How financial constraints distort farms' investment behaviour and regional development: a comparative analysis of four European regions

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HOW FINANCIAL CONSTRAINTS DISTORT FARMS' INVESTMENT BEHAVIOUR AND REGIONAL DEVELOPMENT: A COMPARATIVE ANALYSIS OF FOUR EUROPEAN REGIONS

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Abstract

This paper investigates the impacts of financial constraints on the structural development of four European regions. The spatial-dynamic agent-based model used considers individual farms' investment behaviour while those indirectly interact via land rental markets. Scenarios with different interest rates for borrowed capital and levels of credit restrictions are tested. Results show that higher interest rates slow down the development of otherwise expanding production branches whereas credit restrictions force farms to choose small and cheap investments. Income losses in both cases are compensated by lower rental prices. Impacts on structural change differ considering regional initial situations and their characteristics.

Keywords: farm financing, investment behaviour, credit restrictions, structural change, agent-based modelling.

1 Introduction

As most European farms are not traded on capital markets, their financing mostly rely upon either internal funds (self-financing from equity capital) or bank loans. Those resources are used to cover daily costs as well as long-term investments like land acquisition, adoption of modern technologies used in stables or as machinery, and the renovation or extension of agricultural buildings. Access to capital in order to invest is therefore vital for farms so that they can continue their activity and keep their capital goods updated at the best technological level possible. However, credit constraints or difficult access to credit if at all constitute an impediment to the development of farms which might postpone, change or abandon necessary investments. This can regionally lead to under-investment, under-employment of production factors and underproduction compared to socially-desirable levels and threatens the rate of return on investments, technology adoption, and finally, productivity (Curtiss, 2012).

Capital needed for long-term investments on-farm can rarely be entirely financed out of farm's own resources. Therefore, farms have to borrow capital from lenders of the private (commercial or cooperative banks, private investors) or the public sector (state banks, public institutions). Once farms enter the credit market they have to negotiate a possibly satisfying contract with a potential lender. However, credit markets work imperfectly even in the most developed market economies, largely due to imperfect and costly information (Swinnen and Gow, 1999). As a result, high interest rates apply or credit restrictions occur and farms cannot obtain any credit at any rate, even for "good" investments from lenders' perspective.

European farmers might generally benefit of good access to capital and credit compared to farmers in other regions of the world, as the most profitable, efficient and reliable the agriculture and food sectors, the most finance and credit are attracted (OECD 2001). However disparities across countries and regions can be observed and are due either to country or

regional specific regulations, to wealth and structural disparities between farms or to privileged access to credit information for some farmers (Pietola et al. 2011).

In addition to informational asymmetries and agency problems limiting farms' access to debt (Stiglitz and Weiss 1981), high transaction costs contribute a lot to imperfections on rural capital markets in form of a gap between costs of internal and external financing. This is because banks charge farmers with excessive risk premium. Thus, timing and size of investment depend on availability of (cheap) internal funds and phenomena of under-investments occur (Hüttel et al. 2010). Pietola et al. (2011) also state that this might lead to under production through the underuse, or even the misuse, of production factors. It seems that some EU member states are aware of this problem and thus introduced credit subsidies for agriculture in different ways. That is, there are premiums on interest rates for investments in agriculture (Lithuania, Latvia, Hungary, Poland, Czech Republic, Bulgaria and France). Based on the findings of Hüttel et al. (2010), Pietola et al. (2011) and Petrick and Kloss (2012), interest rates vary among EU member states and are either too high because of market imperfections or too low because of subsidies.

This study aims at filling a gap in the field of farm financing under constraints. To our knowledge there is no research considering both a restricted access to credit and the development of farms through their interactions on land markets, which both in turn influence farms' investment behaviour and development opportunities. This seems important as farms' expansion possibilities have to be considered together with future on-farm investments in the farm planning problem. This will be investigated thanks to the spatial-dynamic agent-based model AgriPoliS. It will be analysed how farms' investment behaviour changes with different interest rates as well as different levels of credit rationing. Moreover, different portfolios of regional investment options as well as initial regional farm structures condition individual development possibilities (i.e. North European farms cannot grow orange trees). Therefore, four case study regions in Germany, Hungary and Czech Republic will be modelled. This additional choice of mere regions provides a broad overview on potential impacts of financing restrictions in the farming sector and on agricultural structural change.

2 Material and method

2.1 General purpose of the model and representation of farms' investment behaviour

AgriPoliS is a spatial-dynamic agent-based model[1] able to provide aggregated results at the regional level, but at the very individual level as well. In the model farms individually act by applying a mixed integer programme (MIP) containing a set of region specific production activities and investment options. Auxiliary activities are introduced in order for farms to use overcapacities or to overcome scarce resources (labour, capital, milk quota etc.). Such auxiliary activities are for example short-term borrowing of capital to finance production or savings deposited at the bank. Farms are able to react to price or policy changes as well as to structural changes in their neighbourhood by renting or leasing land, by changing their production system or by choosing to quit agriculture. All these decisions are made by applying the MIP with the goal to maximise farm households' income or, in case of legal entities, profit. Farms compete for land with their neighbours; therefore there is an indirect interaction between all farms through the land market. AgriPoliS is a spatial model because farms integrate transport costs between the farmstead and the field in their economic calculations. The model is dynamic because from year to year, farms are able to evolve: grow

[1] A description of AgriPoliS (Agricultural Policy Simulator) documenting recent developments according to the ODD-protocol can be found in Sahrbacher et al. (2012). For the description of the details we refer to Happe et al. (2006) and Kellermann et al. (2008). Here we focus on a brief overview of the model and provide details about the assumptions concerning investments.

or shrink, hire or fire workers, continue farming or close down. Accordingly, it allows simulating endogenous structural change (Sahrbacher et al. 2012).

Investment options are characterised by their type (hog house, cowshed, machinery, hiring a worker for a year or working off-farm for a year), production capacity (number of places per stable, amount of area manageable with a machinery equipment), investment costs, maximum useful life, age, maintenance costs and labour saving due to size effects. For each type of investment various gradations in the size of the investment allow for economies of size. Economies of size arise from decreasing costs per unit of investment and lower labour requirements the larger the investment. During the model initialization, a random age is assigned to farms' different buildings and sets of machinery. Investments cannot be used longer than their useful life which varies between 8 and 24 years depending on the type of investment. Therefore farms have to re-invest if they want to continue within a certain branch of production. This decision is made by applying the MIP where investments are integer variables, i.e. they are not dividable. Farms only have the possibility to invest at the beginning of the year. In AgriPoliS investments are financed by a fixed share of equity (v) and borrowed capital ($1-v$). Long-term borrowing of capital for investments is in principle not restricted as long as a farm's liquidity covers the equity share of an investment. In case of high credit restrictions farms have limited access to credit and therefore need more equity capital to finance investments. As a consequence, either investments have to be postponed or farms cannot invest at all. In such a situation farms have to decide how to use their scarce financial resources, which means farms might only reinvest in the most profitable production branches and cannot expand in other ways.

Short-term borrowing is restricted by a credit limit (CL) set at 70% of land assets' value (LA) and 30% of the equity financed share of asset l ($A_{ec,l}$, with $l = 1,..,L$):

$$CL = 0.7 \cdot LA + 0.3 \cdot \sum_{l=1}^{L} A_{ec,l} \tag{1}$$

So far short-term credits have sometimes been used to finance investments. However, this has not been an issue as long as credit restrictions for long-term borrowing had been low. Now that significant credit restrictions for long-term borrowing are being tested, a restriction prohibiting the use of short-term credits for investments has been added.

As investment and production are mutually interdependent, they are simultaneously considered in the MIP. The number, type, and combination of investments are not restricted. In principle, a farm agent will invest in one object or a combination of objects if the expected average return on the investment, determined in the farm-planning problem, is positive, i.e., if profit increases. For investment-planning purposes, all expenditures related to an investment, i.e. 1) the annuity of borrowed capital ($A_h \cdot (1-v) \cdot CRF_{i_{bc},N_h}$, with A_h the cost of investment h , CRF_{i_{bc},N_h} the capital return factor at the interest rate on borrowed capital i_{bc} over the investment's useful life N_h), depreciation of own capital ($A_h \cdot \frac{v}{N_h}$) and maintenance costs (MC_h) are distributed equally over the investment's useful life (N_h). Maintenance costs are expressed as a percentage (w) of total investment costs. Accordingly, the average annual costs AC_h of an investment considered in the objective function of the farm-planning problem are calculated as:

$$AC_h = A_h \left[(1-v) \cdot CRF_{i_{bc},N_h} + \frac{v}{N_h} + w \right]. \tag{2}$$

To avoid capital shortage due to investments the sum of costs in average bounded by production activities and investments has to be smaller or equal to farms' liquidity. Therefore, the average bounded equity capital for an investment h is equal to $A_h \cdot v \cdot f$ where i_{ec} is the interest rate for equity capital at the bank and f is defined as:

$$f = \frac{(1+i_{ec})^{N_h}}{(1+i_{ec})^{N_h}-1} - \frac{1}{N_h \cdot i_{ec}}. \quad (3)$$

Once a farm decides to leave agriculture investments are lost for the sector. They cannot be sold to other farms, i.e. investment costs are sunk. For instance if a farm had invested in a cowshed five years before closing, the building would stay idle after the farmer gives up. Farms decide to quit agriculture when their expected farm income for the next year is smaller than the opportunity cost for their own labour, capital and land or when they are illiquid.

Farms' liquidity at year t is calculated by subtracting land assets (LA) and the equity share of l other assets (A_{ec}) from equity capital of the preceding year (EC_{t-1}):

$$L = EC_{t-1} - LA - \sum_{l=1}^{L} A_{ec,l}\ . \quad (4)$$

Farms are assumed to withdraw a certain amount of money per family working unit from the household income for their own consumption. If this minimum withdrawal ($WD_{\min}$) is larger than the household income Y, farm's equity capital is reduced. If $WD_{\min}$ is smaller than the household income, an additional share ε of the remaining farm household income is consumed and the remaining share $(1-\varepsilon)\cdot(Y-WD_{\min})$ is then charged to the farm agent's equity capital. Thereby, farms can accumulate equity capital which can be used to finance future investments.

At the beginning of the simulations some variables (age of the farm, age of buildings and machinery, managerial ability, location of farms and the duration of each plot's rental contract) are randomly initialized. The vintage of assets determines the date of re-investment. Farm's age determines the time the handover of the farm to a successor will occur. It is assumed that there is always a successor for each farm. At such a generation change, opportunity costs of labour are assumed to increase by 25%. In this way, a potential successor's choice to work off-farm, where salaries are assumed to be higher than in agriculture, is considered. If the successor decides to take over the farm, opportunity costs for labour are set back to the level prior to the generational change. The location of the farm and its managerial ability (modelled as reduced variable costs) determines its competitiveness relatively to the surrounding farms.

In scenarios with high credit restrictions the value of other assets is higher because the self-financing share of other assets than land ($\sum_{l=1}^{L} A_{ec,l}$) is higher. Consequently, liquidity is lower. To avoid this, equity capital has been proportionally increased in the scenarios with high credit restrictions for each selected farm so that farms start with the same level of equity capital in each scenario. However, it was not possible to provide each farm with exactly the same liquidity in all scenarios at the beginning of the simulations. Actually, during the model's initialization phase selected farms are cloned and their assets' vintage randomized. That is, equity and liquidity are slightly different among cloned farms between scenarios at the beginning of the simulations. This has no impact on the outcomes observed in the different scenarios though.

2.2 Case study regions

For this study four regions with different characteristics have been chosen: the Altmark in Eastern Germany; the Allgäu, a grassland region in Bavaria (South Germany); Vysocina in the central part of Czech Republic; and Borsodi Mezoseg in the north-east of Hungary[2]. The choice of those four different regions located in different EU countries and subject to different institutional, agronomical and economic constraints is justified to provide an overview of impacts of different credit opportunities and interest rates levels. Those impacts can actually vary depending on 1) the capital-intensity of the local agriculture, 2) farms' debt level and 3) local profitability of agriculture. The advantage of choosing those four quite different regions is that they present similarities with real regions for which similar outcomes could therefore be expected.

To represent the regions in the model structural data such as the distribution of farms regarding their size, specialisation, legal form, herds' sizes, as well as their share of grassland have been extracted from agricultural statistics in a first stage. In a second stage farms have been selected from the Farm Accountancy Data Network (FADN) and then weighted (i.e. cloned) to represent the structural characteristics best (Sahrbacher 2011, Balmann et al. 2010). Further data were collected to represent regional production branches, i.e. labour and machinery requirements for each activity, outputs per hectare, prices as well as corresponding investment options linked to each activity (for instance cowsheds for 40, 100 etc. dairy cows). The value of other assets than land assets, i.e. machinery and buildings used for production, are based on standard investment costs (KTBL several issues).

Regional data shown in Table 1 are based on FADN data and other model input data (share of hired labour, livestock density and other assets), from other statistics (land price, other assets) or from other statistics combined with model assumptions (liquidity, equity, borrowed capital, debt ratio and share of land assets in equity). For each model farm the amount of family labour available for agriculture is taken from the FADN. The amount of family and hired labour used in agriculture is determined by the MIP depending on the labour demand of the different production activities. Livestock density at the individual and regional level is depending on the solution delivered by the MIP as well.

The amount of borrowed capital is determined by the borrowed capital financing share ($A_{bc,l} = A_l \cdot (1-v)$) over all assets. The borrowed capital financing share is assumed to be of 70% in the reference scenario. Debt ratio and the share of land assets in equity capital is a result of the above mentioned values and therefore depend on the assumptions on which these values are based.

As shown in Table 1, the Altmark and Vysocina are dominated by large scale farms. There farms rely on a high share of rented land (89% and 93%) and on a high share of hired labour (72% and 82%). In the Altmark farms are specialised each by one third in field crop production, dairy production and mixed production systems. A minority of farms are specialised in pig production. Compared to Vysocina livestock density is almost 50% lower (Balmann 2010). In Vysocina most farms are field crop (50%) or mixed farms (35%), but there are also some intensive livestock farms keeping dairy cows or pigs and sows, which results in a livestock density of 0.6 LU/ha.

Borsodi Mezoseg can be considered as intermediate between the Allgäu and the both large scaled regions Altmark and Vysocina, as there are also some large farms there which cannot be found in the Allgäu. Farms are specialized each by approximately one third into field crop production, grazing livestock production and mixed production The Allgäu is dominated by

[2] These regions have been modelled in the EU-projects IDEMA (Vysocina) and MEA-Scope (Borsodi Mezoseg), a project financed by the federal state of Saxony-Anhalt (Altmark) and the project "Structural Change in Agriculture" (SiAg, Allgäu) financed by the German Research foundation.

family farms which rely almost exclusively on family labour and own on average 67% of the land. Farms are specialized either in dairy production or beef fattening as all land in the region is exclusively used as grassland. The labour input of 4.2 AWU/100 ha is to be linked to the high livestock density of 1.3 LU/ha which is much higher than in the other regions (0.3 to 0.6 LU/ha).

Table 1: Overview of the model regions

		Altmark	Vysocina	Allgäu	Borsodi Mezoseg
Base year		2006	2001	2006	2004
Av. Farm size	ha	290	190	27	37
Region size	ha	280,140	380,520	26,017	33,364
Number of farms		968	1,908	962	901
Grassland	%	25	20	100	30
Rented land	%	89	93	33	69
Land price*	€/ha	5,791	2,570	10,226	824
Hired labour	%	72	82	2	45
Livestock density	LU/ha	0.36	0.63	1.34	0.32
Labour intensity	AWU/ 100 ha	1.41	1.86	4.19	1.44
Dominant farm type		field crop dairy (biogas) mixed	mixed, intensive livestock	dairy (biogas)	field crop, mixed, grazing livestock
Assets	€/ha	2,479	1,345	15,674	1,564
Land assets	€/ha	619	182	6,857	255
Other assets	€/ha	1,574	846	7,405	1,067
Liquidity	€/ha	286	317	1,412	242
Liabilities	€/ha	2,479	1,345	15,674	1,564
Equity	€/ha	1,361	874	10,391	812
Borrowed capital	€/ha	1,119	471	5,283	753
Debt ratio	%	45	35	34	48
Land assets in equity	%	46	21	66	31

Sources: FADN, KTBL, regional bookkeeping statistics and own calculations based on model data.
Notes: LU = Livestock unit, AWU = annual working unit (1800 hrs/year).
*: except in the Allgäu (FADN), prices are intermediate values from statistics as strong dynamics occur from year to year (Ciaian et al. 2012, Neue Landwirtschaft, several issues).

The Altmark and the Allgäu are provided with an additional investment alternative, namely the biogas production. This investment option is currently intensively used in both German study regions thanks to the Renewable Energy Resources Act. In addition agritourism has been introduced in the Allgäu as it currently is a relevant investment option.

2.3 Scenarios

Two sets of scenarios are run in order to analyse a) how different levels of interest rates for borrowed capital and b) credit constraints affect farms' investment behaviour. Therefore, a first scenario used as reference (REF) is run for all regions with a long-term borrowing interest rate of 4.5% and a short-term borrowing interest rate of 6.5%3. Consequently farms in

[3] These values are averages of values collected over the four regions for the year they were calibrated for.

all regions are confronted to identical costs for borrowed capital. In the REF scenario the borrowed capital financing share is set at 70%, i.e. borrowing long-term capital is no much restricted. Therefore, farms only have to finance 30% of an investment with equity capital. Those reference restrictions for borrowed capital are model assumptions which changes will serve as basis for the tested scenarios. Short term savings interest rates are set at a country specific level and long-term saving interest rates considered for the calculation of opportunity costs of capital accounting for the exit decision of a farm are assumed to be 1% higher. For both sets of simulations, the results are an average over 10 replications[4].

In the first set of simulations interest rates of borrowed capital are either reduced by 2% or increased by 2 and 4%. This considers situations where the agricultural credit market is subsidized e.g. as in Lithuania, Latvia, Hungary, Poland, Czech Republic, Bulgaria and France and where interest rates on the agricultural credit market are much higher than on the general credit market (Sweden, Cyprus, Slovakia, Denmark, Greece and Estonia, Pietola 2011). Interest rates for savings remain unchanged as neither credit subsidies nor imperfections on the credit market are assumed.

In the second set of simulations the borrowed capital financing share is reduced stepwise from 70% to 50%, 25% and 10% while interest rates are kept at their reference level (4.5 and 6%). This set of simulation is of particular relevance when considering former Central and East European Countries' (CEEC) regions (here Vysocina and Borsodi Mezoseg) where small farmers encounter difficulties to have access to credit at all (Swinnen and Gow 1999).

3 Results

3.1 Variation of interest rate level

At first, Table 2 shows which production branches emerge (indicated with plus) or decline (indicated with minus) in the reference scenario. The decline (expansion) of production branches is caused by missing re-investments (carried out re-investments). The speed of decline depends on whether at least some farms re-invest in a production activity or whether no farm re-invests.

Table 2: General development of production activities in the model regions in the reference scenario

	Altmark	Vysocina	Allgäu	Borsodi Mezoseg
Breeding sows	+ +	- -		
Fattening pigs	+ +	- -		
Dairy cows	- -	- -	-	-
Beef cattle	+	+		-
Suckler cows	+	+		-
Bull suckler			-	
Biogas plants	+ + +		+ +	
Agritourism			+ +	
Machinery	+	-	+	- -

Source: Own simulations.

Legend: "- -": production declining; "-": production moderately declining; "+ + +": production most expanding; "+ +": production expanding; "+"; production moderately expanding; blank: no production in the region.

[4] In each replication following random parameters have been varied: localisation of farms in the region, managerial ability of the farmer or farm manager, age of assets (buildings and machinery) and duration of each plot's rental contract. Replications allow minimizing the influence of those random parameters on results and therefore improve results' reliability.

In the Altmark and the Allgäu only dairy production is declining. All other production activities are expanding and the option to invest in biogas plants seems particularly attractive. In Vysocina the increase in beef cattle and suckler cows is policy induced as there have been top-up payments for these activities during the phasing in of payments between 2004 and 2011. In Borsodi Mezoseg all production branches are declining.

Regarding overall structural impacts, the number of farms closing dramatically increases with higher interest rates in the Altmark and in the Allgäu (25% and 10% less farms respectively at the end of the simulation with 4% higher interest rates), whereas in Vysocina and Borsodi Mezoseg farm exit rate is hardly affected by interest rates. This is because in the Allgäu, a grassland region, there is hardly any alternative to cattle production. With higher interest rates farms cannot invest as much as necessary to ensure their income and are forced to close down during the simulation. The same holds for the Altmark, with the difference that field crop production is an alternative to livestock. The general decline in labour-intensive livestock productions accelerated with higher interest rates logically affects labour regionally used in agriculture. Farms do not suffer severe income losses in the long run except in the Allgäu where profits per hectare are significantly lower with higher interest rates. This is because of the presence of capital intensive productions with a high share of interest costs already from the beginning of the simulations. In the Altmark and Borsodi Mezoseg profit losses are compensated later in the simulation thanks lower rental prices. As respectively 89% and 69% of land is rented, rent expenditures are an important item. This adjustment takes some time though, as rental contracts duration is between 5 and 18 years.

Higher interest rates do not affect the rate of abandonment of declining production branches in Vysocina and Borsodi Mezoseg compared to the reference scenario. However, the decline of dairy production in the Altmark and the Allgäu is accelerated with a 4% higher interest rate on borrowed capital and at the end of the simulation, 65% of production capacities remain in both regions compared to the reference scenario.

On the other hand expanding production activities are much more affected by an increase in interest rates on borrowed capital as shown in Table 3. An increase by 4% of interest rates slows down the expansion of all production activities except suckler cow production in Vysocina which substitutes for beef cattle production (which expansion in the reference scenario is essentially policy driven). This investment option seems therefore to be more profitable relatively to beef cattle production; it is the only production activity expanding with higher interest rates as well as investment costs are the lowest.

Table 3: Impact of 4% higher interest rates on production activities expanding in the reference scenario after 25 years

	Altmark	Vysocina	Allgäu
Breeding sows	- - -	*(dec)*	
Fattening pigs	- - -	*(dec)*	
Beef cattle	- -	- -	
Suckler cows	- -	+ +	
Biogas plants	- -		- -
Tourism			- - -

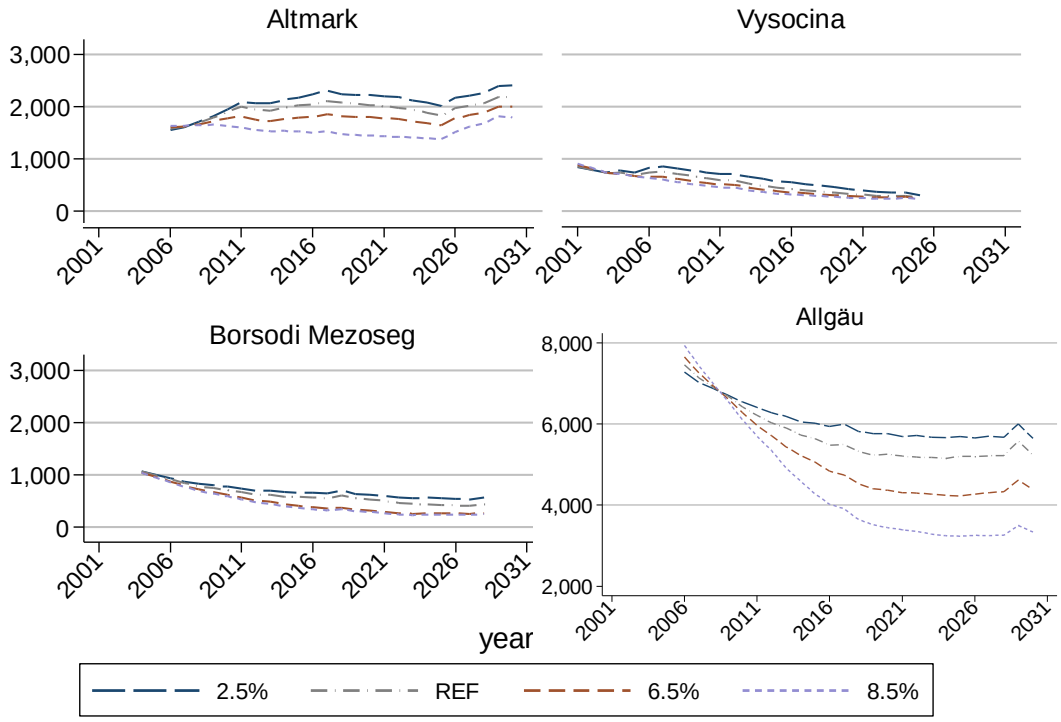
Source: Own simulations.

Legend: "- -": expansion slowed down; "- - -": expansion much slowed down;
"+ +": expansion speeded up; blank: production not present in the region; "*(dec)*": production present in the region but declining in the REF scenario.
Note: there is no expanding production in Borsodi Mezoseg in the reference scenario.

Investments into biogas plants as well as into facilities for tourists become less profitable with higher interest rates. However, it is to note that the structure of biogas production

changes as well. There are less small biogas plants but larger ones. Actually the release of land becomes faster because farm closings are speeded up with higher interest rates. This benefits the remaining farms for which this extra land allows larger investments for biogas production. This holds for the Altmark as well as for the Allgäu. In the case of low interest rates more farms invest into biogas plants in both regions and much more accommodations are provided in the Allgäu.

Finally higher interest rates have a negative impact on the total amount of investments (Figure 1).



Source: own figure.

Figure 1. Development of fixed assets with different interest rates for borrowed capital

Looking at the development of fixed assets representing the total investment development shows that agriculture in Vysocina is hardly affected by higher interest rates. This is due to the low profitability of pig fattening, breeding sows and dairy cow productions. Already in the reference scenario no re-investment occurs. In Borsodi Mezoseg and the Altmark the value of fixed assets becomes lower with higher interest rates. The strong decline in fattening pigs and breeding sows productions has not such a strong impact on the total amount of investments in the Altmark, because the share of field crop production is relatively large. The impacts on fixed assets are the largest in the Allgäu. There, the reduction is mainly determined by the decline of dairy cow production, but all other production activities are declining as well. The average value of fixed assets per hectare is the highest in the Allgäu, because it is a quite intensive and small structured region. The livestock density is with 1.3 LU/ha three times higher than in the Altmark and Borsodi Mezoseg and two times higher than in Vysocina. Additionally, small facilities and machinery are much more expensive than larger ones.

3.2 Variation of credit restrictions

Responses to credit restrictions are somewhat more diverse than in the case of varying interest rates, even though the extents of change are rather small. At first there is no impact on the number of farm closings in Vysocina and only small impacts in the Altmark and Borsodi Mezoseg; in the latter region even less farms close down with higher credit restrictions. Farms

closings are again most numerous in the Allgäu but not as much as with high interest rates. Impacts on farms' incomes are rather low. Whereas in Vysocina and Borsodi Mezoseg no impacts are observed, farms even save some money in the Altmark thanks lower rental prices. In the Allgäu profits are much lower with high credit restrictions but losses are partially absorbed by the decline in rental prices, i.e. lower costs for rented land.

A peculiarity of high credit restrictions is that they do not necessarily lead to fewer investments. The decline of fattening pigs' production in Vysocina and dairy cows' production in Borsodi Mezoseg is slowed down by higher credit restrictions (Table 4). In the Allgäu there is even an increase in the number of bull suckler instead of a slight decline in the reference scenario with low credit restrictions. This development can be explained by stronger impacts on expensive investments than on cheap ones. For example in the Allgäu farms invest much less in dairy cows and biogas plants in case of credit restrictions. But they still have enough liquidity to invest in cheaper/smaller investments like bull suckler (which even increases with credit restrictions instead of declining in the reference scenario), and, interestingly, save liquidity to invest later in the simulation in tourism accommodation. In Borsodi Mezoseg there is no such positive replacement. High credit restrictions have no impact on the decline of beef cattle and suckler cows but nevertheless farms disinvest less in dairy cows. At the same time fewer farms leave the sector. Thus, less liquidity leaves the sector and farms have more capital to invest despite credit restrictions. These replacements cause that the overall impact of credit restrictions is not that strong.

Table 4. Impact of financing restrictions on production activities declining in the reference scenario after 25 years

	Altmark	Vysocina	Allgäu	Borsodi Mezoseg
Breeding sows	*(exp)*	**no**		
Fattening pigs	*(exp)*	**- -**		
Dairy cows	**+ +**	**no**	**+ + +**	**- -**
Beef cattle	*(exp)*	*(exp)*		**no**
Bull suckler			**exp**	
Suckler cows	*(exp)*	*(exp)*		**no**

Source: Own simulations.

Legend: "- -": decline slowed down; "+ +": decline speeded up; "+ + +": decline much speeded up; "no": no change; blank: production not present in the region; "exp": production expanding with credit restrictions compared to the reference scenario; "*(exp)*": production expanding in the reference scenario.

In Vysocina, there is also a replacement of beef cattle by suckler cows like in the case where high interest rates where applied. The Altmark is the only region where there is no such phenomenon to be observed. Except fattening pigs, all production activities in the Altmark decline or investments are delayed with higher credit restrictions, i.e. the whole agricultural sector is slowed down in its development.

4 Discussion and conclusion

The study provides insights on how farms' investment behaviour changes with different interest rates on the one hand, and how credit rationing determines regional development outcomes on the other hand. Whereas interest rates have been varied in a first set of simulations, credit restrictions have been implemented in a way that farms got less credit to finance investments in the second set of simulations. In both cases the analysis distinguished between declining and expanding production branches.

These experiments have required model improvements. Values of land assets have been updated, liquidity has been adjusted so that it fits real data and a new restriction to avoid the

use of short-term credits for investments has been introduced in the farm planning programme. There are still improvement needs though, especially regarding the calculation of farms' liquidity considering other assets' value and between scenarios. Another interesting idea is to make the financing of investments more flexible, i.e. set only a maximum share for borrowed capital and let farms decide whether they want to use this maximal share or whether they use more own capital resources in form of equity.

Results show that higher interest rates for borrowed capital have stronger impacts on farms investment behaviour and on structural change than credit restrictions. Higher interest rates have less impact on declining production branches than on expanding ones in regions where farms do not invest much with lower interest rates anyway. Substitutions between production branches are observed and are due to changes in the relative profitability of those branches with varying interest rates. Overall impacts of higher interest rates on structural change differ depending on the region and the initial situation as well. In capital intensive regions like the Altmark or the Allgäu high interest rates directly affect costs of existing investments and more farms close down for lack of sufficient income. There is even more concern in regions like the Allgäu where little alternative exists outside livestock production in the agricultural sector. In the long run there are no impacts on farm income in less capital intensive regions where field crops are still important (Altmark, Vysocina and Borsodi Mezoseg). In those regions, less investment in livestock production have no strong impact as extensification constitutes a second-best solution for farms. The parallel development of rental prices has a dampening effect as with less intensive livestock production the pressure for land is lower and therefore rental prices tend to decline.

The analysis of different levels of credit restrictions showed that large/expensive investments are more affected than smaller/cheaper investments. The latter could even gain from credit restrictions in a way that their decline is slower or they even start to expand. This shows that credit subsidies might influence production in a way that it supports investments in some branches, which would not be the case without credit subsidies. Furthermore, this also explains why credit restrictions might in general have a lower impact than higher interest rates. Farms can absorb losses of some production branches by extending others. Therefore the impact of credit restrictions on structural change is relatively low as farms have the possibility to switch to other production branches, which is made difficult in the presence of higher interest rates. Again in the Allgäu the impacts are stronger as farms cannot switch to field crop production even though income losses are partially absorbed by lower rental prices.

Results confirm findings reported in Hüttel et al. (2010) and Pietola et al. (2012) stating that credit restrictions might delay or even change the portfolio of on-farm investments provoking underuse, or even misuse, of production factors. However, the variation of interest rates and credit restrictions causing changes in farm financing leads to relatively complex, somehow unexpected reactions as well. This study showed that these reactions are depending on agricultural regional structures, dynamics caused by farm exits throughout the simulation and changes in relative profitability of production branches due to regional policies and institutional frameworks.

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