Growth and Exit in the Agricultural Sector[§]

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1 INTRODUCTION

The structure of primary production has been altered over the last decades. In most Western countries the number of farms has declined, whereas their average size has increased. Land is an immobile, non-duplicable and increasingly scarce production factor since its availability is not only limited, it even declines due to a permanent conversion process of agricultural land towards alternative usages. Thus, farms in Western countries cannot grow unless other farms shrink or exit, resulting in newly available land resources (e.g., Balmann et al., 2006).[1] This causes a strong interdependence of farms within a region (Chavas, 2001). At the same time, the farm size structure differs substantially across regions. For instance, in some regions farms are equally sized in terms of land endowment, while in other regions land is rather unequally distributed among the farms.[2] The regionally differing structures may lead to regionally different patterns of structural change (Harrington and Reinsel, 1995; Goetz and Debertin, 2001). Still, the regional specifity of farm size structure as well as of structural change still remains a puzzle for agricultural economists (Schmitt, 1992).[3]

Against this background, our aim is to improve the understanding of the relation of farm exits, farm growth and the land market in order to explain the regionally different patterns of structural change. Thereby, the objective of this paper is twofold. First, we theoretically analyse the impact of the initial farm (size) structure on both the exit decision of farms inducing free land capacities as well as the allocation of the newly available land resources to the remaining farms in a particular region. We consider an agricultural market with a finite number of firms that produce a homogenous good that they sell at a given price in final or intermediate goods markets. We develop a three-stage game where first the firms decide whether to exit or to continue agricultural production. Given the exit decision of some firms, land resources become available for the remaining firms in the market. In the final stage the firms compete in the downstream market. In the case of increasing marginal cost of production, the large farms have a lower incentive to grow than the small farms, while both types of firm converge in terms of total quantity. However, more efficient farms have a higher incentive to grow than smaller farms. Furthermore, small firms are more likely to leave the market than large firms. Second, we empirically illustrate our theoretical findings by referring to structural change in

[1] The interdependence of growth and exit has been empirically considered, cf. amongst others Zepeda (1995) or Tonini and Jongeneel (2007).

[2] For instance, the phenomenon of a disappearing middle class has been detected by Weiss (1999) in Austria. Moreover, Margarian (2007) found that this phenomenon especially occurs in regions where land is rather unequally distributed among the farms.

[3] Note, such a skewed size distribution of firms is also observed in many industries apart the agricultural sector (Sutton, 2007).

the West German agricultural sector. Analysing the relation between the regional structure and farms' growth, decline or exit activities, we find that regional asymmetries in firm size measured by the concentration of land endowment is positively related to exit rates (mainly small farms) and negatively to the growth rate of the medium farms.

There is a wide literature that deals generally with the dynamics of industries. Many empirical studies about farm growth are often motivated by Gibrat's law (the size of a firm and its growth rate are independent) ignoring economic theory (e.g., Shapiro et al., 1987; Clark et al., 1992; Kostov et al., 2006; Bakusc and Fertö, 2007). However, this strand of literature neglects that industry dynamics are mainly characterized by the simultaneous entry and exit of firms as well as growth and shrinkage.[4] While entry plays a minor role in agricultural markets, there is a strong debate about the firms' incentives to leave the market.[5] Exit decisions are characterized by their (partial) irreversibility, the uncertainty of future expectations about the profitability and the investment's flexible timing that gives them the character of a put option termed 'real options'. Prominent examples where exit decisions have been analysed using real options' theory are Dixit (1989), Alvarez (1998, 1999) and Murto (2004).

Other papers consider the impact of uncertainty with the aim to explore industry dynamics based on competitive equilibrium theory (e.g., Jovanovic, 1982, Ericson and Pakes, 1989, and Hopenhayn, 1992) or based on a dynamic game (Hanazono and Yang, 2009). Besides these models, industry dynamics are also analysed deterministically by means of competition in declining industries, e.g. Ghemawat and Nalebuff (1985, 1990), Londreagan (1990), Reynolds (1988) and Whinston (1988). As Liebermann (1990) notes, all their models differ slightly in their respective assumptions and results but emphasize the strategic liability of the large firm size. Ghemawat and Nalebuff (1985) show that larger firms tend to exit first from a declining industry since they lose their viability more quickly compared to smaller firms. However, the order of exit may be reversed in the presence of economies of scale. If capacity adjustment is possible, large firms reduce capacity first until they have reached the size of the small indicating that survivability is inversely related to size (Ghemawat and Nalebuff, 1990). Whinston (1988) considers lumpy exits while allowing for partial reduction of capacity in a multi-plant setting and shows that if the firms have the same number of plants, those with higher cost leave the market first. Londregan (1990) shows by means of a duopoly that during growth

[4] An exception is Weiss (1999), motivated by Gibrat's Law he analyses growth and the survival of farms jointly however neglecting their interaction.

[5] Besides the literature that uses entry and exit as the main driver of industry dynamics there is also a large literature that focuses on technology innovation or improvement as the driving force behind industry dynamics (cf. among others Klepper and Simons (2000) and the cited literature there).

periods high re-entry costs can act like high exit costs and improve the strategic position of the larger firm.[6] Considering a duopoly with two initially differently sized firms that compete in prices under capacity constraints, Ghemawat (1990) shows that the initially larger firms has the incentive to take up all investment opportunities over time (the overall duopoly profits are maximised at the most asymmetric allocation of capacities) and industry concentration increases (snowball effect). In turn, Krishna (1999) shows that this effect does not necessarily hold by using a game where multiple units of capacity are sold sequentially to two ex-ante symmetric buyers and takes the buyers' endogenous valuation of additional capacities into account (determined by the outcome of the market stage). The convexity of payoffs in the market stage ensures a monopolization of capacity, while increasing returns to scale are not sufficient.

Asymmetric industry structures may also be shown by using a capacity accumulation game played by ex-ante identical firms that differ in their economic fundamentals or strategic positions (cf. among others Saloner, 1987, Leathers, 1992, Maggi, 1996, or Reynolds and Wilson, 2000). Endogenously arising asymmetries in firm size of ex-ante identical firms are shown by Besanko and Doraszelski (2004). They use a dynamic model of capacity accumulation with product market competition where the firms are ex-ante identical in their size, in their cost structure and strategic position. The mode of competition and the reversibility of investments are major determinants of the firm size distribution. The stronger the competition (e.g., price competition) and the higher the depreciation rate (investments are more reversible) is, the more tends the firm size structure towards stronger asymmetries (e.g., one large and one small firm). Another very appealing approach to analyse endogenous market structures has been taken by Esö et al. (2010). Their major finding is that an asymmetric industry structure becomes more likely the larger the pool of resources.

However, a direct application of these models to the agricultural land market is difficult since land is not a freely traded source that can be bought in an upstream market; in Western countries free land is only available if at least one farm leaves the market. Leathers (1992) directly accounts for the interaction of farms in the land market where free land from the exiting farms is traded among heterogeneous farmers. He points to a positive impact of for example price support or demand enhancement programmes on land prices. Even though such programmes may also result in increasing commodity prices, the net effect shows a reduction in the number of farms. Vranken and Swinnen (2006) focus on the development of land markets during

[6] See Frank (1988) as well as Fudenberg and Tirole (1986) for a more general modelling of exit decisions.

the transition period. Analysing the competition of household owned farms with large-scaled corporate farms in Hungary, they find that the dominance of large corporate farms in some regions leads to a constraint access to land for (smaller) household farms. Additionally, Huettel and Margarian (2009) show that strategic interaction – measured by market power of large farms, the potential of high competition for land within a region and possibly high rents of the status quo – is a crucial determinant of regionally differing patterns of structural change. Their findings give further evidence that initial (historic) conditions, such as the number and size of farms, lead to differing local equilibria in the land market characterized by differences in market power relations. Thus, as emphasised by Kellermann et al. (2008), strategic interaction in the land market plays a crucial role for structural change in agriculture. Summarizing, in Western countries the growth of farms hinges on the exit of others. The exit of farms is crucial for any further industry development since exits facilitate the land market, only through exits growth becomes possible.

The remainder of the paper is organized as follows: In Section 2, we provide a theoretical analysis of structural change in agriculture where we consider farm exit as a precondition for farm growth. In Section 3 we empirically illustrate our theoretical findings. Herein we first present the data structure and the methodology and then second, the empirical results are shown. The last section concludes.

2. Exit and Growth: A Theoretical Analysis

In this section, we provide a theoretical model on exit and growth in the agricultural sector. The model is presented in 2.1. We solve the for the equilibrium strategies in 2.2 and discuss our results in 2.3.

2.1 The Model

We consider an agricultural market with *n* farms. Each farm *i* with $i = 1,...,n$ produces a quantity q_i of a homogenous good to be sold in a final or intermediate goods markets. Thereby, one unit of land is used to produce one unit of the homogenous good. We consider two types of farms that differ in their initial land capacity k_i. The large farms $l = 1,...,m$ hold an initial land capacity of $k_l = \overline{k}$, while the small farms $s = m+1,...,n$ have an initial land endowment of $k_s = \underline{k}$ with $\Delta k \equiv \overline{k} - \underline{k} > 0$. We further assume that there are no free land resources available. The total land capacity in the considered market is therefore given by

$K = m \cdot \overline{k} + (n-m) \cdot \underline{k}$. Correspondingly, farms cannot grow unless other farms shrink or leave the market.

The farms incur production costs of $C(q_i)$, which are assumed to be twice continuously differentiable, increasing and strictly convex in quantity, i.e., $C' > 0$ and $C'' > 0$. Accounting for differing cost efficiency levels between the large and the small farms, for instance due to different investments made or different technologies, we weight the cost function of the large farm by a parameter α with $\alpha \in (0,1]$. A lower α indicates a more advantageous production in terms of production costs, while the closer α approaches 1, the less differ the large and the small farms in their cost structure. Summarising, small farms bear production costs of $C(q_s)$, while the production costs of the large farms are given by $\alpha C(q_l)$. Note that the marginal costs of production are the same for both the large and the small farms if α reaches the critical value: $\alpha = \alpha^* \equiv C'(q_s) / C'(q_l)$.

Timing of the Game. The interaction of farms is described by the following three-stage game. In stage one, the farms decide whether to leave the market or to continue production. We denote the respective number of firms leaving the market by $e^l + e^s$ where $e^l \leq m$ denotes the large farms and $e^s \leq n-m$ denotes the small farms ceasing agricultural production. In stage two, the farms that leave the market sell their initially given capacity k_i to the remaining farms in the market. Thus, the $n - e^l - e^s$ remaining firms in the market can obtain a share of the overall available land capacity $\hat{K} = e^l \overline{k} + e^s \underline{k}$. The total production capacity of each remaining firm then refers to $k_i + \tilde{k}_i$ where $\tilde{k}_i$ indicates the farms' additional capacity purchased. Within our framework, we neglect potential entry into agricultural production as it only plays a minor role in Western agricultural markets.[7] In stage three, the farms sell their products at a given price.

Land Market. To decide whether to quit agricultural production or not, the farms compare their profits in the case of continuing production – possibly under extended capacity – and their profits in the case of ceasing production. In the latter case, the farms can sell or rent their initial capacity to the remaining firms in the market. Thereby, the total amount of newly available land resources is a perfectly divisible good. Apparently, there is no land available for redistribution as long as no farm ceases production. In other words, a land market only

[7] Note, the number of farms in the West German agricultural sector continuously declines over time and observed entries are mainly due to re-entry of newly organized farms

emerges if at least one farm leaves agricultural production. We consider a simple market mechanism where the market clearing price for additional land is determined by equating the demand and the supply of land, inducing an unique market-clearing price ω. Hence, we neglect any strategic incentives of the different actors in the market.

Profits. Assuming that each farm pays ω for a unit of additional capacity $\tilde{k}_i$, the profits of the large farms when continuing agricultural production are given by[8]

$$\begin{aligned}&\pi_l\left(q_l,\cdot\right)=p\cdot q_l-\alpha C\left(q_l\right)-\omega\cdot\tilde{k}_l\\&\text{with } q_l\leq\overline{k}+\tilde{k}_l,\end{aligned}\tag{1}$$

while the profits of the small firms refer to

$$\begin{aligned}&\pi_s\left(q_s,\cdot\right)=p\cdot q_s-C\left(q_s\right)-\omega\cdot\tilde{k}_s\\&\text{with } q_s\leq\underline{k}+\tilde{k}_s.\end{aligned}\tag{2}$$

If, in turn, the farms cease agricultural production, they sell their initial capacity to the competitors. Furthermore, they can opt for an earning alternative that yields a net revenue of ψ. Accordingly, their profits when realizing the outside option refer to

$$\hat{\pi}_i\left(\cdot\right)=\omega\cdot k_i+\psi\ \text{ with } k_i\in\left\{\underline{k},\overline{k}\right\}.\tag{3}$$

Maximising (1) with respect to q_l, the optimal production of a large farm $\overline{q}_l$ is determined by $p\equiv\alpha C'(\overline{q}_l)$ if $\overline{q}_l\leq\overline{k}+\tilde{k}_l$. Analogously, the optimal production of the small farm $\overline{q}_s$ is implicitly given by $p\equiv C'(\overline{q}_s)$ if $\overline{q}_s\leq\underline{k}+\tilde{k}_s$ Thus, the equilibrium quantity of farm *i* is given by

$$q_i^*=\begin{cases}\overline{q}_i & \text{if } \overline{q}_i\leq k_i+\tilde{k}_i\\ k_i+\tilde{k}_i & \text{otherwise.}\end{cases}\tag{4}$$

Ensuring firms' incentive to grow, we focus only on those cases where the capacity constraint is binding, i.e. $\underline{k}<\overline{k}<\overline{q}_i$. Equilibrium production is, then, restricted to the total capacity of a firm, i.e. $q_i^*=k_i+\tilde{k}_i$.

2.2. Land Market and Exit

We solve for the equilibrium strategies of the farms by working backwards. Our equilibrium concept corresponds to subgame perfection. We first consider the final stage of the game which is given by our results in (4). By proceeding further backwards, we solve for the out-

[8] In order to simplify the notation, we omit the arguments of the functions where possible.

come of the land market, taking as given the number of exiting firms. Finally, we analyse the farms' exit decisions.

Land Market. Taking the exits of $e^l + e^s$ farms as given, the available land resources $\hat{K} = e^l \overline{k} + e^s \underline{k}$ can be bought by the $n - e^l - e^s$ remaining farms in the market. The demand for additional land capacities can be derived by the first-order conditions of profit maximisation with respect to $\tilde{k}_i$, i.e.

$$\frac{\partial \pi_s(\cdot)}{\partial \tilde{k}_s} = p - \omega - C'(q_s) = 0 . \tag{5}$$

and

$$\frac{\partial \pi_l(\cdot)}{\partial \tilde{k}_l} = p - \omega - \alpha C'(q_l) = 0 , \tag{6}$$

respectively. The equilibrium additional capacities $\tilde{k}_i^*$ are increasing in the market price p, while they are decreasing in ω and the initial capacity k_i. Furthermore, $\tilde{k}_l^*$ is decreasing in α. This implies that the farms incentive to grow is increasing in the efficiency of their production technology.

To compare the incentives to grow between the small and the large farms, we consider first the case where both types of farms use the same production technology and do not differ with regards to their cost efficiency, i.e. $\alpha = 1$. According to the assumption of convex cost, this implies that the large farms produce at a higher marginal cost and have a lower incentive to grow than the small farms, i.e. $\tilde{k}_l < \tilde{k}_s$. Finally, both types of firm converge in terms of total quantity, i.e. $\overline{k} + \tilde{k}_l^* = \underline{k} + \tilde{k}_s^*$. If, instead, the large farms have a more advantageous production technology and produce more efficiently, i.e. $\alpha < 1$, a trade-off emerges. On the one hand, the large firms tend to have a higher valuation for additional land resources than the small firms because they benefit from their advantageous cost function. On the other hand, the initial land endowment of the large firms exceeds the initial land endowment of the small firms and this implies higher production costs at the margin. Correspondingly, the relation between the cost parameter α and the initial land endowment k_i determines whether it is the large or the small firms having a stronger incentive to grow and to opt for additional capacity in the land market. Thus, we have $\tilde{k}_l^* \geq \tilde{k}_s^*$ for all $\alpha \leq C'(q_s)/C'(q_l)$, while the opposite holds for $\alpha > C'(q_s)/C'(q_l)$.

The market-clearing price ω is determined by equating the total amount of newly available land resources and the total demand for new capacities. That is, the considered allocation rule in the land market refers to conventional supply and demand terms. Aggregating the demand functions of all remaining farms in the market – the large and the small ones – we obtain the overall demand function for additional land capacity, i.e. $\tilde{K}^* = \sum_{i=1}^{n-e^l-e^s} \tilde{k}_i^*$. The supply function is given by the sum of the newly available capacities, i.e. $\hat{K} = e^l \overline{k} + e^s \underline{k}$. Equating the aggregated demand and supply functions, i.e. $\tilde{K}^*\left(\omega^*,\cdot\right) \equiv \hat{K}$, we obtain the equilibrium market clearing price ω^*. If the initial land endowment is relatively large, the farms hardly have any incentive to grow. This induces a lower demand for additional land resources and induces a lower land price. Likewise a increasing number of farms leaving the agricultural sector and thus an increasing supply results in a lower land price. Accordingly, the land price is increasing in the number of initially large farms if $\alpha \le C'(q_s)/C'(q_l)$ as this increases the overall demand for additional capacity.

Lemma 1. *There exist an equilibrium market clearing price* ω^*. *Comparative statics reveal that the land price is decreasing in the initial land endowment, i.e.* $\partial\omega^*/\partial\overline{k} < 0$ *and* $\partial\omega^*/\partial\underline{k} < 0$. *Furthermore, the land price is decreasing in the number of exiting farms, i.e.* $\partial\omega^*/\partial e^s < 0$ and $\partial\omega^*/\partial e^l < 0$. *Finally, the equilibrium market clearing price is increasing (decreasing) in the number of initially large firms* m *as long as* $\alpha \le C'(q_s)/C'(q_l)$ $\left(\alpha > C'(q_s)/C'(q_l)\right)$. ■

Proof. There exists an unique equilibrium land price ω^* since $\tilde{K}^*\big|_{\omega=0} > \hat{K}$, $\partial\tilde{K}^*/\partial\omega < 0$ and $\partial\hat{K}/\partial\omega = 0$. Applying the implicit function theorem and denoting $\Omega = \tilde{K}^*\left(\omega^*,\cdot\right) - \hat{K}$, we get $sign\left(\partial\omega^*/\partial k_i\right) = sign(\partial\Omega/\partial k_i)$ since $\partial\Omega/\partial\omega < 0$. Due to $\partial\Omega/\partial\overline{k} = -e^l + \left(m-e^l\right)\partial\tilde{k}_l^*\left(\cdot\right)/\partial\overline{k} < 0$ and $\partial\Omega/\partial\underline{k} = -e^s + \left(n-m-e^s\right)\partial\tilde{k}_s^*\left(\cdot\right)/\partial\underline{k} < 0$, respectively, we get that $\partial\omega^*/\partial k_i < 0$.

Correspondingly, we have $sign\left(\partial\omega^*/\partial e^j\right) = sign(\partial\Omega/\partial e^j)$ with $j = l,s$ since $\partial\omega^*/\partial e_j < 0$ due to $\partial\Omega/\partial e_j = -\left(k_j + \tilde{k}_j\right) < 0$. Turning finally to the comparative statics in *m*, we get $\partial\Omega/\partial m = -\tilde{k}_s + \tilde{k}_l$ and thus, $sign\left(\partial\omega^*/\partial m\right) = sign(\partial\Omega/\partial m) < 0$ if $\tilde{k}_s > \tilde{k}_l$ and if $\alpha > C'(q_s)/C'(q_l)$, while $\partial\omega^*/\partial m \ge 0$ if $\tilde{k}_s \le \tilde{k}_l$ and if $\alpha \le C'(q_s)/C'(q_l)$. ■

Exit. In the first stage of the game, firms decide whether to leave the market or to continue production. Thereby, the firms compare the profit of continuing and the earnings in the case of leaving the market. Plugging $\omega^*(\cdot)$ into $\tilde{k}_i^*(\omega,\cdot)$, we obtain the additional capacity that each remaining firm gets from the overall available land resources, i.e., $\tilde{k}_i^{**} = \tilde{k}_i^*(\omega^*,\cdot)$. Hence, the initially small firms leave the agricultural sector if

$$\omega^*(\cdot)\underline{k} + \psi \geq \pi_s(\cdot). \tag{7}$$

Analogously, the initially larger firms exit if

$$\omega^*(\cdot)\overline{k} + \psi \geq \pi_l(\cdot). \tag{8}$$

It turns out that those farms are more likely to leave the market that have the lower valuation for additional capacity. Thus, the large firms leave the market if $\alpha > C'(q_s)/C'(q_l)$. That is, the equilibrium number of large firms leaving agricultural production e_l^* is given by $\omega(\cdot)\overline{k} + \psi \equiv \pi_l(\cdot)$ if $\alpha > C'(q_s)/C'(q_l)$. In turn, the small firms are more likely to cease agricultural production if $\alpha < C'(q_s)/C'(q_l)$ and e_s^* is given by $\omega^*(\cdot)\underline{k} + \psi \equiv \pi_s(\cdot)$. If the production technology of the large farms is considerably advantageous compared to the small firms, i.e., α is very low, then even the some of the remaining large farms would cease production but only after the small farms have left the market. This is due to the fact that a decreasing value of α improves the large farms' valuation for additional resources which increases the price ω. The more α approaches to zero the more large firms leave.

Proposition 1. *Comparative statics reveal that e_j^* is decreasing in both $\overline{k}$ and $\underline{k}$. The impact of the number of initially large farms m on the exit rate is ambiguous: e_j^* is increasing (decreasing) in m if $\alpha \leq C'(q_s)/C'(q_l)$ $\left(\alpha > C'(q_s)/C'(q_l)\right)$.*

Proof. There exists an e_j^* if $\psi > \pi_j(\cdot) - \omega(\cdot)k_j$ since $\pi_j(\cdot) - \omega(\cdot)k_j$ is monotonically increasing in e_j, while ψ does not depend on e_j. Applying the implicit function theorem and denoting $\overline{\Omega} = \omega(\cdot)k_j + \psi - \pi_j(\cdot)$ with $j = l, s$, we get that $sign\left(\partial e_j^* / \partial k_j\right) = sign(\partial\overline{\Omega} / \partial k_j)$ since $\partial\overline{\Omega} / \partial e_j = \left(\partial w^* / \partial e_j\right)\left(k_j + \tilde{k}_j\right) < 0$. Hence, we have $\partial e_j^* / \partial k_j < 0$ since $\partial\overline{\Omega} / \partial k_j = \left(\partial\omega / \partial k_j\right)\left(k_j + \tilde{k}_j^*\right) < 0$. Turning to the comparative statics in *m*, we have

$sign\left(\partial e_j^* / \partial m\right) = sign(\partial\bar{\Omega} / \partial m) = \left(\partial\omega / \partial m\right)\left(k_j + \tilde{k}_j^*\right) \geq 0$ if $\alpha \leq C'(q_s)/C'(q_l)$, while $\partial\bar{\Omega} / \partial m < 0$ implying $\partial e_j^* / \partial m < 0$ if $\alpha > C'(q_s)/C'(q_l)$. ■

Our results reveal that the less efficient farms exit agricultural production. However, the farms – either large or small – are less likely to cease agricultural production if the initial land endowment of farms is relatively high. This is due to the fact that a larger initial land endowment reduces the farms' valuation for additional capacity implying a lower land price which, in turn, makes exit less profitable. Accordingly, the intensity of structural change heavily depends on the initial land endowment of farms. At the same time, the cost structure used by farms plays a crucial role. Assuming that the large farms are more efficient than the small farms, i.e., $\alpha \leq C'(q_s)/C'(q_l)$, a higher share of large farms in a region positively affects the exit rate of small farms. If in turn the large farms are less efficient than the small farms, i.e., $\alpha > C'(q_s)/C'(q_l)$, a higher share of small farms with increasing exit probability results. In other words, a higher share of large farms leads to a lower exit probability. This implies that an ex-ante asymmetric farm size distribution in terms of land endowment among the farms has different implications: The exit of small farms is increasing in the number of large farms if the large farms are sufficiently efficient and their initial land endowment is not too large. In turn, the exit of small farms increases in the number of large farms, if the large farms' efficiency is relatively low and their initial market share is relatively high.

2.3. Discussion & Extensions

Our theoretical results are based on several crucial assumptions. First, our analysis is based on the assumption of increasing marginal costs of production. In the agricultural sector, however, also increasing returns to scale are observed which is equivalent to decreasing marginal cost of production. Then, the value of additional units of land is increasing. As a consequence, the resulting optimal allocation would involve only one single farm. This phenomenon of natural monopoly is well known for industries to which entrants are not naturally attracted and the single farms benefits from economies of scale with declining average cost in output. Furthermore, in our theoretical framework the land market is based on a simple allocation mechanism. However, a comparison of our results with Huettel et al. (2010) where the land market is modelled based on a Vickrey auction mechanism that gives an efficient allocation of the free capacity, shows that this does not change the final results. Against this background, our used approach here can be judged as a proxy for more complex though efficient allocation mechanisms such as land market auctions.

3 EXIT AND THE ALLOCATION OF CAPACITY: FIRST EMPIRICAL FINDINGS

In this section we empirically highlight several aspects of the theoretical findings using farm-level data for the West German agricultural sector. We first present the data and the used statistical methodology (3.1) and second (3.2) the empirical findings. The analysis with its specific focus on the impact of regional asymmetries should be seen in a subsequent order, starting from the exit decisions, we illustrate our findings about the relation between (1) farm exits and regional (a)symmetries. This is followed by (2) the joint analysis of the relation farm growth, decline as well as exit and regional (a)symmetries. Finally, farm growth is explored in more details and we show the findings about (3) the relation between the growth rates of the large farms, regional (a)symmetries and regional production characteristics.

3.1 Data and empirical methods

The used farm-level data come from the agricultural census and are provided by the RDC[9] comprising single farm observations for West Germany. Overall, three time observations are available: 1999, 2003 and 2007. This allows us to construct two periods: 1999-2003 and 2003-2007 in order to measure changes in the farms' land endowment over time. In contrast to the Farm Accountancy Data Network (FADN) data, it is possible to measure all farm specific activities like growth or shrinkage within each period, including entry and exit. However, this comes at the cost that no financial variables like profits or cash flow are available. However, based on survey results about farmers' own assessment, ex-post, the second period was characterized by more favorable macroeconomic conditions for the agricultural sector compared the first period (for a similar characterization see also Huettel and Margarian, 2009). Unfortunately, also no detailed information about the regional land market (e.g., number of bids, number of participants, demander) is available.

In 1999, 441,485 active farms are observed in the Western Federal States. We define three size classes measured in terms of land endowment, viz. small (1-30 hectares), medium (30-50 hectares) and large (>50 hectares). Based on them, it is possible to measure changes in the farm size distribution within each period. Furthermore, regions are defined at the county level (NUTS III, Landkreis), in sum 321 counties exist. In order to account for the regional farm size structure and the respective distribution of land among the farms within one variable, we refer to the Gini coefficient. Based on the observations for 1999 and 2003 the coefficient is defined as $Gini_r = 1 - \sum_{j=1}^{J} (v_{(j-1)r} + v_{jr}) \cdot (u_{jr} - u_{(j-1)r})$, where j denotes the respective size category (small, medium, large) and r denotes the respective region with $r = 1, ..., 321$. Fur-

[9] Research Data Centres of the Federal Statistical Office and the statistical offices of the Länder.

ther, v_{jr} refers to the cumulative share of class *j* on the total number of farms for region *r*, thereby indicates '-1' the respective lower size class. u_{jr} stands for the cumulative share of land of class *j* on the total amount of acreage used in region *r*. The Gini coefficient measures the degree of asymmetries in firm size (land endowment) and indicates whether the used acreage is concentrated in one size category. If the agricultural area is equally distributed among the size classes within a region, the Gini coefficient is rather low and we expect a tendency towards a symmetric farm size distribution. Contrarily, a high Gini coefficient indicates a concentration of the acreage in the small or the large size category with only relatively few farms in the respective other categories; shortly, it reflects asymmetries in the farm size distribution.

Further variables that will be used in the subsequent analysis are the share of exiting farms among the total number of farms in the respective region and time period, the share of shrinking farms, i.e., farms that reduce their size in terms of land endowment and the joint share of exiting and shrinking farms. In order to account for changes in the land endowment of the large farms, in particular for the growth of the large farms, we take the percentage change rate of permanently large farms in their land endowment, i.e. farms that are from 1999 on in the large size category. Summary statistics of all variables are shown in Table 1.

Table 1 Summary statistics of the used variables

Variables	# observations	Mean	Standard deviation	Min	Max
Gini coefficient	642	0.55	0.08	0.31	0.75
Share of exiting farms	643	0.14	0.04	0.05	0.30
Share of shrinking farms	643	0.03	0.02	0.00	0.09
Joint share of exiting/shrinking farms	643	0.17	0.04	0.05	0.30
Growth rate large farms (%)	643	9.16	5.65	-30.93	47.25

Source: Own calculations based on RDC data 1999-2007.

In order to state the relations (1), farm exits and regional (a)symmetries, and (3), the relation between the growth of the large farms, regional (a)symmetries and regional production characteristics, we refer to general linear models (proc GLM in SAS 9.1.3). Assuming a normal error distribution, we estimate the models by Maximum Likelihood (see Neter et al. (1996) for further details about this kind of models). The general linear model (GLM) provides the advantage to combine the linear regression model with a variance analysis and it is possible to estimate varying coefficients for different regions. In order to define the differently characterized regions, we refer in a previous step to a variance analysis and classify three types of regions: structural regions (e.g., large farm size and asymmetry), specialized regions with regard to the production type (e.g., mixed or dairy) and the socio-economic environment and development (e.g., urban-positive or rural-positive).[10] Since the structural regions seem to be the most important ones, we present in Table 2 the descriptive statistics of the used variables in their respective region. The classification 'equal' indicates that land is rather symmetrically distributed among the firms, while 'unequal' refers to an asymmetric distribution of firm size measured by the Gini coefficient. The classifications 'very large', 'large' and 'small' indicate the mean average firm size, respectively.

Table 2 Summary statistics in the structural regions

Variable	Region characterized by average farm size land distribution	Mean	Standard Deviation	Min	Max
Growth rate large farms	large equal	9.51	6.37	-3.33	43.93
	large unequal	9.10	2.87	3.12	16.53
	small equal	9.61	4.57	-11.81	29.48
	small unequal	9.18	6.85	-30.93	47.25
	very large	7.77	2.70	2.01	16.47
Share of exiting/ shrinking farms	large equal	0.18	0.04	0.08	0.25
	large unequal	0.19	0.04	0.08	0.30
	small equal	0.15	0.02	0.08	0.20
	small unequal	0.17	0.04	0.05	0.28
	very large	0.18	0.03	0.10	0.30
Gini coefficient	large equal	0.52	0.05	0.39	0.71
	large unequal	0.59	0.03	0.51	0.67
	small equal	0.47	0.05	0.31	0.60
	small unequal	0.60	0.06	0.38	0.75
	very large	0.53	0.06	0.42	0.66

Source: Own calculation based on RDC data 1999-2007.

The illustration of point (2), the relation of farm growth, decline as well as exit and regional (a)symmetries is taken out of a full Markov Chain analysis as provided by Huettel and Margarian (2009). The respective transition probabilities reflect the likelihood of a farm to move

[10] We use within the multivariate variance analysis to characterize each of the three differently characterised region types several variables. For the structure regions we used the average farm size, the Gini coefficient, the share of small and large farms, respectively, and the share of part time farms. For the production type regions we use the share of grazing livestock farms, share of pig and poultry farms, share of cash crop and horticultural farms, respectively as well as the number of dairy cows and pigs per ha, respectively, Finally, for the socio-economic regions we use the share of constructed area, the absolute value and the change in the gross value added per inhabitant, the absolute number as well as the change of people in the regional labour force as well as the share of people in the agricultural labour force. Further details can be found in Huettel et al. (2010).

from one pre-defined size category to another or to stay within a category in a given period. The categories with regard to production status and size are small, medium, large or being inactive. The probabilities are directly derived from the farm individual decisions for each of the periods and thus reflect farm growth, decline, exit or persistence.. By means of a multinomial formulation, it is possible to express the series of the log of a ratio of probabilities as a linear function of the explanatory variables (for further details of this procedure see for instance Gourieroux (2000)). Several variables have been used to explain the transition probabilities, here of particular interest is the impact of the Gini coefficient in 1999: this allows us to illustrate the relation between asymmetries (initial with respect to the period) and growth, decline or exit activities.

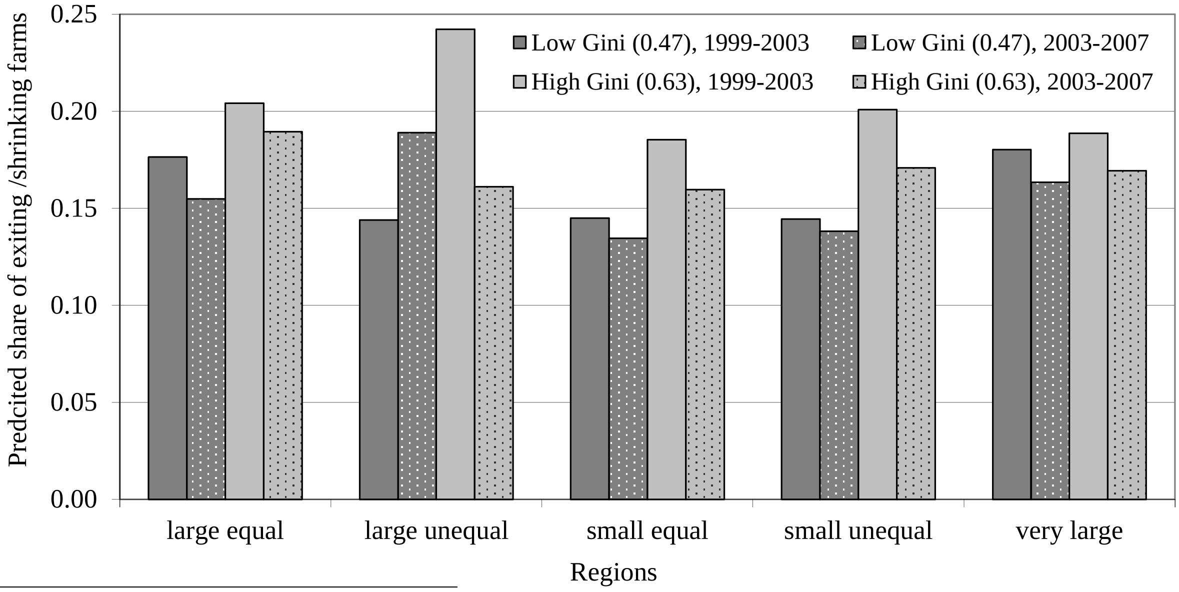
3.2 Empirical findings

The empirical illustration should be judged as a first analysis that may serve as a base for a full structural empirical model. It should be further noted that the results for (1) and (3) are of explorative nature.

(1) Relation of Farm Exit and the Gini coefficient. A generalised linear model has been estimated in which the share of shrinking and exiting farms is regressed on the Gini coefficient, the share of exiting/shrinking farms and the growth of permanently large farms (farms that remain in the large size category over both periods). Note, the variables are used in their centred form to reduce the heterogeneity in the data.

The main variable of interest in the results is the impact of the Gini coefficients in 1999 and 2003, respectively, on the share of exiting and shrinking farms. As explored above, this coefficient indicates to what extend the initial farm size distribution is concentrated. For the first period, the Gini coefficient of 1999 is relevant for the farms' respective decisions in the subsequent time period (1999-2003) and similarly, the Gini coefficient of 2003 is relevant for the second period (2003-2007) in order to account for the initial farm size distribution. In Figure 1 the relationship between the predicted share of exiting/shrinking farms for different levels of the respective initial Gini coefficient (holding all other variables fixed at zero) is illustrated for the structural regions. The estimated coefficients and their standard errors are presented in the Appendix in Table A1 (Model 1).

Figure 1: Relation between the rate of exiting/shrinking farms and the Gini coefficient



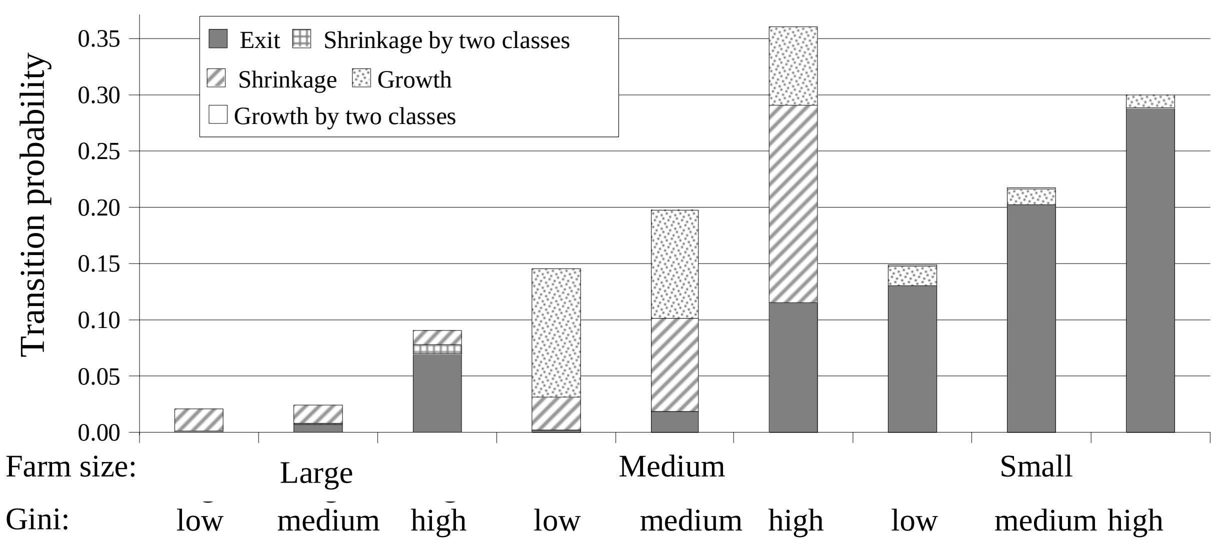
Source: Own calculation based on RDC data 1999-2007.

With a *low* Gini coefficient in 1999 (dark grey bars), the predicted exit rate is highest in regions with many large farms (‘large equal’ and ‘very large’). With a *high* Gini coefficient in 1999 (light grey bars), the exit/shrinking activity is generally higher and is highest in the ‘large unequal’ regions. Note, the first period (1999-2003) was characterized by less favourable conditions. In contrast, the second period (2003-2007; indicated by bars with dots) was characterized by positive macroeconomic expectations. The results reveal that the ‘large unequal’ regions with an initially *high* Gini coefficient (2003) show the lowest exit rate of all regions in that period. This sensitivity of farms towards changing conditions seems to be highest in these ‘large unequal’ regions characterized by strong initial asymmetries. Contrary to the latter finding, regions with a ‘large unequal’ farm size distribution but a *low* initial Gini coefficient in 2003 (dark grey with dots) show an increase in the share of exiting/shrinking farms in the second period.

A possible reasoning behind this finding is, that in such regions as indicated by the initially symmetric structure and the large average farm size, more large firms act in the regional market for land leading to a high aggregate demand for additional scarce land resources. Since we expect the willingness-to-pay for additional land to be high among growth-oriented farms (e.g., through benefiting from economies of scale), we expect the willingness to pay to increase in the second period under more favourable economic expectations, and this in turn, may cause a higher exit rate among smaller farms. The findings give first empirical evidence for the theoretical findings referring to Proposition 1 stating that the exit rate is affected by the presence of the number of large firms. Further, the exit rate is the higher, the higher the asymmetries are and the higher the average farm size within a region.

(2) Joint Analysis of Farm Exit, Growth and Decline. Here, we directly refer to the full Markov chain analysis of Huettel and Margarian (2009) with the advantage that growth, decline and exits are can be analysed jointly considering the direct dependency of growth and exits. Note that this comes at a cost since in the Markov chain model growth of the large farms cannot be detected. In Figure 2 we illustrate the findings about the relation of farm exit, growth and decline to the regional asymmetries measured in terms of the Gini coefficient (note, since the aim is account for the initial asymmetries, the Gini coefficient of 1999 is used). The farm individual activities are summarized in the transition probabilities. Since in the multinomial formulation there is a non-linear relationship between the Gini coefficient and the respective ratio of transition probabilities, we show the relation to the respective transition probabilities for three different levels of the Gini coefficient that are derived using the quantiles: low, medium and high. Thus, for each size category the predicted probability to grow by one or two size categories, to exit or to shrink by one or two size categories for a low, medium and a high initial Gini coefficient are presented.

Figure 2: Partial Effect of the Gini coefficient on the transition probabilities



Source: Own calculations based on RDC data 1999-2007.

The findings as shown in Figure 2 reveal that the exit probability of all size categories is the higher, the higher the Gini coefficient is, thus the stronger the asymmetries in a region are. The *smallest farms* have the highest exit probability (irrespective of the level of the initial Gini coefficient). Further, the *medium farms* grow to a higher extent than small farms do. This may be explained by the expected higher valuation of initially larger firms for additional land resources. However, growth of the medium farms declines with an increasing Gini coefficient where the highest shrinking probability of the medium-sized farms is observed with a high Gini coefficient. Given a higher valuation of large firms for additional land resources, the medium farms' are therefore expected to have a higher incentive to shrink rather than to grow (see Proposition 1). The results show also that contrary to common beliefs shrinkage is a notable phenomenon and might represent a rational action if farms' future growth potential is expected to be low.

(3) Relation of Growth of the Large Farms, Exit and the Regional Structure. With regard to this relation, we would expect that the higher the share of exiting and shrinking farms is (that refers to a higher availability of land resources), the stronger is the differentiation of farms with respect to their size in a region. Starting from heterogeneous farms within a region we expect the large farms to grow at the highest rates. Since in the Markov chain model growth of the large farms cannot be explored, we use the mean growth or change rates of the large farms in their land endowment and regress them on the centred Gini coefficient, the centred share of exiting/shrinking firms and additionally, the share of shrinking and exiting farms using a generalised linear model in order to illustrate this relation. Also here we classify the regions and allow for varying coefficients. The estimated coefficients and their standard errors are presented in the Appendix in Table A1 (Model 2).

The findings reveal that the growth of large farms is increasing in the rate of exiting and shrinking farms. In other words, the large farms grow least in regions if the rate of exiting and shrinking farms is low and most if the rate of exiting and shrinking farms is high. However, the rate at which the farms grow and the magnitude of the impact of the exit-share differs between the structural regions and highly depends on the initial distribution of land between the farms. If the share of exiting farms is low (note, this also implies that the pool of available land resources is small), the impact of the exit-share on the growth rate increases with the Gini coefficient: the higher the Gini coefficient is, the stronger are the growth rates determined by the exiting farms. Due to the lower exit rates the lower availability of free land resources limits the growth possibilities are limited. Thereby we would expect that the price for land increases. On the contrary, if the share of exiting and shrinking farms is high in the regions (note, this may imply that the pool of available land resources is large), the impact of the exits on the growth rates decreases in the Gini coefficient: the higher the Gini coefficient is, the lower is the impact of exits on the growth rates. A low Gini coefficient together with a higher availability of land (supply shift) may foster a stronger differentiation of farms within a region with respect to their size. The results further show a significantly higher impact of the

Gini coefficient on the growth of the large farms in rather urban regions, in regions with a 'large equal' farm size structure and in regions that are characterised by mainly cash crop farms (note, these farms purely grow via increases in land endowment).

Summarising, we find that regional asymmetries in firm size are positively related to exit rates and negatively to the growth rate of the medium farms. Shrinking is a common strategy of medium-sized farms in the presence of (possibly dominant) large farms. While the exit rate of the small farms is highest, medium farms grow stronger than small farms. These findings are in line with many of the hypotheses found in the literature as well as with our own theoretically derived expectations. Therefore, the first empirical findings reinforce the papers' central point that farms' exit and growth behaviour is mutually depend and partly determined by the specific situation in the land market.

4 Concluding Remarks

This paper sets out to analyse the impact of the initial farm size structure on both the exit decision of farms inducing free land capacities as well as the allocation of the newly available land resources to the remaining farms in a particular region. Against this background a model of structural change has been set up where the farmers' valuation of additional land has become endogenous. Assuming cost advantages for larger firms and taking into account an initial heterogeneity of farms in size, we find that large farms tend to grow more than small farms. Large farms' probability to exit is very low and it is the small farms, that increasingly leave the market in the presence of many large farms. Empirical findings point to the fact that regional asymmetries in firm size measured by the concentration of land endowment are positively related to exit rates (mainly small farms) and negatively to the growth rate of the medium farms. The presented analysis has to be judged as a first, preliminary approach in order to reach some primary understanding of possible relations between conditions on the land market and structural change in agriculture. There is still a need of further improvement. For instance, the formal analysis has to be elaborated with the aim to show the possibility of an endogenous evolution of heterogeneity. This should be in a subsequent step translated to structural empirical model that is then directly estimated.

Beyond the methodological issue of this paper, our findings have practical implications. Policy-makers are interested in structural change that is compatible with social concepts and policy aims. Given that structural development is among the policy aims, policies themselves as well as their evaluation and analysis should be carried out at the disaggregated regional level since given the specific situation in the land market, the same policy or its changes need not have the same structural effects in different regions. Our analysis here does not necessarily represent a justification for policy interventions. The existence of several possible equilibria in farm-size structure might imply that the most efficient one is not realised and might remain a non-realisable goal given that many markets may be imperfect. Additionally under such complex circumstances, a huge amount of detailed information and data would be necessary in order to address effective structural policies. The necessary discrimination between farmers in different regions within such effective structural policies might not just create practical also ethical and judicial problems.

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APPENDIX

Table A1: Estimated coefficients for the models explaining the rate of exiting/shrinking farms and the growth of the large farms

Variables	Interaction of the variable with…	Cluster Characteristic	Model 1 Share of exiting/ shrinking farms	Model 2 Growth of the large farms
Intercept			0.184	6.95
			(0.007) ***	(1.21) ***
Centered Gini coefficient			0.054	-5.08
			(0.085)	(19.30)
Year			-0.018	2.63
			(0.003) ***	(0.44) ***
Centered Gini coefficient	Year		-0.02	--
			(0.118)	
Centered share of exiting/shrinking farms			--	32.49
				(6.68) ***
Centered share of exiting/shrinking farms	Centered Gini coefficient		--	-310.43
				(76.60) ***
Regional clusters with respect to the farm size structure		large equal	0.006	2.96
			(0.006)	(0.91) **
		large unequal	0.009	0.58
			(0.008)	(1.34)
		small equal	-0.019	2.56
			(0.006) **	(1.04) **
		small unequal	-0.012	2.19
			(0.005) **	(0.81) **
		very large	0.000	0.00
Regional cluster indicator with respect to the farm size structure	Centered Gini coefficient	large equal	0.120	40.09
			(0.120)	(14.65) **
		large unequal	0.560	8.46
			(0.189) **	(24.33)
		small equal	0.199	-3.92
			(0.099) *	(14.52)
		small unequal	0.298	-5.96
			(0.096) **	(12.24)
		very large	0.000	0.00
Regional cluster indicator with respect to the farm size structure	Centered Gini coefficient & Year	large equal	0.059	--
			(0.162)	
		large unequal	-0.771	--
			(0.215) ***	
		small equal	-0.080	--
			(0.132)	
		small unequal	-0.131	--
			(0.133)	
		very large	0.000	--