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# **Accounting risk in farm investment calculations: application to dairy farm investment**

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## **Abstract**

Continuous investments are needed in agriculture to improve animal welfare and productivity, and to retain the viability of production. Current markets with increased price risks have made it challenging to determine profitable investments. Traditional investment calculations, such as net present value or liquidity statements, are usually based on static values and, therefore, they totally ignore the risk.

We propose a simple and open access approach to improve the static calculations used in assessing the profitability of an investment. The approach is based on an extended margin calculation where all essential inputs and outputs are defined. A price range (min, max) is defined, in addition to the traditionally used median value for the most volatile variables of the calculation. These three values are used to construct a beta probability distribution of the factor concerned. The beta distribution is a pragmatic and readily understandable distribution. Correlations of different factors may be taken into account.

The probability distribution of the calculation results is formed with Monte Carlo simulation. The investment subsidies contribute to making profitable investments, but direct subsidies may capitalize into investment commodities. Margin insurance could be alternatively applied to reduce an investment risk without the negative side effect of increasing building costs. An application to Finnish dairy farm investment is presented in this study.

**Key words:** Investment support; net present value; decoupling; margin insurance

**JEL classification:** Q12, Q18.

## **INTRODUCTION**

Continuous investments are needed in agriculture to improve productivity and retain the viability of production. Investments in modern production facilities often also increase animal welfare and fire security, for example. Agricultural investments additionally improve rural development. Current markets with increased price risks have made it challenging to determine profitable investments. Traditional investment calculations, such as net present value (NPV) or liquidity statements, are usually based on static values and, therefore, they totally ignore the risk. Risk, measured as the variation in input and output prices and quantities, should be easily implemented in investment calculations. Simulation calculations, which are one option to take risk into account, should be intuitive to understand and should not increase the administrative burden or costs faced by farmers.

An alternative available method for considering the risk in investments is based on real options theory (Dixit and Pindyck, 1994). However, the method is seldom used in practice at the farm level, as it is found complex to understand.

### **Investment promotion measures in Rural Development programmes**

Rural investments in the EU are promoted with different forms of rural development (RD) investment support. Subsidizing investments in rural areas is an essential part of rural development. Investments may also have multiplier effects that enhance the viability of rural areas. One of the key objectives of RD investment support is to promote investments that would not otherwise have been undertaken because of financial risks associated with them. Currently, risks are reduced by direct investment aid payments.

The financial viability of the supported investments is typically assessed with calculations based on NPV, and only viable investments are financed. Procedures ensure that farmers with limited access to credit could invest in agriculture if their production is profitable and the investment meets the criteria of the support. However, investments are seldom stress tested against volatile commodity prices.

In the programmes applied by different countries and regions, the amount of the support is usually EUR 5,000 – 5,000,000, depending on the sub-measure or the operation. The support intensity may also vary between programmes. The support is commonly 40–50% of the acceptable investment cost. Some programmes have additional subsidies, for example for young farmers, joint projects, integrated projects, investments in mountain areas, areas with significant natural constraints, and other areas with specific restrictions. Supplements are also possible for investments within the European Innovation Partnership (EIP), investments associated with agro-environmental and climate activities, and organic farming. The maximum intensity might even be as high as 90% of the total investment cost.

Measures addressed to farm investments (Modernization of agricultural holdings, 121; Support for adding value to agricultural and forestry products, 123; and Support for setting up

of young farmers, 112) have had a significant budget share, but it seems that the actual declared expenditure did not reach the budget in the programme for 2007–2013 (Table 1).

**Table 1. Support to farm investments in RD Policy 2007–2013 (European Commission, 2016a)**

	<b>Modernization of agricultural holdings (measure 121)</b>	<b>Support for adding value to agricultural and forestry products (measure 123)</b>	<b>Support for setting up of young farmers (measure 112)</b>
<b>Programmed total public expenditure, billion €</b>	18.4	8.7	4.91
<b>EAFRD budgeted contribution, billion €</b>	11.9	5.3	2.9
<b>Percentage of EU Rural Development budget (EAFRD contribution)</b>	12.4%	5.5%	3%
<b>Actual declared expenditure (Q4 2006 to Q3 2014), billion €</b>	9.6	3.5	2.4

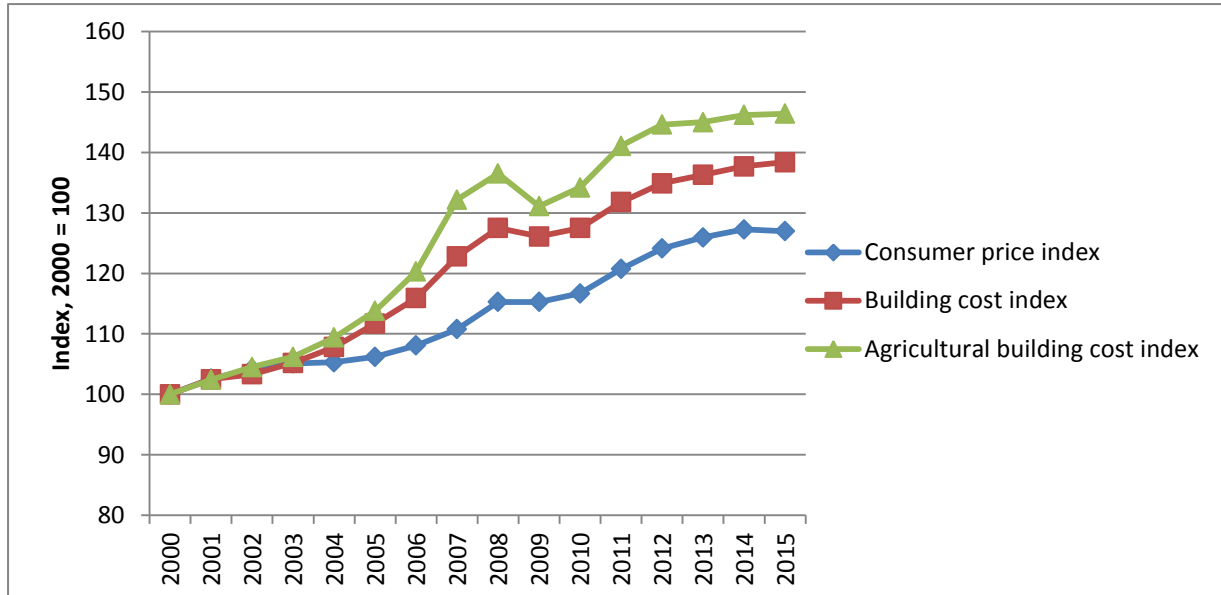
In the 2014–2020 RD programme, most of the investment support is allocated to “Investments in physical assets” (Article 17). The support is composed of four sub-measures: 1. Support for investments in agricultural holdings, 2. Support for investments in processing, marketing and/or development of farms, 3. Support for investments in infrastructure related to the development, modernization and adaptation of agriculture and forestry, and 4. Support for non-productive investments linked to the achievement of agri-environmental and climate goals. Each of the sub-measures has several operations related to different types of investments within the same sub-measure.

The target for total investments (private and public) in agricultural physical assets is EUR 16.8 billion in 2014–2020. The target for the number of farm holdings supported by investments in physical assets in agriculture is 334,400 farms (European Commission, 2016b). The average amount of the targeted investments is therefore a little above EUR 50,000 per investing farm, but the value of eligible investments varies widely between types of investments and countries.

### **Possible problems related to direct (investment) payments**

It is well recognized that area-based subsidies (direct payments) partly capitalize into land values and rents (Feichtinger and Salhofer, 2011). It is possible that the same phenomenon follows investments in physical assets; investment subsidies may capitalize into investment commodities and investment costs tend to rise due to the investment subsidies. We may find some evidence of this phenomenon from Finnish price index data (Figure 1). Agricultural building costs have increased more than the costs in other construction. However, other factors, such as building regulations, also affect the cost development. Therefore, the conclusion is not unambiguous. However, rising costs cause leakage of subsidies out from

their primal targets and, furthermore, profitability in agriculture will be lowered due to the increased capital involved in production. These negative outcomes from investment subsidies call for an alternative option for directing subsidies to lower the risks related to agricultural investments.



**Figure 1. Comparison of building cost indices and consumer prices (Statistics Finland, 2016a-c)**

### Study purpose

In this study, we present a practical way to include deviations in margin calculations and, furthermore, test the possibility to cope with risks related to investments via marginal revenue insurances. The underlying idea of the study relies on the fact that the maximum bid price of the investment is lower if the revenue stream is associated with high volatility. Reducing the volatility improves farmers' possibilities to make a profitable investment. This leads to an alternative for strategy where subsidies are used to lower the investment costs faced by the farmer; subsidies could be partly targeted to moderate income volatility (risk management). Both of these policy options are plausible under current CAP regulations. Investment promotion measures under rural development programmes have already been described above. CAP policy regulations for risk management are also under rural development programmes (Articles 36-39 of Rural Development Regulation, RDR). The question that arises is: what is the exchange ratio between the two policy options, i.e. between direct support and insurance schemes, to reduce income volatility from the farmer's point of view?

The choice between direct aid and risk management is a customary issue in current agricultural policy, and different choices have been made. Agricultural policy in the US favours risk management; more than a half of the agricultural policy budget is targeted at risk management practices (Zulauf and Orden, 2012). On the contrary, in the EU, only a tiny share of the agricultural policy budget is targeted at risk management. State aid expenditure

on crisis and risk management measures in the EU is currently around 4% of the total agricultural budget (European Parliament, 2016).

Investment calculations indicating the risks also allow the development of margin insurances linked to investments. The margin insurance could reduce the need for direct investment subsidies, similarly to subsidies targeted at moderate income volatility. However, in this article, we do not develop margin insurance or set a fair premium for it. The target of this article is, first, to propose a simple and open access approach to improve the static calculations used in assessing the profitability of an investment and, secondly, to discuss the utility of margin insurances as an alternative to manage the financial risks of the investments.

## **MATERIALS AND METHODS**

We first produce an investment calculation in which the risk related to input and output prices and quantities can be systematically taken into account. The approach is based on an extended margin calculation, where all essential inputs and outputs are defined to determine the margin on investment costs. For some of the most volatile variables, a range (min, max) is defined, in addition to the traditionally used median value.

The three values (min, median, max) are used to construct a PERT (Program Evaluation and Review Technique) distribution, which is a special form of beta probability distribution. The PERT distribution was originally developed for the US Navy Special Projects Office in 1957 to support the US Navy's Polaris nuclear submarine project (Malcolm et al., 1959). In this complex project, the details and durations of all activities were not known, but the project management required an estimate of the project finishing time. For each subproject, the most optimistic, most likely and most pessimistic time required to accomplish each activity were estimated. Timing deviations of the subprojects formed the probability for the entire duration of the project.

The PERT or beta distribution (the term used in this paper) is a pragmatic and readily understandable distribution that allows asymmetry of the deviation. In agriculture, deviations of prices or yields may often be skewed one way or another. Another advantage of the beta distribution is the fact that only three parameters are needed for its definition. These parameters may be solved from historical data or they may be based on expectations. The lowest value may be set, for example, for the intervention price or the low value use of the product, whereas the highest value may address good market conditions. The median set in between these values describes the most likely value.

The density function  $f(x)$  of a beta-distributed variable  $x$  is defined with its minimum (min), median (m.likely), and maximum (max) values as follows (Palisade Corporation, 2013).

$$f(x) = \frac{(x-\min)^{\alpha_1-1}(\max-x)^{\alpha_2-1}}{B(\alpha_1, \alpha_2)(\max-\min)^{\alpha_1+\alpha_2-1}} \quad (1)$$

where

$$B(\alpha_1, \alpha_2) = e^{\text{GammaLN}(\alpha_1) + \text{GammaLN}(\alpha_2) - \text{GammaLN}(\alpha_1 + \alpha_2)}$$

$$\alpha_1 \equiv 6 \left[ \frac{\mu - \min}{\max - \min} \right]$$

$$\alpha_2 \equiv 6 \left[ \frac{\max - \mu}{\max - \min} \right]$$

$$\mu \equiv \frac{\min + 4 \cdot m.\text{likely} + \max}{6}$$

Correlations of different factors and their deviations may be taken into account in the calculation. The probability distribution of the calculation results (NPV) is formed with Monte Carlo simulation. This distribution indicates the probability of making a profitable investment given that the investment expenditure is known.

## Application

An application of the investment calculation to a Finnish dairy farm investment is presented in this study. A building investment for 142 dairy cows was the starting point of the numerical example. The returns on dairy cow facility investments were derived with a margin calculation based on field data from Finnish dairy farms: typical Finnish dairy farms in the International Farm Comparison Network (IFCN), and Finnish dairy farms in the Farm Accountancy Data Network (FADN). The risk factor was included in the average milk yield, and in the price of milk, roughage, grain and rapeseed meal.

The milk production per cow was determined from the Finnish dairy herd recording system, with the year 2013 as the period observed (Table 2). The median yield used in the study represents the actual median of the data. The minimum and the maximum yield for the investing farm were set at the lower and upper quartile, respectively. These quartiles are assumed to indicate the possible milk yield variation after the investment. The variation may be caused by changes in technology, an increase in the number of animals, and the disease pressure caused by new animals in the herd.

The annual average milk producer price over the years 2005–2015 (European Commission, 2016c) was used to determine the milk price range (min, median and max of the observed prices). The price of barley was determined as the annual mean producer price, and the rapeseed meal price as the mean rapeseed price over the years 2005–2015 (Luke, 2016a) with industry handling and freight costs. The cost of grass silage is not available in the time series, but crop production yield statistics (Luke, 2016b) and the nitrogen fertilizer price index (Statistics Finland, 2016c) are collected annually. We used production costs from the year 2013 (Ellä, 2014) and formed an indicator for price variation from the available variables.



Grass yield statistics were changed to an index representing yield variation, which was approximated to represent 80% of the annual price. In addition, the nitrogen fertilizer price index was used with a weight of 20%. The cost variation was determined over the years 2005–2015, from which the minimum, median and maximum values were taken. The descriptive statistics of the price variables are presented in Table 2.

**Table 2. Minimum, median and maximum values of the selected input and output variables of the margin calculation**

	Minimum	Median	Maximum
Average milk yield of the herd, kg	8,009	8,837	9,591
Milk price, €/kg	0.346	0.395	0.459
Grass silage price, €/kg	0.105	0.141	0.155
Barley price, €/kg	0.096	0.136	0.187
Rapeseed meal price, €/kg	0.180	0.320	0.423

The correlations between milk, grass silage, barley and rapeseed meal price series were calculated with the Microsoft Excel correlation tool over the years 2005–2015 and are presented in Table 3.

**Table 3. Correlations between price variables**

	Milk	Grass silage	Feed barley	Rapeseed meal
Milk	1.00			
Grass silage	0.65	1.00		
Feed barley	0.82	0.59	1.00	
Rapeseed meal	0.86	0.61	0.90	1.00

The complete calculation with variable deviations was run with a Monte Carlo simulation of 10,000 iterations. @RISK software (Palisade Corporation, 2013) was used in the simulation. The program generates the distributions of possible outcome values, taking into account pre-defined correlations. Correlated sets of random numbers are used in sampling each of the correlated distribution function. The sample matrix of rank correlation coefficients approximates as closely as possible the target correlation coefficient matrix (Palisade Corporation, 2013).

The NPV of the facility was derived from the annual margin on investment costs. The annual margin was €786 per cow per year when the input and output prices and quantities were assumed to be at their median values. In the basic scenario, we used an interest rate ( $p$ ) of 2% and duration ( $t$ ) of 15 years while deriving the NPV. The building expenditures are highly dependent on technology choices and vary case by case. In this study, the building expenditure of an animal facility was assumed to vary between €10,000 and €14,000 per cow, indicating the variation in current investments in a free-stall barn with diverse levels of

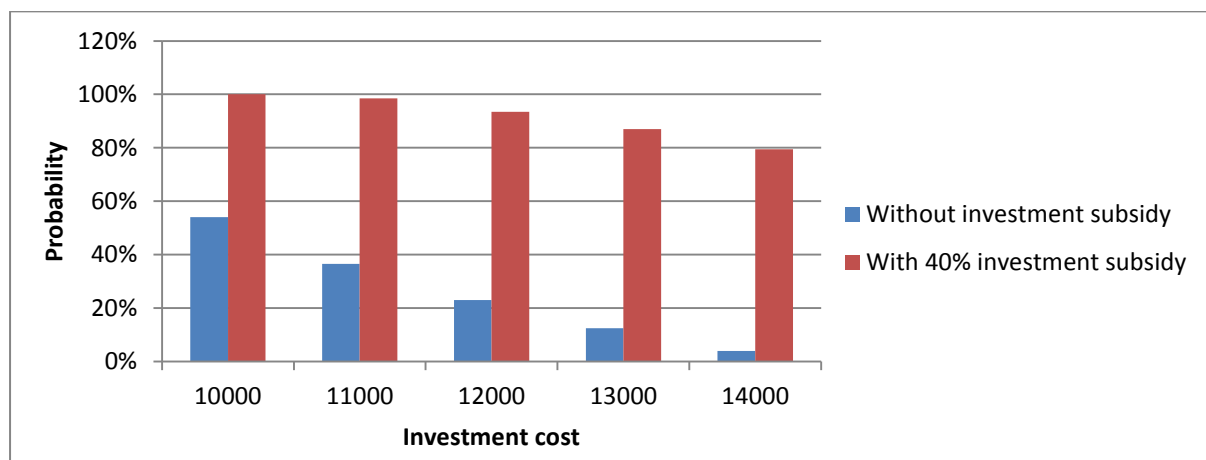
technology. Assuming the annual return ( $R$ ) on the investment to be equal throughout the duration of the investment, NPV was derived as follows:

$$NPV = R \times \frac{1,0p^t - 1}{0,0p \times 1,0p^t} \quad (2)$$

The investment calculation with Finnish parameters was further used in a case study in which margin insurance for the investment was considered as an option for direct investment support.

## RESULTS

The success of investment with volatile input and output values is measured with the probability that the NPV exceeds the investment cost. The results indicate that the probability of making a profitable investment is 1.00 with the lowest investment cost and 0.80 with the highest investment cost if an investment subsidy of 40% is allowed. Without a subsidy, the corresponding probabilities are 0.54 and 0.04. With the median price of the investment, the probability of a profitable investment is 0.93 with the investment subsidy and 0.23 without the subsidy (Figure 2).

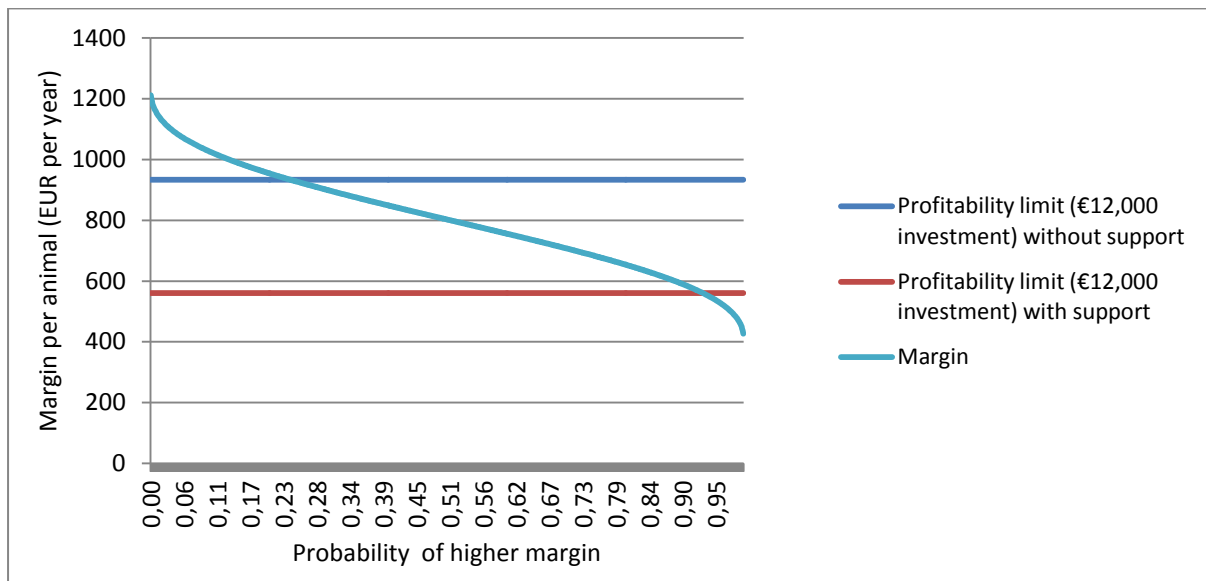


**Figure 2. Probability of achieving an NPV equivalent to investment costs**

In the case of a median investment cost of €12,000 and the typical subsidy rate of 40%, the subsidy for the investment is €4,800. The present value of the subsidy is in this case €374 per year. With the subsidy included, the annual margin should be at least €560 to be able to meet the profitability target (NPV equal to or exceeding the investment cost). With the full investment cost without subsidies (€12,000), the margin should be at least €934 (Figure 3).

If the investment is supported with margin insurance instead of direct payment, the insurance should cover the low incomes and raise the probability of success to the same level as with the investment subsidy. In this case, the probability of achieving an NPV equivalent to or higher than the investment cost is raised to same level as with investment support.

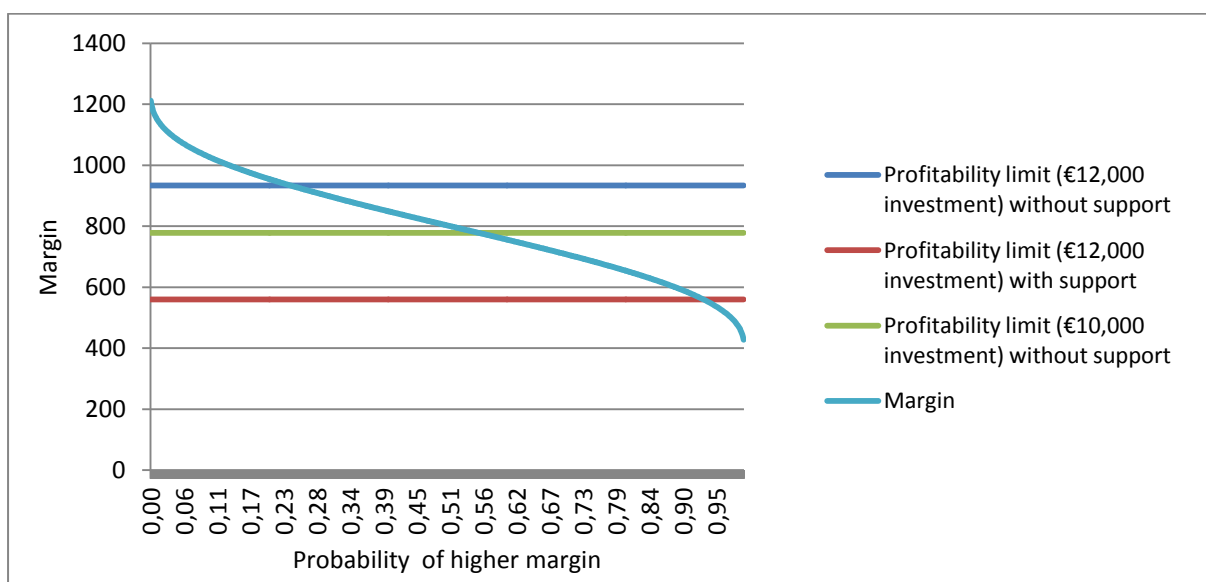
The annually varying indemnity payment is the difference between the margin reached and the trigger (€934), but not higher than NPV of the investment support.



**Figure 3. Margin distribution compared to supported and non-supported investments**

The probability of a margin equal to or less than €560, where indemnity equals the present value of the subsidy, is 0.07. The expected value of an insurance that ensures the margin of €934 with 93% probability is €146.50.

If the farmer is able to build with a lower cost than average (€10,000), but the insurance trigger is kept at €934, the farmer has a 32% probability of receiving a surplus from the insurance above the profitability target (Figure 4).



**Figure 4. Margin distribution compared to different investment costs**

## DISCUSSION AND CONCLUSIONS

Considering investment calculations from the perspective of risk and seeing the results as probabilities of success should be brought into everyday use. For this purpose, a beta distribution with just three parameters is simple enough to reflect the risk. At the farm level, it is easy and apprehensible to comprise the lowest and the highest possible yield or price of a product. It is also worth noting that adding more than one deviation to the calculations enables situations to be handled where multiple risks occur simultaneously. These are the nightmare situations, but well-performed risk analyses also include plans for these cases.

In present times, the reduction of bureaucracy related to policy management should be one of the key objectives in policy development. The current investment subsidy system, where subsidies are granted on the basis of expenses and their receipts, is relatively easy to monitor and gives few opportunities to abuse the system. However, we should not ignore the problems related to it; it seems that building costs tend to rise as investment subsidies are paid. Margin insurance might be one option for decoupling support from the actual investment cost. The reasoning behind the idea is similar to decoupled agricultural production support in general, maintaining necessary production (investments) but not accelerating input use (investment cost).

Supporting investments in agriculture has also been a measure to increase animal welfare and fire security, for example. In the Finnish context, building regulations in supported construction have exceeded the minimum requirements of the valid legislation, and therefore promoted forward-looking building. These positive effects may not be achieved as easily with the examined hypothetical insurance-based support.

Direct payment for the investment is paid at the beginning of the new activity, and the entrepreneur does not have to worry about it afterwards. Insurance for future years requires annual active following of the margin or index-based mechanism for verifying the compensation validity.

The biggest difference comes with the possible investment revenues. Direct, single investment aid does not affect the future margins faced by the farmer. However, it makes the profitability requirement of production lower, as the investment cost is directly lower. Moreover, the revenue possibilities are also higher when less of the revenue is spent on the interest cost. In our case example, there is a 94% possibility of reaching or exceeding the target. In the median investment cost example, the presented insurance covers losses that fall under the profitability target, but the possibility of a higher margin than the target is only 24%.

The key advantage of hypothetical decoupled investment support is that it motivates to most cost efficient construction, because the subsidy is not dependent on investment cost. The comparison presented in this paper is a simplified discussion opener for further development of alternative ways to promote agricultural investments in a reasonable manner.

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