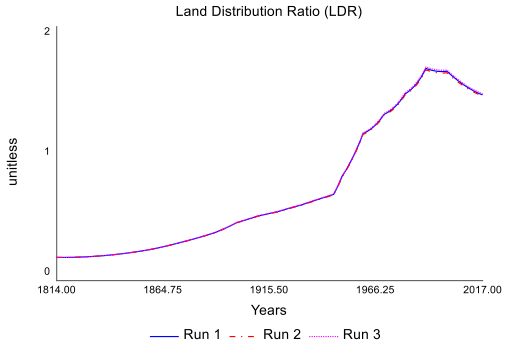


*Figure A.2: Sensitivity Analysis of the LDR Effect on the overall LDR behavior*