Agricultural Production and Income Dynamics in Latvia

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Abstract

In this study we use system dynamics to evaluate possible development scenarios of agricultural sector in Latvia. Growth and balancing forces of agricultural economic are investigated along with dynamics of capital, land and labor allocation. Resource stocks are considered from two perspectives: a) breakdown between crop and livestock farming activities b) allocation between commercial and self-subsistence farms. Total production output and per-capita income of the population employed in the sector are chosen as key development indicators. Impact and efficiency of public support policies for agriculture are discussed.

Keywords: agricultural development, policy assessment, farm income

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Content

Background and purpose of the study

Agriculture historically has developed in Latvia as important industry with high economic and social value. Large proportion of population lives in rural areas and for the major part of it agriculture constitutes safety net with basic employment and purveyance opportunities. In the last 20 years there have been two major events (collapse of Soviet Union and accession to European Union) that have created fundamental transformations in politico-economic environment in Eastern Europe. Thus many beliefs about role and importance of agricultural sector, which not always live up to today's situation, persist in farmers and policy makers minds.

During 2006 Ministry of Agriculture of Latvia has carried out a study project to evaluate possible development scenarios for Latvia agriculture from 2007 to 2020 year. This study was undertaken along the project with attempt to have systemic perspective on discussed issues.

The purpose of the study is to evaluate medium and long term development scenarios of aggregated output and per capita income of Latvia's agriculture sector. Trend for the main agriculture development indicators estimated by the project group is shown in the Figure 1. As a sub-goal impact and role of public farm support policies shall be evaluated. Crop and livestock farming branches are treated separately considering project stakeholder interests as well as to get insight about inter-sector dynamics of different policy alternatives. System dynamics model is built to capture feedback structure of agricultural economic

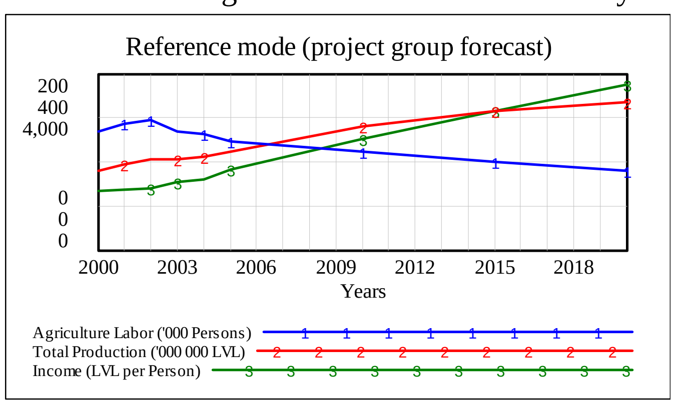

Figure 1. Agriculture development indicators trend.

and to make sense of the dynamics of relevant indicators - aggregated output and per capita income.

System dynamics has been used for agriculture development and policy studies and our work to some extent has been built on them. Particularly it has been inspired by agriculture dynamics model of Pakistan [Saeed 1981] and structural change studies in US diary farming [Pagel 2002].

Model structure

Basic assumptions

Model structure is derived from policy goals discussed previously. Income per worker in agricultural sector implies that we need to look at the farm income and labor dynamics. Total output is derived from farm production and commodities price level. As we intend to analyze development of the two major agricultural segments in Latvia - crop and livestock farming – several model parameters have dual components. There are many farms that operate in both sectors and thus share capital, labor and other resources. However on aggregate level we assume that sectors function independently (livestock feed production we include in livestock sector). Investment and production expansion decisions between sectors are assumed to be based on current and expected farm income. In this paper we detail crop farming sector structure and if relevant highlight differences with livestock farming.

To facilitate model usage in policy discussions we have chosen to split farms in to two categories. In the first we include small farms that produce agricultural products mainly for self consumption and in the second those who produce mainly for the market. The border between categories is blurry therefore it is selected based on availability of data. Following EU Farm Accountancy Data Network definitions split is based on farm economic size. Since EU accession comprehensive statistics is available for farms with size over 2 European Size Units (ESU). Still very limited data are available for smaller farms. Although some of the farms with size below 2 ESU might actually sell part of their products usually there is no economic justification for the production as it is subsidized by significantly underpaid labor or other income sources. Also in the most cases those farms do not have sufficient financial and management capacity to expand the production. Thus we consider land and people employed by them but do not account for their incomes. In the rest of this paper we use term Farm to denote those with economic size over 2 ESU[1].

Growth and balancing forces

It is well understood that many decisions farmers make are strongly influenced by their lifestyle as well as social and cultural setting. Focus of this study is mainly on economic analysis therefore in many cases only ‘hard facts’ are considered. We have identified three major reinforcing loops that drive the growth of crop farm production (Figure2). In the current development stage where many farms still have low capital intensity

[1] In reality there is no strict border between commercial and self-subsistence farms and according to some statistics [SUDAT] it would be reasonable to assume higher limit (close to 4 ESU). Assumption about the place of separations has secondary significance for the purpose of our study therefore we have chosen it for the sake of convenience and availability of data.

(comparing to more developed EU countries) Capital Investment loop is dominant. Farm capital increase is boosting production which leads to higher revenues and consequently drives more investment. Income level is the main driving force also for Production Expansion loop. If there is sufficient capacity (which is determined by farm capital here) farms will acquire more land that will allow further output increase. Third reinforcing loop is emerging from Productivity Growth. New capital investments allow farms to use better technologies which reduce the need for manual work as well as decrease production costs which in turn boost farm profits and lead to further investments.

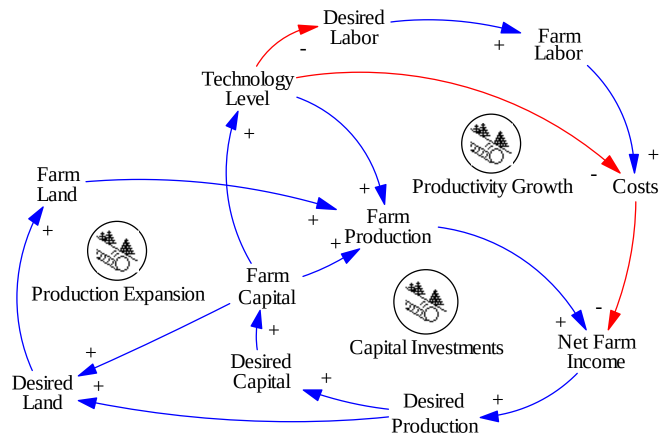

Figure 2. Growth Forces

However there are also limits for the growth expressed by multiple balancing forces (Figure 3). First of all capital investments and production expansion in agriculture cannot be funded alone by farm incomes and there is a need to take a loan. Farmers ability to borrow is essential for agricultural development however there are obvious limitations. Increasing debt service will reduce incomes and growing debt to asset ratio will limit possibility for further capital investments. Land Availability is another limiting factor for production expansion. Although if looking at the country level there is significant amount of under-cultivated land, in more developed regions farm density is higher and farmers usually have limited proximity area which they would be willing to cultivate. Thus increasing incomes and desire to expand production would push land prices up which to some extent would taper further expansion. Production output growth would be eventually slowed down also by factors such as quotas and limited demand. After EU accession Latvia is fully integrated in to the EU Single market which is enormous compared with domestic production capacities. So far there has not been any conclusive study addressing competitiveness and demand potential of Latvia's agricultural sector. Estimates of domestic demand and export potential were not our focus also in this study however it is clear that it is not unlimited. Thus we believe that substantial production output increase would create

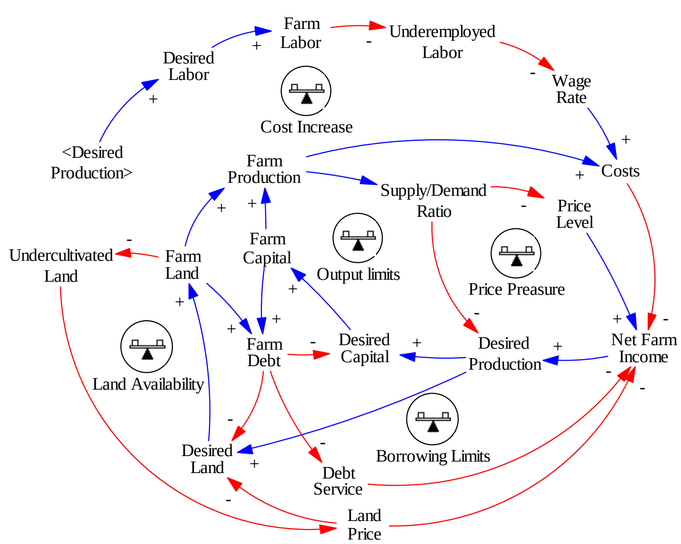

Figure 3. Balancing Forces

price pressure that would stress incomes and thus creating another balancing feedback loop. The final factor we consider here is production and labor cost increase related to output expansion. Exogenous factors (from agricultural sector perspective) such as energy and capital maintenance prices comprise significant part of variable production costs. Similarly economic development in Latvia in recent years has been exceptionally high and has significantly increased off-farm income opportunities and pushed up wage rates for skilled labor force. Thus farm output increase would create additional endogenous forces for labor and production costs that would in turn influence farm incomes and desire for further expansion.

Farm Production Output

Farm production output estimate is one of the most challenging tasks in this study. A detailed bottom-up calculation of aggregated output considering different crop and livestock farming cultures is traditionally used in agrarian economic studies in Latvia. However we consider that this approach is unsuitable for our study as the main goal is to analyze overall long-term dynamics of agricultural sector (which would be otherwise lost in cumbersome number of variables for which limited or no data are available). Therefore we have chosen macro level view and use of Cobb-Douglass production function to model agricultural production input and output relationships [Barro 1998].

Equation 1. $$Y = A \cdot L^{\alpha} \cdot K^{\beta} \cdot Z^{\gamma}$$

where: Y is Output
L is Labor input
K is Capital input
Z is Land input
A is Technology parameter (capital output potential in this paper)
α, β, γ are production factor scale parameters

Similar functions has been previously used [Vira 2003] to describe agricultural output for certain time period in Latvia. However it is not clear how production function parameters would change in the long term in response to major technological or structural changes in the sector. As suggested in some studies [OECD 2002] we assume that Cobb-Douglass function parameters are constant. We assume that sum of parameter is equal to one which express that constant return to scale is supposed. There is important difference between production function parameters in crop and livestock farming sectors. As livestock itself is included in farm capital it has much higher impact on livestock farming output compared to crop farming where land has the highest relative weight.

Simplified approach is chosen for price setting process. Previous research suggest [LVAEI 2005a] that prices for different agricultural commodities will be mainly influenced by factors that are outside the scope of this study (price convergence to average EU levels, changes in consumer demand and purchasing power, integration with new markets). Thus we assume single endogenous feedback where average price for crop and livestock farming products will respond (with low elasticity) to aggregated production level changes.

Desired production level is one of the central decision points that determine overall dynamics of the system. We suppose that desired production is anchored to actual production level and adjusted by current and expected future income levels. Exogenous limiting factor for total output which expresses production limits implied by production quotas (milk and sugar), domestic consumption and export potential are considered. Farm capital and land allocations are based on desired production level. It is important to note that it follows thence that resource allocation decisions would be influenced by any production-coupled support payments. In the next chapters dynamics of production function inputs is discussed.

Capital investment

Capital investment loop is primary growth factor for agricultural production. Farm capital is composed of investments in production buildings, machinery, livestock, processing equipment and related technological processes. Labor productivity and output potential change in response to technology development and they are modeled as capital efficiency attributes. Although capital composition for livestock and crop farming sectors differ, feedback structure driving investments is similar. Hence here we'll examine only crop farm capital dynamics (Figure 4).

Desired capital investment is driven by desired production output as well as capital adequacy to sustain current and future production. Desired production output is

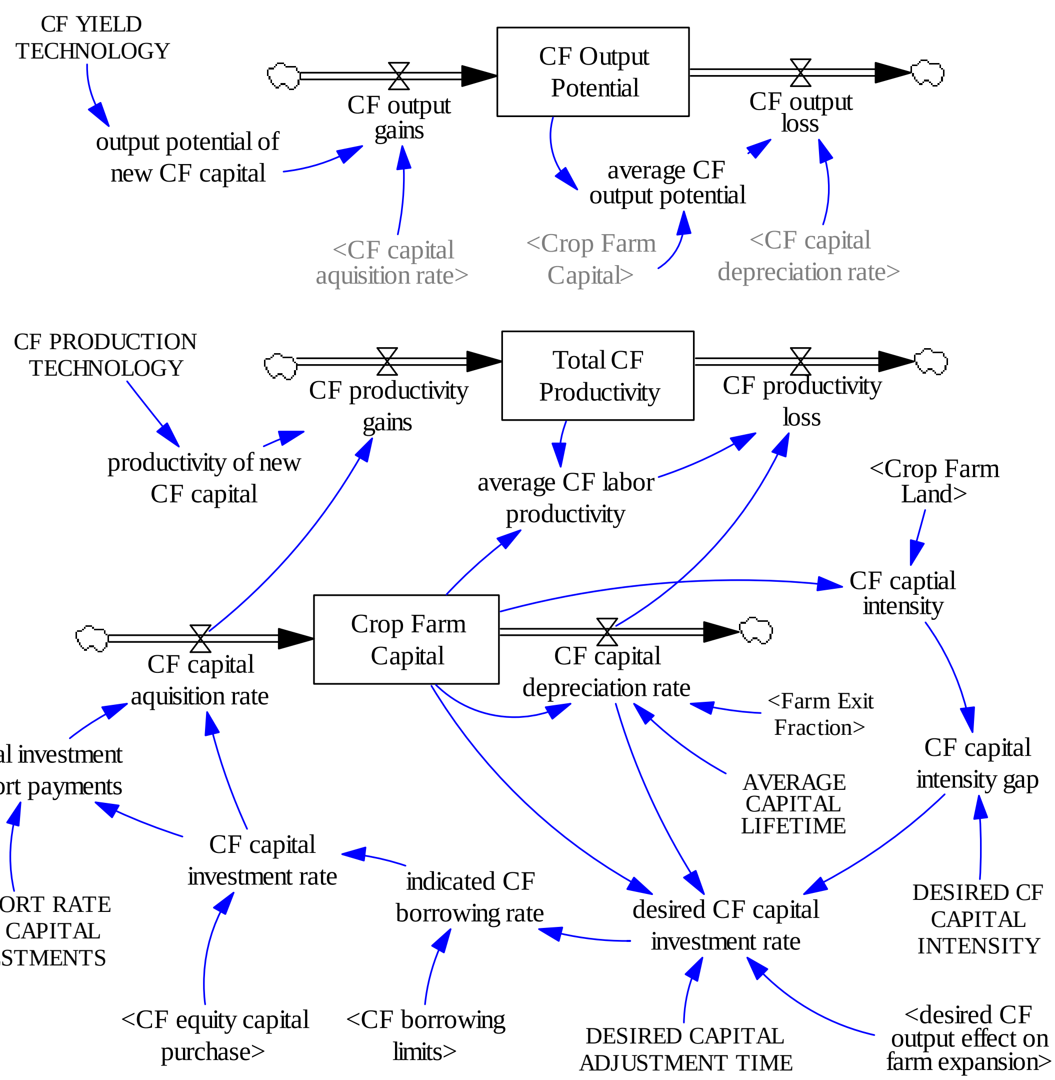

Figure 4. Structure for Crop Farm Capital Dynamics

determined by currently perceived and expected future income and to some extent by support payments that are coupled with specific crop production. In crop farming capital adequacy can be estimated in relation to cultivated land area therefore capital intensity ratio is introduced. Increasing capital intensity express diminishing production returns thus capital investments would slow down when desired capital intensity level is approached.

On the other hand to sustain desired capital level maintenance payments shall be taken into account. To estimate desired investment rate average capital adjustment time is considered[2]. It captures expected delays for investment decisions and capital acquisition. It is also assumed that farms would not sell any excess capital and let depreciation bring it back to the desired levels. On farm exits we consider that any income from capital sales would be spent outside agricultural sector.

There are three main sources for capital investment funding – money can be borrowed from the lender, allocated from disposable farm income or acquired from government support payments. Borrowing usually is a primary source for financing major capital investments or production expansion but it is limited by farm financial capability to take extra loans, which usually depends on outstanding loan to asset ratio and ability to repay the debt. Remaining part of capital purchases or maintenance can be financed from disposable farm income. Income ratio used for capital investments is assumed exogenous (although in reality it might be influenced by farms financial health or certain government incentives). Government and EU programs for agricultural capital investment support have become important source of funds along with EU accession. Payments are allocated to support farm capital and technology investments.

The basic role of the economic capital is to ensure required production capacity. However it can be also used to deploy technologies which either allow more effective use of labor force or enable higher output with regards to production resources (for example by introducing crop variety with higher yield, or new production practices). Therefore two attributes – Crop Farm Labor productivity and Output Potential are introduced and they are modeled as co-flows for capital investment. It enables modeling growth potential of productivity and yield technologies.

Land utilization

Land dynamics is considered from two perspectives – land allocation between crop and livestock farming activities and dynamics of total cultivated farm land (Figure 5). Former allocation is modeled in rather straightforward way where actual fraction of land under crop farming sector adjusts to the desired fraction. Adjustment time varies for different farms (farms with diverse activities are more flexible than highly specialized) however for our purposes results are not sensitive to this parameter. Similarly it is assumed that increase to total farm land would be allocated between sectors according to desired land fraction in each sector. Total farm land decrease would not change land allocation

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[2] For simplicity capital adjustment time is assumed constant in our study. In reality delays would vary significantly for different capital components (e.g. delay would be much lower for purchased capital goods compared to building construction time). High income expectations or interest rate changes also might affect capital adjustment times [Pagel 2002] but those feedbacks are omitted.

between sectors (this is a simplification as in reality more land probably would be abandoned in less profitable sector).

Desired land areas for crop and livestock farming are determined by farm willingness to expand production as well as by their financial and technical ability to do it. For livestock farms expansion decision is expressed with desired aggregated livestock level (which is a function of desired capital investments) and land required to support the expansion is derived from that. For crop farms land is the primary production input. Therefore desired cultivated land is directly linked to desired production output level. Other factors that are considered to influence farm land expansion are land price and ratio between desired and actual capital intensity. The later encompass farms technical ability to expand the production. Land price impact represents farmer's willingness to expand from financial perspective. It's assumed here that ability to fund land acquisition will not directly impact expansion decision. With relatively low land prices it would be easier for farmers to borrow against land pledge. With land prices going up farmers would be less interested to invest in expansion and it would become more difficult to borrow needed funds. Recent studies have shown [LVAEI 2005a] that land price is determined by area based support payments and marginal income of agricultural land. There is close correlation between land rent and sell prices. In this study we assume that ratio between farms owned and rented land constant.

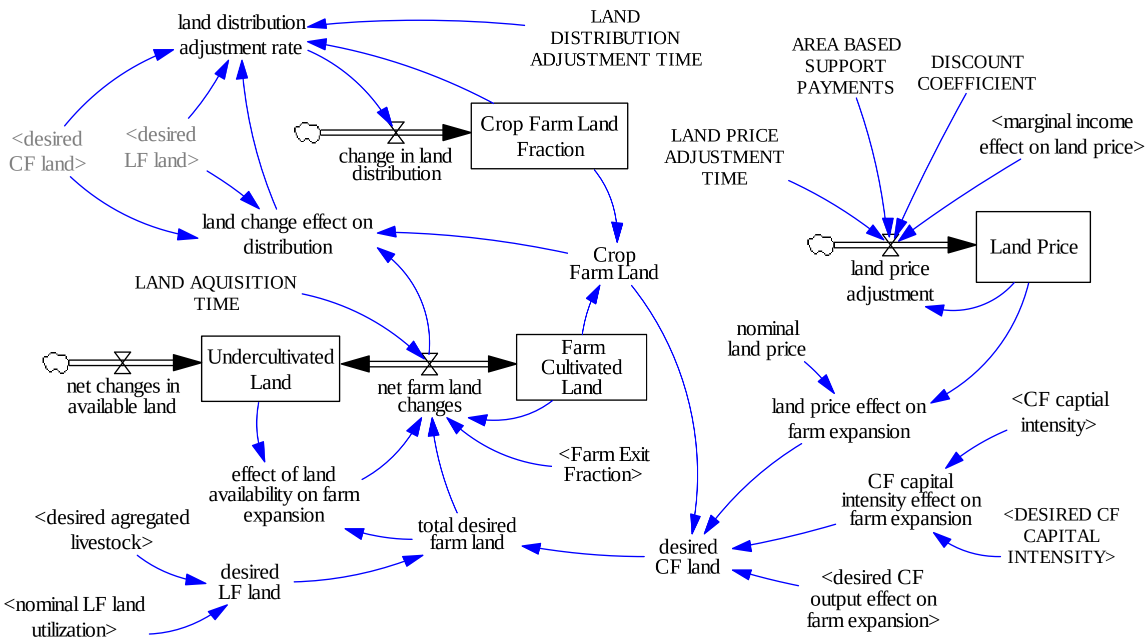

Figure 5. Structure for Agricultural Land Dynamics

Total cultivated agricultural area is divided in to stocks – Farm Cultivated and Under-cultivated Land. Farm Cultivated Land includes both owned and rented areas that are cultivated by commercial farms. Under-cultivated land comprises other cultivable agricultural areas. Dynamics is modeled from farms perspective thus additional land is acquired when needed and cultivated land adjusts to desired level. Even though on aggregated level in Latvia there is abundance of agricultural land, in more developed regions farm density and land utilization ratio are relatively high. Therefore land availability impose some constrains for expansion. Farm exits proportionally reduce cultivated land stock.

Labor dynamics

Modeling labor allocations dynamics in agriculture is challenging due lack of reliable data. Activity based accounting is very rarely used in farms in Latvia and labor force often is involved in off-farm activities. Many farms are involved both in crop and livestock farming and do not account for work (and other resources) spent in each sector. Significant (and diverse for different production cultures) seasonal effects also complicate the labor allocation dynamics.

Nevertheless similarly to land allocation we consider labor dynamics from two perspectives – total farm labor dynamics and labor allocation between crop and livestock sectors (Figure 6). It's assumed that actual fraction of labor allocated to crop farming sector adjusts to labor force demand relative to livestock sector. Also recruitment of new resources in each sector is according to relative demand. It's assumed that farm exits do not change labor allocation between sectors. Farm labor force demand is derived from crop and livestock farm production output and respective average labor productivity indicators. Work force employed in agriculture is split in to two stocks – Farm Workers (employed in farms with size over 2 ESU) and Underemployed (working in farms below 2 ESU or occasionally employed). It's assumed that number of farm workers over time would adjust to desired level and any excess labor is absorbed in underemployed stock. Although currently the number of underemployed labor is much higher compared to farm labor, farms face difficulties to employ more people due to regional varieties and inadequate skill mix. Average wage rate (which is further used to estimate labor costs) over time would adjust to changes in off-farm income trend and would be slightly affected by labor force availability.

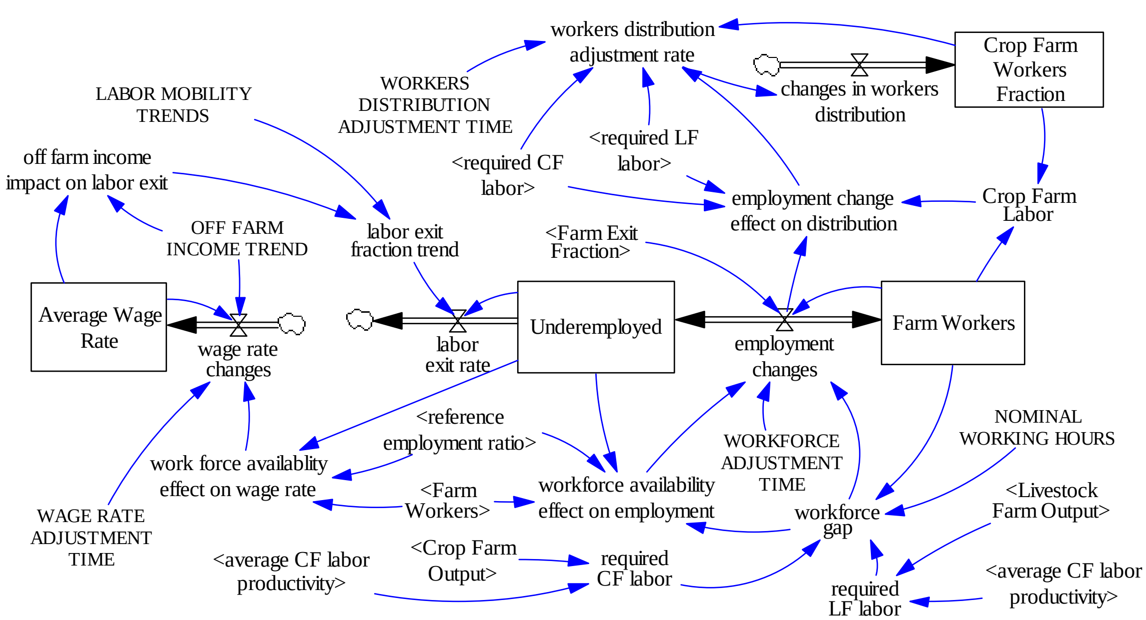

Figure 6. Structure for Labor Dynamics

To simplify the model it is assumed that only underemployed might exit agricultural sector and farm exits would reduce Farm Workers stock. Underemployed exit fraction initially was assumed exogenous and contingent on off-farm income and labor mobility trends. However as our study suggest change to underemployed labor exit rate might be important leverage for long term development thus would require future attention. Similarly demographics dynamic initially was not focus of this study however there are significant implications on long term due to high mobility of younger generations and low attractiveness of rural employment.

Farm financial model

In our study farm financial model consists of two main components - debt management and income distribution. Those topics have been well set forth in previous system dynamics studies [Pagel 2002] and we have built our model based on them.

Debt management component consists of farm loan and interest rate co-flow structure. New loans are taken to finance capital and land acquisition. Borrowing limits and interest rates are determined by current debt to asset ratio and lenders evaluation of farmer's capability to repay the debt (which is based on expected future income).

Farm income is calculated from production output, support payments, and variable costs. One of the specifics of agricultural sector is that often farm operator's family is employed without direct wage payments and it constitutes significant part of sector labor force. In many farms there is no external labor employed at all. In those cases family living expenses are part of farm's running costs and are not separately accounted. Also as there is no data on how much effort is spent for each activity in farms involved in both crop and livestock farming here we calculate full labor costs based on prevailing wage rates and required labor force in each sector (which in turn is estimated from production output and average labor productivity). Considering the scale of agricultural production in Latvia to other economic activities and EU market it is fair to assume that farmer production decisions do not impact resource prices (other than labor). Thus fuel, electricity and other variable resource prices are taken as exogenous. Resource consumption is slightly influenced by productivity technology growth. Special attention is paid to land rent fees to evaluate impact of area based support payments.

Applicable taxes and interest payments for outstanding debt are paid automatically from farm income. Indicated loan repayments are made as long as funds are available (income don't become negative). If there is any retained income it is accumulated and either consumed by farmer or spent for equity capital purchase. Perceived current income is modeled by smoothing actual income over one year (time frame is chosen due to strong seasonal effects) and used to build expectations about future incomes.

Very few new farms enter agricultural sector and with high confidence it can be assumed that this trend will continue also in future. In model we assume that entry rate is zero (as those few start-ups often would take over land and labor resources from other farms). Crop and livestock farm exit rates are anchored to current estimates and are influenced by off-farm income trend, perceived farm income as well as average debt payment to income ratio.

Preliminary results and possible policy impact

Although model has been quite well calibrated to fit available data this is not sufficient to build full confidence in its accuracy. Due to the limited reliable historical data (comparable statistics for agricultural sector in line with EU Farm Accountancy Data Network are available since 2004) as well as short time frame of the study rigorous quantitative model testing was not performed. However we believe that model gives some insights for alternative development scenario evaluation and could facilitate policy discussion. It is based on systemic approach which helps highlighting flows in event based thinking, enables sanity check of development scenarios as well as shows possible consequences of well intended policies. Although discussion on inefficiencies of agriculture support policies has long history in scientific literature [Saeed 1998] and studies of international organizations [OECD 2002] it seems advantageous if they can be communicated using dynamic model simulations and explained by eliciting underlying feedback structure.

First let's explore quite obvious disproportion between population employed with agricultural activities and their output. Thus in 2005 agricultural sector (including forestry) employed about 10.8 per cent of economically active population and produced only 3.2 per cent of GDP [STAT 2006]. In high level policy discussions long-term target was announced that by the year 2020 agricultural per capita income shall reach at least 80 per cent of average EU income level (which in 2005 by our estimates was below 20 per cent). For commercial farms such income increase even in the most optimistic scenarios would mean stretching production, capital investment and borrowing limits. This still might be not possible due to significantly lower support payments compared to more developed EU countries. In year 2000 only about 9 per cent from persons employed in agriculture were working for commercial farms (size over 2 ESU). Simulation results of agricultural labor distribution dynamics (Figure 7) shows that even in the most optimistic scenarios fraction of persons employed in commercial farms will not raise much above 15 per cent. Therefore policy target seems utterly impossible. There is no magic policy that could solve this problem. High leverage alternative could be policy with focus on educational efforts for underemployed population and off-farm job creation. Policy simulation implemented by increasing labor mobility trend gives significantly better outcome than any combination of support for farming activities (Figure 8). Of course here we can't evaluate possible implementation effectiveness of such policy.

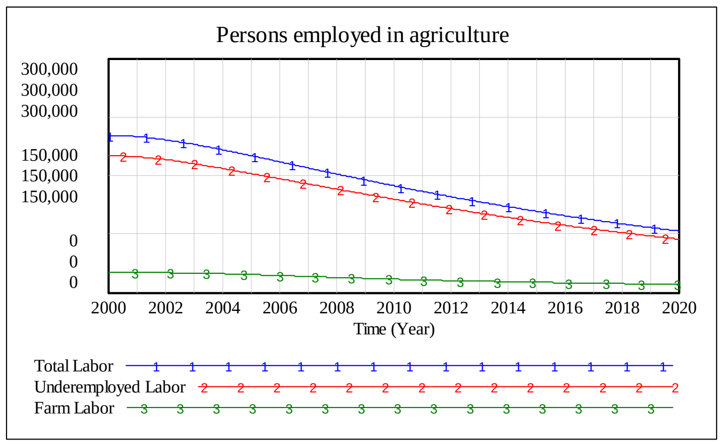

Figure 7. Agricultural Labor Dynamics.

After joining EU the largest funding is allocated for support payments which are distributed based on cultivated agricultural land. Area-based payments are considered to be with relatively high transfer efficiency [OECD 2002] and are quite equitable in Latvia case considering fragmented land ownership. However there are several side-effects which can be explain from model feedback structure. There is direct correlation between area-based payments and land price and rent [LVAEI 2005a]. As notable part of the cultivated land is rented from landlords part of support payments does not stay with intended beneficiaries (as shown by [Saeed 1981] probably the only way to reduce this effect is to impose tax on land rent). Higher land prices impede farm expansion however they also lead to more extensive production practices (environmental side-effects of the later are not considered here). Although area-based payments give relative advantage for crop farming (it is more land intensive and marginal effect on production is higher than for livestock farming) they are less market distorting than production-coupled support mechanisms. Last but not the least - area-based payments constitute relatively larger part of income for small farm and therefore have important role of basic social security.

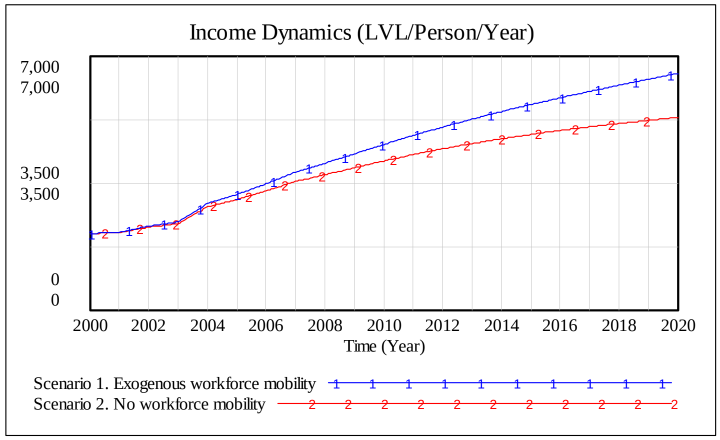

Figure 8. Agricultural Income per Capita

Payments coupled with specific agricultural activity currently constitute the second largest support scheme. This support mechanism is actively advocated by farmers and some policy makers and it is positioned as targeted and fair alternative. However in longer run such policy creates several unintended consequences which at least partly offset short term benefits. First problem which is well studied arise because of earnings that farm households loose when they divert their land and labor from other uses to the production of farm commodities benefiting from support (opportunity costs of production factors). These costs have to be subtracted from the increased earnings farm households get from producing supported commodities in calculating the net gain in farm household income [OECD 2005]. In model it can be shown by introducing income support in one of the sectors (crop or livestock). We can observe that in few years time resources are allocated away from unsupported sector thus reducing output and incomes. Such market distortion might create other consequences such as reduced prices and eventually reduced support as funds allocated to schema are split between more beneficiaries. Other risk which can't be directly tested with model but can be derived from the feedback structure is related to reinforcement of production limits balancing loop as coupled payments reduce flexibility of farmer's decisions and thus hinder production diversification. Even though it is possible to elicit these problems with current model version it does not allow to quantify transfer efficiency of specific support policies (due to high aggregation level).

Capital investment and technology transfer policies, particularly if not coupled with specific production activity, gives better outcome (in terms of per capita income and total output) in the long run. Increased capital investments and technology growth would create price pressure which would reduce profitability for less advanced farms (particularly those which don't have management or financial ability to implement better technologies). However as Latvia is integrated in EU market increasing farm competitiveness is of major importance for successful long-term development. Overall productivity gains from major capital investments from EU funding are evaluated very low by some researchers. This might point to implementation difficulties of this type of policy.

There are innumerable studies of agricultural economics around the world and models with varying degree of complexity have been built. Although model presented here would require some more testing and fine tuning it provides important insights about possible agricultural development in Latvia. It helps in creating shared understanding about policy issues for different stakeholders. Systemic view chosen here is particularly useful to discover realistic scenarios of agricultural development and evaluate impact of public policy alternatives.

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