POLICY IMPACTS ON LEGUME-BASED AGRICULTURE AT EU LEVEL

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Abstract
The impact of policy scenarios on economic welfare and the environment depends to a large extent on their direct effect on land use: a strong increase in the cultivation of legumes means a significant environmental impact and a sizeable impact on other variables such as farmers' incomes, cost to taxpayers and imports and exports. The impact of realistic policy alternatives aimed at promoting legumes is likely to be limited. In particular, they may not be able to reverse the trend in the decline of grain legumes.

Keywords: grain legumes, policies, economics, environment, modelling

1. Introduction

Because they stimulate biological nitrogen fixation, legumes (a) reduce the need for N fertilizer both for themselves and for the succeeding crop; (b) legume crops produce little or no emissions of nitrous oxide, an important greenhouse gas, when growing; and c) legumes contribute to soil organic carbon, an important resource for improving soil structure and composition, as well as being a form of carbon sequestration and therefore reducing greenhouse gas emissions. See Bues et al. (2013) for a further and more thorough discussion.

The challenge of increasing the use of legumes in cropping systems can briefly be described as a contradiction between, on the one hand, the considerable environmental benefits of these crops and, on the other, the decline in the production of legumes in Europe while their consumption is increasing (Helming et al., 2014). The underlying reasons for this must be sought in the economic domain: the decreasing production of legumes is due to the lower and more uncertain revenue they bring to farmers; while the increasing consumption is related to our demand for animal products, requiring large quantities of high-quality vegetable protein, particularly for pigs and poultry.

This paper looks at the prospects for mitigating this problem of decline in the area and production of legumes. In doing so, the effects of both autonomous developments and policies are examined by means of simulations in the shape of scenarios: imagined situations in which a policy or a supposed trend occurs, as compared to a counterfactual in which it does not. In this study, the model CAPRI is used to calculate the impact of such scenarios on a number of important economic and environmental variables at regional level.

This paper first provides a description of the scenarios applied (first a reference scenario, then potential policies). This is preceded by a general description of the economic aspects of legume-growing, providing the basic information to be fed into the model through the scenarios. The scenario narratives are followed by a description of the model CAPRI. Next, the outcomes of the various simulations are presented and discussed, and the final chapter, naturally, offers some conclusions based on the exercise as a whole.

2. The economics of including legumes in cropping systems[1]

Legumes (defined as cultivated plants of the *Fabaceae* family) have long been grown as the primary source of protein for human nutrition. Animal protein from fish, meat, eggs and milk was available but mostly scarcer and thus more expensive. Livestock was grazed mostly on land unsuitable for crops, or on fallow. For millennia, a combination of cereals and pulses has formed the basis of a healthy diet in many cultures in Europe, Asia, Africa and Latin America. The soil-enhancing properties of pulses and other legumes were also well known.

The growth of prosperity has profoundly altered our diets and therewith our farming systems. In Europe total human consumption of pulses increased from 1984 to 1996, while it remained rather stable afterwards (source: CAPRI database). In Europe and elsewhere, protein consumption from livestock products has added to the human consumption of pulses. Livestock products have become cheaper (although still more expensive than beans) by intensification of production, including intensification of feeding. Particularly non-ruminant animals such as pigs and poultry need digestible protein-rich feed.

Thus, the expansion of livestock production in richer countries has led to a considerable increase in the consumption of legumes. Most of this increase has been in the form of soybeans and soybean meal (the by-product of soya oil extraction). Nearly all of this soya used in the EU is imported: in 2010, the 28 member states of the EU imported 15 million tonnes of soybeans and 30 million tonnes of soybean meal, together the soybean equivalent of 53 m tonnes.[2] This is because (a) soybeans are probably the best-quality source of vegetable protein on the market, and (b) the climate in most European countries is more suited for growing cereals than soybeans.

Stockfeed manufacturers in Europe became aware of the high quality of soybean meal in the early 20th century (Prodöhl, 2010). However, it was the Dillon Round of GATT agreements (1962) that really launched large-scale imports of soya into Europe: the European Economic Community (precursor of the EU) had insisted on high import tariffs for cereals in order to protect its wheat farmers from foreign competition. In compensation, it had accepted the tariff-free import of grain substitutes – mostly soybeans and cassava. It was this opening-up of the European market to cheap imports of stockfeed that made the expansion of intensive livestock-keeping possible. It led to significant gains for European livestock farmers and to cheap products for European consumers.

Europe's current dependence on imported proteins is not primarily caused by its inability to grow enough by itself: the production of especially grain legumes (pulses and soybean) is in long-term decline, from 4.7% of all arable land in 1961 to 1.9% in 2011 (Bues, et al., 2013). This is due to a) competition from low-cost legume producers in other countries, mostly from North and South America, as mentioned; this has been aided by tariff-free imports; b) competition from wheat and other cereals for land in Europe; c) competition from nitrogen fertilizer as an alternative way to maintain soil nitrogen levels; this has been aided by the availability of cheap fossil energy for manufacturing nitrogen fertilizer and d) decoupling of crop-based premiums in the EU.

European policymakers noticed early on that the support for wheat and its absence for pulses would led to changes in cropping patterns, and that the increasing dependence on

[1] This section is largely based on: Bues et al., 2013.
[2] Figures calculated from FAOStat data.

imported vegetable protein represented a risk (European Commision 1973: 14-16, European Parliament 1975). Therefore, a subsidy for so-called protein crops (faba bean, pea and sweet lupin) was introduced in 1981. In the 1992 MacSharry reform, this subsidy was replaced by an area-based premium. The discontinuation of support for protein crops in 2006, as part of the Fischler Reform of 2003, led to a steep decline in areas under grain legumes, even though until 2012 some countries still paid a smaller premium for legumes. Farmers clearly react to subsidies, but these have not been able to fully compensate for the long-term downward trend (Bues et al., 2013).

The average gross margin of grain legumes in a number of European countries and regions for which figures are known has been calculated at €240 per hectare, compared to €584 for wheat (Bues et al., 2013: 87). Moreover, pulses tend to be more risky crops than cereals (Bues et al., 2013: 88). Also, cereal yields have increased faster than those for legumes in recent decades, probably at least in part due to the higher support level for cereals (Bues et al., 2013: 28).

However, these figures include only the immediate yield of the legume crop itself, not the beneficial effect it has on succeeding crops. If we include this pre-crop effect, grain legumes are still less profitable than competing crops, but the difference is much smaller; and in some cases rotation systems with legumes produce higher gross margins than those without (Bues et al., 2013). It is to be noted that this pre-crop benefit will be greatest in regions where at present the proportion of cereals in arable land is high, such as Poland, western Germany and northern Italy.

On the other hand, the higher yield variability is usually quoted as a disadvantage of legume crops. This variability (expressed as the mean divided by the variance) is in peas, for instance, typically 50-60% higher than for wheat (Bues et al., 2013).

3. Scenarios

To show the impact of a particular scenario, we must compare its outcome with a counterfactual, i.e. where the events simulated under that scenario do not take place. The proper counterfactual, therefore, is not the present situation but what will happen if present trends continue. Hence, for the reference scenario we let present trends continue without any change in policy. It is not to be regarded as a forecast of what is most likely to happen, but only a projection of what will happen under certain circumstances.

The most straightforward way to promote legume cultivation would be to pay a premium, in order to compensate farmers for the lower profit they can obtain from these crops. The first policy scenario therefore simulates a situation where a payment per hectare for growing grain legumes is introduced. Such a payment would be similar to the protein-crop premium which existed until recently in the CAP. Hence, it would not be linked to production, as the former coupled payments were. In the model CAPRI legumes are represented by pulses and soybean.

Another possibility is to include legumes in the Ecological Focus Areas (EFA) which will come into being as a result of the CAP reform, effective from 2014. They are intended as a contribution to making European agriculture more environmentally sustainable. 7% of arable land and of land under permanent crops or horticulture must be EFA land (5% for the first few years). This is a condition for 30% of the direct farm payment, to which farmers are entitled under Pillar 1 of the CAP. There are several options which farmers can use to qualify for EFA, all aimed at increasing environmental benefits from land management: buffer strips, fallow with semi-natural vegetation, maintaining landscape elements, and various forms of environment-friendly practices. One of these could be growing grain legumes.

4. The CAPRI model

CAPRI stands for Common Agricultural Policy Regional Impact. It is a global partial equilibrium model for the agriculture sector with a focus on the EU27, plus Norway and the Western Balkans. It calculates the effects of EU agricultural and trade policy on production, income, markets, trade and the environment from a global to a regional scale (NUTS2) to farm type scale (http://www.capri-model.org).

The CAPRI model contains two interlinked components: a supply module and a trade or market module. The lowest aggregation level of the supply module consists of 1,888 non-linear programming models representing up to 10 farm types in each NUTS2 region (Britz and Witzke, 2012). The farm-type programming models can also be aggregated to NUTS2 regional farm models. In this paper the NUTS2 aggregation level is applied. In that case the supply model includes 276 NUTS2 regional farm models representing the EU27, Norway, Turkey and the Balkans. The data are based on the Economic Accounts for Agriculture (EAA). The (regional) farm models have fixed input-output coefficients for each production activity with respect to land and intermediate inputs. Normally a low and high yield variant for the different production activities are modelled. Requirements regarding NPK balances of crops and feeding requirements of animals are taken into account. A land supply module allows for land leaving and entering the agricultural sector and transformation between arable and grass land in response to relative price changes. These models cover around 50 crop and animal activities for each of the farm types and include around 50 different inputs and outputs (Britz and Witzke, 2012).

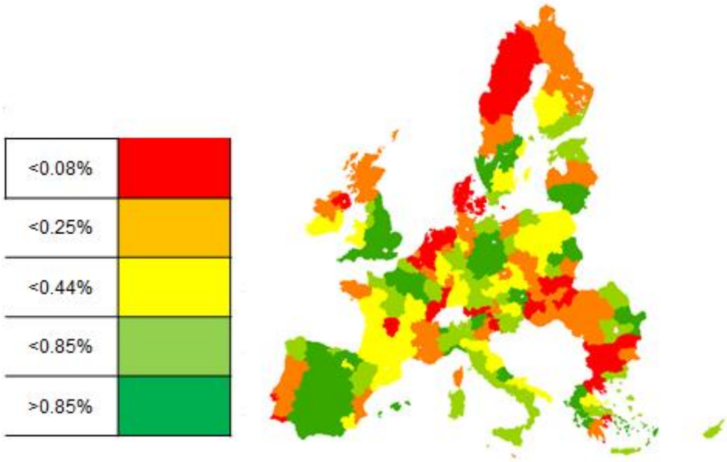
The trade module is a comparative-static spatial global multi-commodity model. It covers 47 primary and secondary agricultural products, and models bilateral trade between 60 countries grouped in 28 trade blocks. The CAPRI market model is iteratively linked in a transparent and consistent way to the layer of non-linear regional mathematical programming models.

5. Results

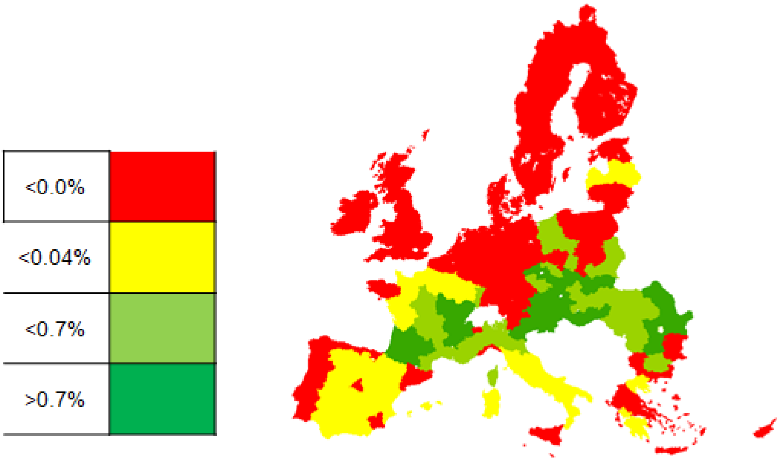
In the reference scenario, i.e. with a continuation of current trends, there will be a decline in the cultivation of legumes. The area under pulses will decrease by 327,000 hectares or 24% over the period 2009-2020. Cultivation of soybean will increase, by 213,000 hectares or 70%, meaning an overall net loss of 114,000 hectares for legumes, or 7% of the area in 2009. According to our reference scenario developments per country can be quite different from the EU average. Strong increases are due to an expansion of soybean cultivation in countries where the climate is suitable (e.g. Bulgaria, Romania, Hungary, Czech Republic, Austria). In absolute figures the largest decreases in the area under grain legumes are expected in France, Italy and Britain (see Helming et al., 2014).

Map1 and Map 2 below show the shares of pulses and soybeans in the total Utilised Agricultural Area per region (UAAR) in 2020 in the reference scenario. It appears that regions with a relatively high share of pulses can be found in different parts of Europe:

Lithuania, England, Spain, southern Sweden, eastern Germany, northern France, eastern Romania and parts of Greece. Soybeans are grown much less than pulses (compare Map 1 with Map 2). Relatively high shares can be found in southern and central France, several Central European countries and Romania.



Map 1. Share of pulses in total UAAR per NUTS2 region in 2020 (reference scenario)



Map 2. Share of soybeans in total UAAR per NUTS2 region in 2020 (reference scenario)

Table 1 shows the average fertilisation balance for some selected crops in the EU27, as given by CAPRI. Pulses and soybeans clearly make a positive contribution in that they require much less N fertiliser. Moreover, if harvested they can serve to remove excess nitrogen from the soil.

In the first policy scenario, the legume premium is implemented in CAPRI such that the total premium paid in any one NUTS2 region does not exceed 2% of the direct farm payment budget from Pillar 1 of the CAP per country. In regions with a very limited acreage of grain legumes and relatively high direct farm payment budgets, this could lead to a very high payment per hectare. To avoid this, we have assumed that the legume premium per hectare should also not exceed the national average direct farm payment per hectare.

Table 1. EU27 average fertilisation balance per crop in 2020 in the reference scenario

	Mineral nitrogen	Manure nitrogen	Other nitrogen	Nitrogen removed	Nitrogen surplus
	kg N per hectare				
Soft wheat	123	20	52	-149	46
Soya	37	12	32	-227	-146
Pulses	12	4	37	-128	-75

Source: CAPRI

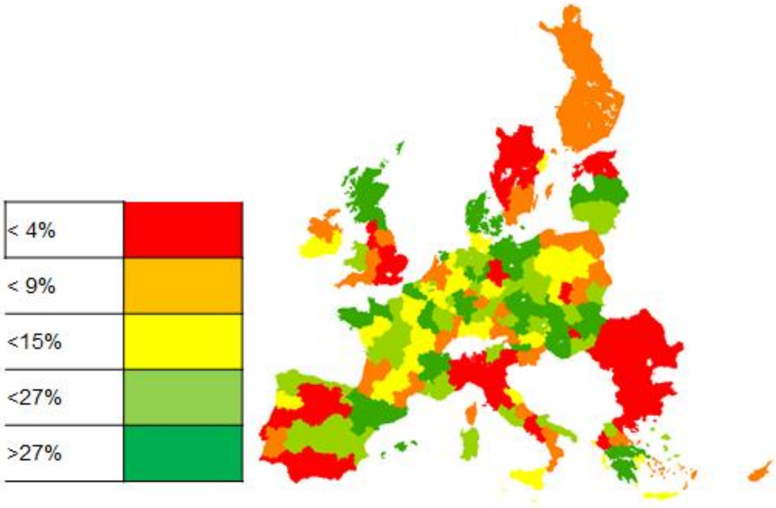
The budget for area-based legume payments goes at the expense of the direct farm payments. Hence, total Pillar I payments will decrease in regions with no legumes production and little potential for doing so, while it will increase in regions with a relatively high share of legumes in the total cropping plan.

The premium will make grain legumes more profitable, causing more land to be allocated to them. This could provoke an overshooting of the initial regional budget. It is assumed that the premium per hectare will be reduced proportionally if the available budget is exceeded.

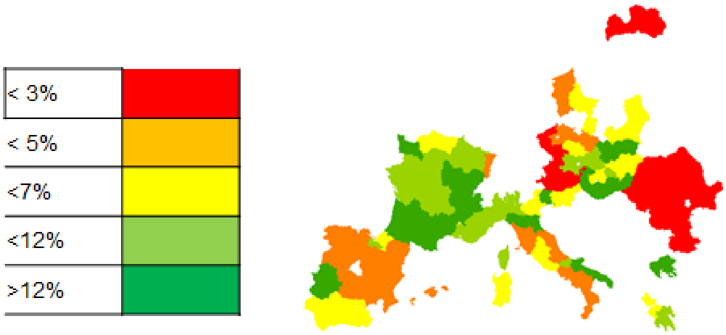
The payment per hectare for grain legumes, as calculated according to the scenario described above, ranges from about €70 in Latvia to over €425 in Greece. It should be noted that this payment is provided on top of the direct farm payment in Pillar 1. Again, the introduction of these payments also leads to a redistribution of total Pillar 1 payments (direct farm payments and hectare premiums) per region.

The important question is, of course, to what extent these payments lead to more land cultivated with legumes. The area under pulses increases by 13% compared to the reference scenario, and the area under soybean by 11%, for the EU27 as a whole. This is modest compared to the steep decline that legume cultivation has undergone in recent years, but at least it is a change in the trend.

However, the effect by region is quite variable, as can be expected from the differential payments and the differences in production possibilities. The regional impact on acreage of pulses and soybeans is shown in Map 3 and Map 4 respectively. Regions with relatively low increase in the area under pulses can be found in England, Spain, northern Italy and in Romania and Bulgaria. It should be noted that in general these regions already have a relatively high share of pulses in their regional cropping plan. As for soybean, the largest increases are found in France (Map 4).



Map 3. Change in hectare of pulses per NUTS2 region (percentages)



Map 4. Change in hectare of soybeans per NUTS2 region (percentages)

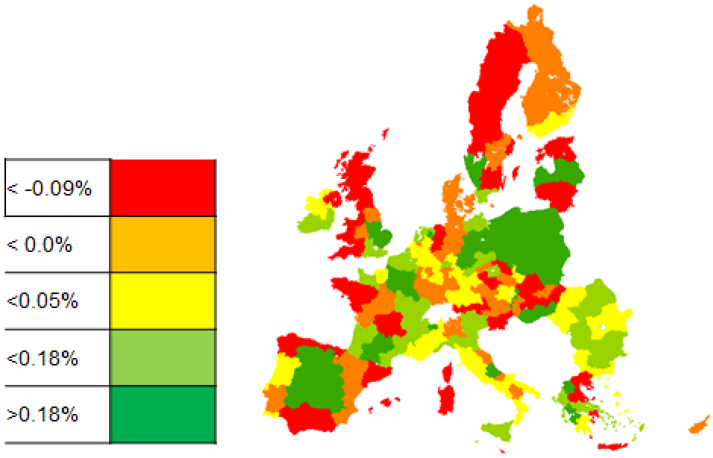
However, the legume premiums also have an impact on the total agricultural area. The total UAA in the EU27 decreases by 0.015%, or about 27,000 hectares. This is because direct farm payments decrease in regions with very little cultivation of legumes. In these regions low-input and low-margin crops are substituted for high-input and high-margin crops.

Market balances of soya seed, pulses and soya cake show that the increase of net production exceeds the increased human consumption, processing and feed use. As a result imports decrease and exports increase. Average prices of soybeans and pulses in the EU27 decrease by about 4% and 3% respectively. These decreases are much stronger in the 12 new member states (5-6%) than in the 15 older members (2-3%). Prices of all other marketable and intermediate agricultural products (roughage, young animals, animal manure) will increase.

Total global warming potential (GWPT) in CAPRI captures methane emissions (CH_4), nitrous oxide emissions (N_2O) and carbon dioxide emissions (CO_2) in CO_2 equivalents. It appears that the scenario under consideration has very limited impact on the environmental indicators provided in CAPRI. Average GWPT per hectare in the EU27 actually increases (+0.01%), but because there is less farmland the overall GWPT is about constant.

At regional level the development of the Global Warming Potential can be quite different from the EU27 average. The increase in Global Warming Potential in Poland, Denmark, southern Italy, southern Portugal and parts of Belgium, in particular, can be explained by the (limited) increase in cattle herd, among others induced by a relatively high share of grain legumes in animal feed and a lower price of grain legumes. Moreover, part of this effect is explained by the decrease in agricultural land (especially in regions with a limited amount of grain legumes) and the increased intensity of production on remaining agricultural land (changes in cropping plan), which offset the positive impact of increased acreage of pulses and soybeans on global warming potential. Results show that the average impact on total nutrient surplus per ha is also about zero. In the case of the nitrate balance, this is because the increased input of N through biological nitrogen fixation cancels out the decreased input of N from chemical fertiliser.

Farm incomes increase because of slightly higher prices for agricultural products other than pulses and soybeans and lower input costs – because of lower use of purchased mineral fertiliser. Moreover, the share of the EU premium budget not spent also decreases. However, the impact at regional level varies, with increases in some regions and decreases in others (Map 5).



Map 5. Farm income per NUTS2 region. Percentage change in legume premium scenario compared to reference

For the scenario with legumes included in the Ecological Focus Areas (EFA), we suppose that, in view of the environmental benefits of legumes, farmers can opt for growing legumes (pulses or soybean) as one of the ways to fulfil EFA requirements. Other ways are to leave the land under semi-natural vegetation (i.e. fallow) or to use it for landscape elements such as hedgerows or ponds.[3] In CAPRI, the EFA requirement is endogenously modelled, where the cost of non-compliance is included directly in the objective function, while compliance costs

[3] Such landscape elements cannot be modelled in CAPRI, as they are not included in the utilized agricultural area (UAA). The EFA regulation applies to farms with a total area (excluding permanent grassland) of more than 15 hectares (EU Memo/13/621 of 26 June 2013). In many cases, such farms will already have 7% of their total area under semi-natural vegetation, but we do not have the data to specify this. The model therefore assumes that a farmer who does not already have 7% of his land under fallow or set-aside must take the necessary measures – or, to be precise, a NUTS2 region must take such measures.

are included as a shadow price on the EFA requirement (Britz and Witzke, 2012; 127-129). Results show that the requirement is fulfilled in almost all regions.[4]

Table 2. Land use in 2020 in reference scenario and changes in EFA scenario as difference with reference

	EU27		15 old member states (pre-2004)		12 new member states (2004-07)	
	Reference scenario	*EFA scenario*	*Reference scenario*	*EFA scenario*	*Reference scenario*	*EFA scenario*
	'000 hectares					
Utilized agricultural area	182,345	36	128,196	37	54,149	0
Arable land	124,182	1,033	83,863	829	40,319	204
Pasture	58,163	-997	44,333	-793	13,829	-204
Set-aside, obligatory idling	2,786	2,239	2,786	1,868	10	371
Other fallow land	5,854	700	3,374	358	2,480	342
Pulses	1,022	35	836	26	186	9
Soya	516	17	194	12	322	4
Remaining arable crops (cereals, etc.)	114,004	-1,958	76,673	-1,435	37,322	-522

Source: CAPRI

Compared to the grain legume premium scenario discussed above, this scenario gives the regional farmer more freedom to produce and to adjust the cropping plan. The regional farmer could also choose to increase fallow land or set-aside in order to fulfil the requirement. This leads to a much smaller effect on the cultivation of legumes (Table 22): the area under legumes increases by only 3.4%. The increase in grain legumes is dampened by higher marginal costs and lower market prices. There is a far larger effect on set-aside land and fallow: these increase by almost 3 million hectares, partially at the expense of arable crops, and partially through a reduction in pasture land.

The increase in acreage of pulses is relatively large in, for instance, the Netherlands and Denmark. Here the marginal compliance cost, viewed as a premium on growing pulses, is relatively high. In the Netherlands the low initial share of fallow land also plays a part. Regions with a decrease in acreage of pulses can also be observed. This is explained by the decrease in prices of pulses and increased costs of land, which more than offset the implicit subsidy on pulses. This happens, for instance, in northwestern Spain. Concerning soybeans, the largest increase in acreage can be found in France and in Italy.

[4] This would probably not be the case if all individual farm types were included separately e.g. high-margin, specialised and intensive arable farms. However, CAPRI's regional approach (see Section 4) means that, since each region is treated as a farm, individual farm structure is not taken into account and the cropping plan is optimised at regional level, assuming interaction between individual farms. Hence, the arable farmer could, after a certain time period with structural change, also use marginal land of the grassland farmer to fulfil his own EFA requirement.

6. Discussion and conclusions

The expectation for the reference scenario is that the total area under grain legumes will decline further, as it has done for several decades. On the other hand, the decline will be modest and relatively smaller than the expected decline in arable land, so the proportion of legumes in arable land will actually increase slightly.

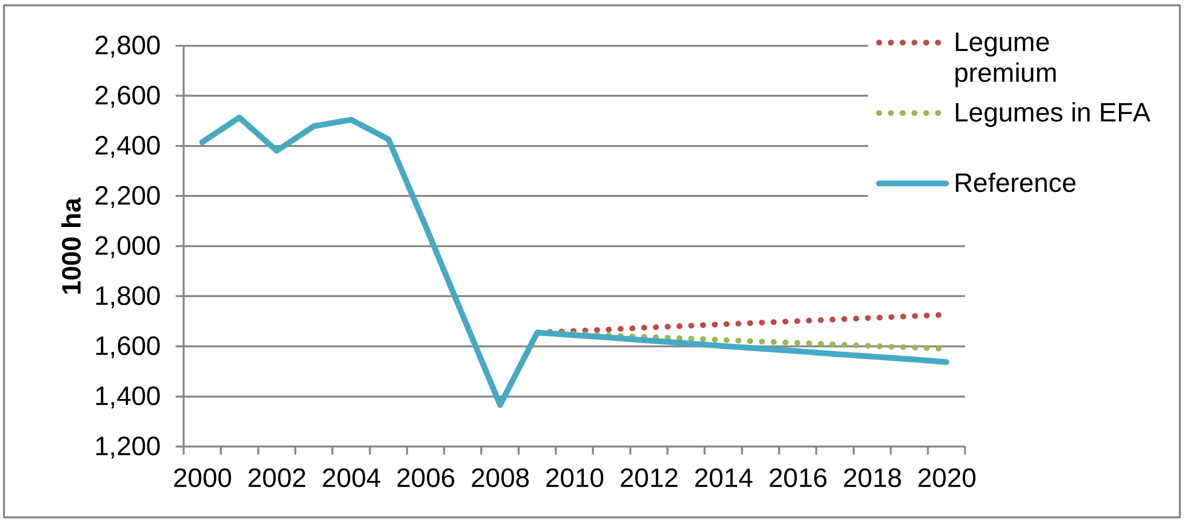


Figure 1. Area cultivated with grain legumes under different scenarios

The policy scenarios we examined all have only a small effect on the acreage of grain legumes in the medium term (Figure 1).The overall impact of the hectare premium (such as existed until recently in the CAP for peas, field beans and sweet lupins) is quite limited. There is a sizeable effect on the area of land under legumes, but it is achieved at a cost of several hundred euros per hectare, and even then it is not sufficient to achieve a level of legume cultivation comparable to what it was in the past (Bues et al., 2013; Helming, et al., 2014). This is perhaps different from the rather strong response of arable farmers to incentives and disincentives regarding legumes observed in the past. However, it should be kept in mind that part of the area-based legume premium is paid by the sector itself through a reduction of the direct farm payment.

The EFA policy produces significant results in some countries, which could be a reason for letting member states decide on how to implement EFAs. Results of this scenario might be underestimated with respect of the real impact on pulses. The choice of a farmer between switching to legumes or leaving land fallow is difficult to predict. On the one hand, legumes will never cover the full EFA requirement, since not all land is suitable for legumes or because the farmer is not willing to accept the extra costs and risks. On the other hand, the full farm heterogeneity is not included in CAPRI and the increase in fallow land seems rather high, so actual increase in legumes under an EFA scenario may be higher than our forecast.

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