Dynamic impacts of a financial reform of the CAP on regional land use, income and overall growth

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Abstract— **In this paper we investigate the impacts of abolishing the Common Agricultural Policy (CAP) for the post-2013 European Union (EU) financial perspective and the impacts of re-investing the released funds on research and development (R&D).**

We apply a linked system of models to analyze the impacts for the EU member states. The linked system consists of five land-use sector models (agriculture, forestry, urban area, tourism and transport infrastructure), which are connected to a macro-econometric model. Additionally, a land cover model is used to disaggregate land use countries to a 1 km² grid.

Three scenarios are analysed. In the *"baseline"* currently decided policies are assumed to be continued until 2025. In the *"tax rebate"* scenario agricultural support (first pillar) is removed, and the member states' contributions to EU lowered. In the *"R&D investments"* scenario agricultural support is also removed, and the released funds are used to increase general R&D efforts in the EU.

We find that in both liberalization scenarios, agricultural producer prices drop compared to the baseline. Agricultural production drops too, but less so in the *"R&D investment"* scenario due to productivity gains resulting from the increased R&D spending. In some countries, the productivity gains totally offset the negative impact of liberalisation on agricultural production. Smaller agricultural production implies less agricultural land use, and the more so in the *"R&D Investment"* scenario where productivity increases.

The fall in agricultural production and prices negatively affects economic activity and households' purchasing power, but the reduced direct taxation compensates this effect and results in a GDP gain of 0.53% and 0.8 million additional jobs. In *"R&D investment"* GDP gain reaches 2.57% and yields 2.95 million additional jobs in EU in 2025. The GDP, consumption and employment gains in the *"R&D Investment"* scenario widely exceed the losses in the agriculture sectors.

The analysis indicates that if no external effects of agriculture are considered, then the CAP is an inefficient use of tax money, and that a considerable contribution to reaching the goals of the Lisbon agenda would be achieved if the same amount of money was instead invested in R&D.

Keywords— **CAP reform, economical growth, land use**

I. INTRODUCTION

In 2005 there was considerable debate in the European Council of Ministers on the long-term EU budget (known as the financial perspective) for the period 2006-2013. There was considerable pressure from several member states to further reduce or even abolish the Common Agriculture Policy (CAP), while there was a British proposal to spend the funds that would be released towards achievement of the Lisbon Agenda—i.e. by spending them on research & development (R&D). These proposals were unsuccessful, but in 2012 a new financial perspective will have to be decided upon, and three major issues are foreseen to be:

- The direct, decoupled income support of the CAP is difficult to justify vis-à-vis taxpayers and consumers, and furthermore achieves its objectives poorly [3];
- The trade-distorting effects of the CAP are an obstacle to the trade liberalization desired by the EU;
- The slow progress of the Lisbon Agenda (cf. [10], p. 23-26).

In this paper, we specify and investigate a policy reform that jointly addresses those issues. The policy change consists of (*i*) complete removal of the direct income support in CAP Pillar I, (*ii*) a radical trade liberalization that all but removes agricultural border protection unilaterally for the EU versus all third countries, and (*iii*) transfer of the funds thus released in Pillar I either to general R&D or to general tax refunds. The scenarios are quantitatively analysed for the year 2025, and is evaluated against a baseline where currently decided policies are extended.

The hypothesis underlying the exercise is that the common budget currently used for (partially) decoupled income support in agriculture could contribute substantially to the goals of the Lisbon agenda. Furthermore, the agricultural sector will suffer a substantial income loss, but that loss is likely to be small compared to the economic growth induced by the increased R&D spending.

The analysis requires a detailed agricultural sector analysis of the direct effects of the reform, and a macroeconomic analysis of the effects of increased R&D spending. We may, however, expect bi-directional feedback effects: On the one hand, the expected changes in the agricultural sector may be sufficient to influence the rest of the economy. On the other hand, the changes in the rest of the economy invoked by the R&D spending will also affect agriculture. In order to take such feedbacks into account, a system of linked models is used, in which a joint equilibrium is sought for several sector models, a macroeconomic model, and a land use model.

II. METHOD

A. Models

A linked system of models was designed to analyze the effects of financial reforms on the EU member states (except Bulgaria and Cyprus) at national and local level. The modelling system has been described in detail in [9] and is here shortly summarised. The linked system consists of five sector models: agriculture (CAPRI), forestry (EFISCEN), urbanization (SICK), tourism (B&B) and transport & infrastructure (TIM). All five sector models are connected to the macro-econometric model NEMESIS. Additionally, the land cover model Dyna-CLUE is used to disaggregate land use within the countries to a 1 km² grid, which is useful for evaluating impacts on a disaggregated scale but also for communicating results between models of different spatial resolution.

NEMESIS is a recursive dynamic macro-econometric model built for all 27 EU member states (plus Norway, USA and Japan) and 32 production sectors [4]. Important features of NEMESIS are: i) its endogenous R&D decisions allow modification of the efficiency of all 32 production sectors that are in the model; and ii) its land use module establishes an agricultural land supply function and national land use balances. The land module also directly includes the three sector sub-models SICK, TIM, and B&B. With these sub-modules, NEMESIS calculates land claims by housing as well as commercial and industrial building, land claims for rail and road transport infrastructures and land claims by tourism respectively.

CAPRI offers a detailed representation of the European agricultural sector on regional scale [5]. The model consists of a supply module and a market module. Regional agricultural production is determined for about 250 regions and 50 agricultural products. This is done by maximizing gross value added of a representative regional farm subject to technological constraints and a behavioural quadratic cost term, given constraints set by land, policy, fertilization and feeding restrictions. Demand is modelled on member state level and for about 40 regions in rest of the world. Products of different geographical origin are distinguished on the demand side in a manner based on [1], with a two stage budgeting process similar to that in GTAP [8].

EFISCEN is a matrix transition model for European forests [12]. The matrices describe the state of the forest. Each matrix represents a certain forest type and contains age and volume classes over which the forest area is distributed. Transitions of area between classes represent natural processes and human actions. For a given demand for wood, EFISCEN checks whether the demand can be satisfied and projects forest resource development under that demand.

Dyna-CLUE projects land cover changes at 1 km^2 grid for 16 land cover types [17], [16], [13], driven by exogenous changes in national land use demand provided by NEMESIS. The NEMESIS land use categories (arable cultivation, grass production and urban areas) are associated to (aggregated) classes of the CORINE 2000 land cover inventory, which is used as the basis for projecting future land cover changes. Land cover allocation is based on location characteristics and conversion characteristics. Location characteristics capture the suitability for each land use for each location, based on biophysical and socio-economic factors [14], [15]. Land cover elasticities determine the resistance of a land cover type to change, and transition sequences determine the possibility of land cover conversions.

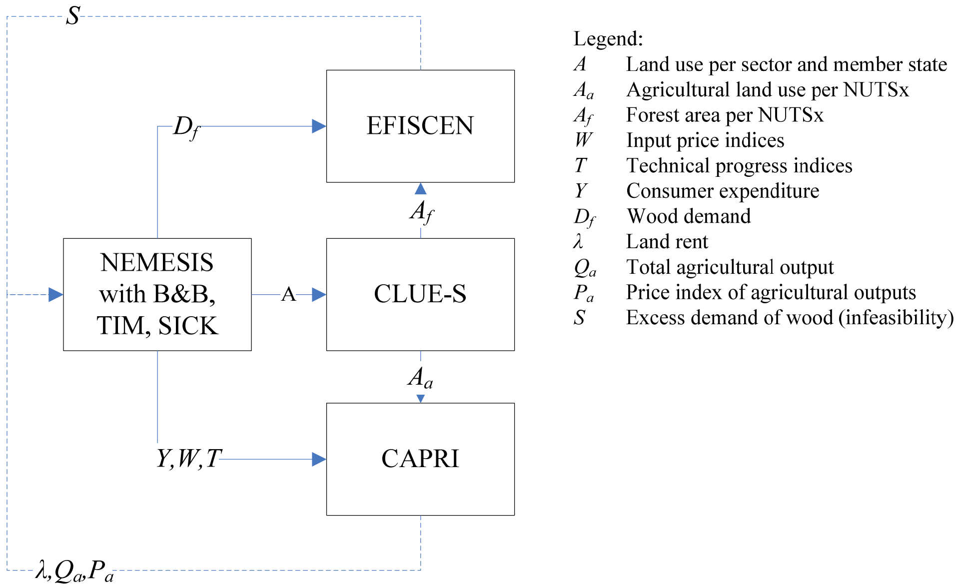


Figure 1: Flow of information in the linked up model system [9]

B. *Model linkages*

Mutual dependence between agriculture and the rest of the economy is expected. On the one hand, agricultural gross value added, land price and price index are outputs from CAPRI that enter NEMESIS as inputs; On the other hand, NEMESIS computes land use by all sectors, providing available land for CAPRI and EFISCEN, and also providing consumer expenditure, price indices and technical progress resulting from R&D spending (for CAPRI) and wood demand (for EFISCEN). Dyna-CLUE is used to disaggregate changes in the national land balances to the regional resolutions used by EFISCEN and CAPRI. A joint equilibrium is computed using an iterative recalibration approach explained in [9], similar to that in [6], [7] or internal in CAPRI [5]. Figure 1 illustrates the linkages and the process to find the joint equilibrium.

Two aspects of the linkages that are of high relevance for the outcomes of the analysis are (i) the shared land balance and (ii) the links for technical progress. The land balances work in a hierarchical manner, illustrated in figure 2, (c.f. [11], [9]). Relative to agriculture, the claims for urban, tourism and transport are superior (represented by grey bars) and the claim from forestry is inferior. The superior land claims are determined by NEMESIS at national level. The share of the remaining land (L) that is allocated to agriculture (x) is determined by the intersection of land supply (S) and demand curves (D) for agriculture, and determines the land constraint for CAPRI. The schedule D is iteratively adjusted to the outcome of CAPRI. Dyna-CLUE downscales the land use and adds stable areas. Land not used by agriculture ($L - x$) is covered by forest or other (semi-)natural cover that may become available for forestry. Based on wood demand by NEMESIS, EFISCEN projects the forest resource development on the forest area. Dyna-CLUE handles the necessary disaggregation of land claims from national level in NEMESIS to regions of CAPRI and EFISCEN.

The link for technical progress allows transfer of funds from CAP Pillar I to general R&D, and includes the feedback to CAPRI from R&D-induced factor productivity changes for several inputs computed in NEMESIS. In the baseline scenario, the total Pillar I spending is computed in CAPRI, and in any other scenario, the difference to that amount is computed and stored. That amount of money is communicated to NEMESIS, which may use it as an exogenous shift in its R&D module, computing factor productivity changes.

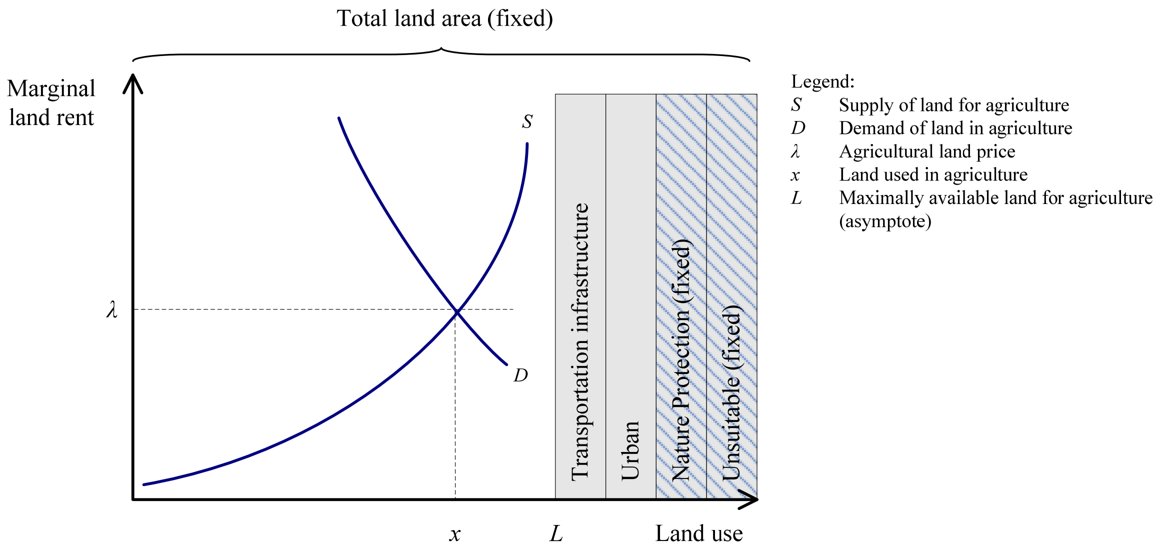


Figure 2: Land balance ([11], [9], Verburg, personal communication).

The changes in factor productivity affect all sectors via their input uses, and have therewith the potential of boosting the whole economy. Specifically for agriculture, the factor productivity indices are communicated to CAPRI, where they are used to shift the input needs of agriculture. The inputs for which productivity changes are modelled are listed in table 1.

Table 1: Mapping to CAPRI of technical progress indices computed in NEMESIS

Production factor in NEMESIS[a]	Mapped production factor in CAPRI
Fertilizers	N,P,K fertilizers (excess reduction)
Pesticides	Pesticides
Seeds	Seeds
Cattle fodder	Feeding in all animals (excess reduction)
Labour	Scale quadratic cost term
Energy	Scale quadratic cost term
Machinery	Maintenance cost for machinery
Buildings	Maintenance cost for buildings
Other equipment	Scale quadratic cost term
Remonte (young animals)	Scale quadratic cost term
Other intermediate consumption	Pharmaceutical inputs, electricity, energy for drying (for cereals), fuel, lubricants, other inputs, services

[a] Only factors of production for which technical progress is endogenously computed ant that are relevant for agriculture are considered here. Note that the greatest effects in absolute terms of increased R&D spending are found outside of agriculture.

C. Scenarios

One baseline scenario and two countervailing scenarios are analysed for the time horizon 2025. The parameter settings are shown in Table 2. In the table, “market support” denotes agricultural price support mechanisms. Continuation implies implementation of currently decided policies but no further reforms. Abolition means a radical liberalization, including: MFN bound tariff rates down by 90%, trigger prices and minimum border prices removed respectively lowered by 50%, consumption subsidies down by 90%, intervention and export subsidies abolished, sugar and dairy quotas lifted. Direct support includes the single farm and single area payment schemes and the remaining coupled payment of the first pillar except the ones under article 69 which are not modelled. The set-aside requirement for agricultural land is dropped if direct support is abolished.

Table 2: Model parameter settings in the scenarios

Model	Parameter	Scenario: Baseline	Scenario: Tax rebate	Scenario: R&D investment
NEMESIS	Use of freed CAP funds	(n.a.)	Lower taxes	Increase R&D
CAPRI	Direct support	yes	no	no
	Market support	yes	no	no
Dyna-CLUE	Agricultural set-aside	yes	no	no

In the *baseline* scenario, currently decided policies are assumed to be continued until 2025. In “*tax rebate*”, agricultural subsidies of the first pillar are removed, and the member state contributions to EU lowered. Furthermore, the border protection and market support for agricultural products is all but removed, unilaterally for the EU. In "*R&D investments*", the same agricultural policy reform is implemented, but here the released funds are not returned to the member states directly, but are instead used to increase the R&D efforts in each country proportional to the country's GDP. For all scenarios trends in exogenous variables such as demographic changes, labour participation and oil prices are extrapolated from the recent past, according to [10].

III. RESULTS

In the following presentation of results, expressions like "increases", "decreases" etc indicate a comparative static comparison, i.e. the difference of some scenario to the baseline in the year 2025. It is *not* to be confused with changes from the present up to 2025.

A. Agriculture

Following the 2003 Luxembourg agreement, most direct payments were (partially) decoupled from production. Apart from their capitalisation into shadow land rental price, the decoupled payments have little influence on production in the CAPRI model, a conclusion also confirmed by [3]. The removal of *direct payments* in the CAP financial reform thus affects land prices and agricultural income more than production and prices. In contrast, the unilateral removal of *market support* impacts importantly onto both European agriculture prices and production.

The impact of the financial reform on the agricultural producer price index is shown in figure 3 for EU-27 countries plus Norway. One can see that in the *"Tax Rebate"* scenario (TR), producer prices decrease by about 8% in EU27, with a minimum decrease of 3% in Norway (excluded from reform), and a maximum decrease of 21% in Luxembourg. The figures are quite similar in the *"R&D investment"* scenario (TR_R&D), with price decreases of 9% in average in EU27. The greater price decrease (10% greater drop in price) in the latter scenario is due to the larger agricultural production caused by the increased productivity resulting from the increased R&D expenditure.

The extent of price decreases in the *"Tax Rebate"* scenario depends on the magnitude of market supports cuts, trade relations of the EU and the composition of agricultural production. Animal products are generally protected more than crop products, and are consequently most strongly affected by a reform.

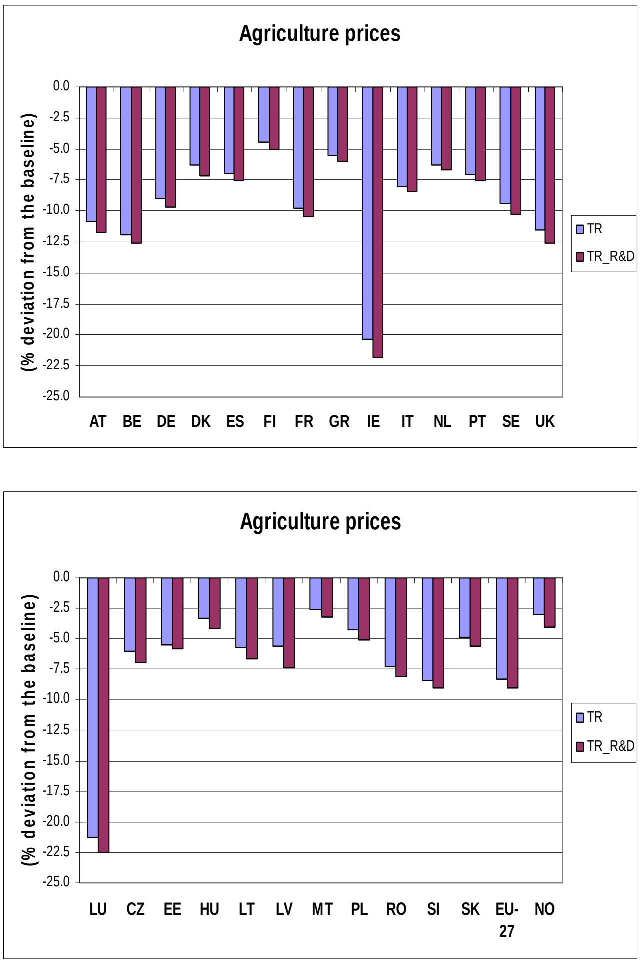


Figure 3a, b: Agriculture prices (% deviation from the baseline)

In general, the reform leads to decreased production. The drop in EU27 production is somewhat stronger in *"Tax rebate"* with 1.3% decrease and less pronounced in the *"R&D investment"* scenario, where it is 1.1%. The drop is smaller in the latter scenario because the productivity is higher as a consequence of the higher R&D spending.

The country or region specific impact of the financial reform on agricultural production depends of the production mix and of the level of support in the baseline. Some countries, like Denmark, are less affected by the reform, and some even take advantage of it, like the Netherlands where agriculture production rises 1.55% in the *"Tax rebate"* scenario. In the *"R&D investment"* scenario, the productivity gains resulting from increased R&D efforts permit the countries of Belgium, Denmark, Luxemburg and Malta to totally offset the negative impact of liberalisation onto agriculture production and lessen the negative impact in the other countries.

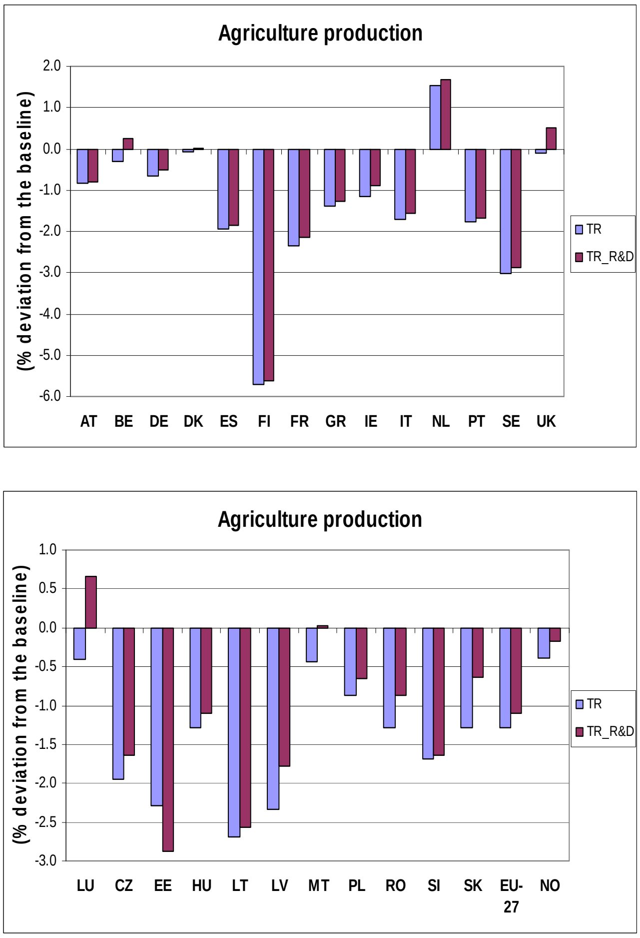


Figure 4a, b: Agricultural production, deviation from baseline

Changes in crop prices influence the production and prices of animal products via the high shares of crop products in feedstuffs (about 50 to 70%). Thus, removing the market support affects also less protected products like pork and poultry. When cereals prices drop, pork and poultry becomes more profitable, so that in countries with a considerable livestock production, like Malta, the income gains offset the losses in the cereal and other meat sectors. For this reason in the *"Tax rebate"* scenario, agricultural production falls only by 0.44% in Malta against 1.3% in EU27.

B. Economy

The agricultural policy reform in *'Tax Rebate'* and *'R&D Investment'* implies a release of about 40 billion euro (constant value 2000). In *Tax Rebate*, that amount is used to lower the member states' contributions to the EU by reducing direct taxation of firms and households in NEMESIS. The effect counteracts the direct negative impact of the reform on gross domestic product (GDP) caused by reduced agricultural output by increasing the disposable income of households and consequently final consumption. However, jobs destructions in agriculture are not fully compensated by new employments elsewhere in the economy.

In R&D Investment, the money saved from the CAP is invested in R&D, where it makes an important contribution to European Barcelona objective of investing 3% GDP in R&D (called R&D intensity) in Europe. The 40 extra billion euro raise R&D intensity from about 1.85% in 2007 to 2.25%. That policy significantly improves European employment and growth, (cf. [4]). As we have seen above, it also increases agricultural productivity, here captured by the link between CAPRI and NEMESIS.

On the macro economic side, CAP liberalization acts via two main mechanisms, that we here refer to as the *price effect* and the *revenue effect*.

Price effect: Firstly, one must consider the extent to which the fall in producer prices will be transmitted to consumer price. The share of food in households expenditures is about 14% in Europe. The share of meat represents alone is about 3% to 4% of consumer' expenditures and the prices of animal products decreases by about 15% in both counterfactual scenarios. For crops, prices decrease by approximately 3%.

Fluctuations in agricultural prices are not fully reflected in consumer prices [2]. The share of raw materials in production cost is declining with the degree of manufacturing of the produces, and labour, capital, energy and other variable cost constitute up to 80% of the price of the final product. Also, the margin behaviour of food industry will determine the repercussion in consumer price of the fall in the cost of agriculture raw materials. In the economic model NEMESIS, food industries apply a constant mark-up over unit production price in long term.

The net effect of the rather strong price drop in agricultural producer price and the changes in prices of products other than food following the reform, is a fall of the consumer price index in EU27. This proportionally increases households' disposable income, and as food consumption is price-inelastic, it increase expenditures on other products than food. Also, the fall in agricultural output and food prices affects other sectors as textile and catering.

Figure 5 shows the change in consumer price index in the individual countries. In *Tax Rebate* the changes range from a small increase of 0.3% in Denmark to 1.21% in Latvia. In *R&D Investment*, the prices generally decrease and by much larger amounts than in *Tax Rebate*. That effect is due to the increased supply resulting from the increased productivity. The particular effect in a country depends on the initial fall in agricultural prices, the share of food in households' expenditures, and the initial R&D spending. Yet another important factor influencing the consumer prices are the change in employment, which affects wages, which in turn influence production prices in all sectors (Phillips effect).

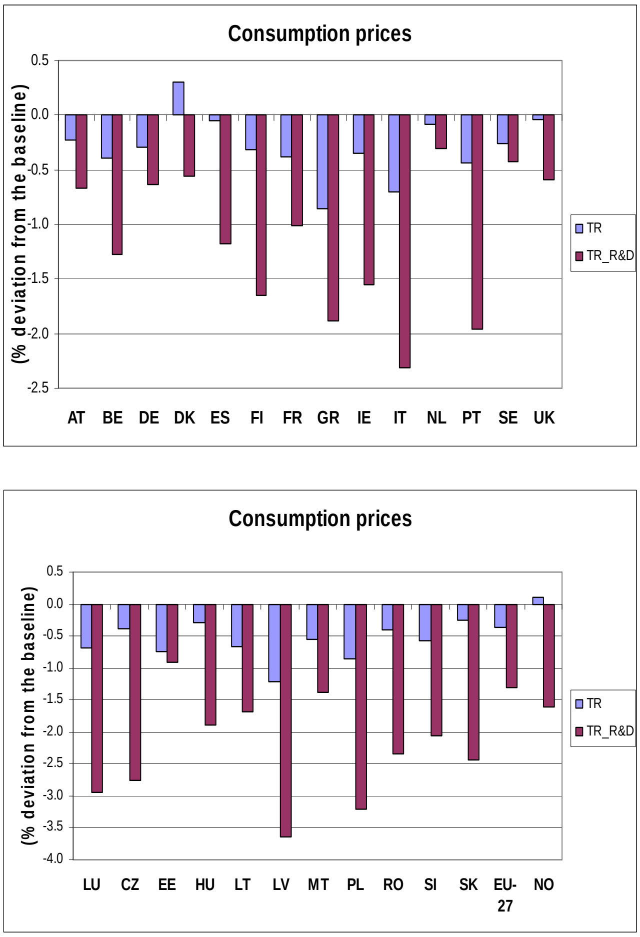


Figure 5a, b: Consumer price index, deviation from baseline

Revenue effect: The other important channel through which the CAP financial reform influences the rest of the economy is the revenue effects of the policy. The total revenues generated by agriculture generally falls, because direct supports and prices fall, in turn reducing production, employment and farm revenues. This influences economic activity negatively and reduces households' purchasing power. On the other hand, the 40 billions cut in CAP subsidies induces an equivalent direct taxation reduction that increases households' net disposable income.

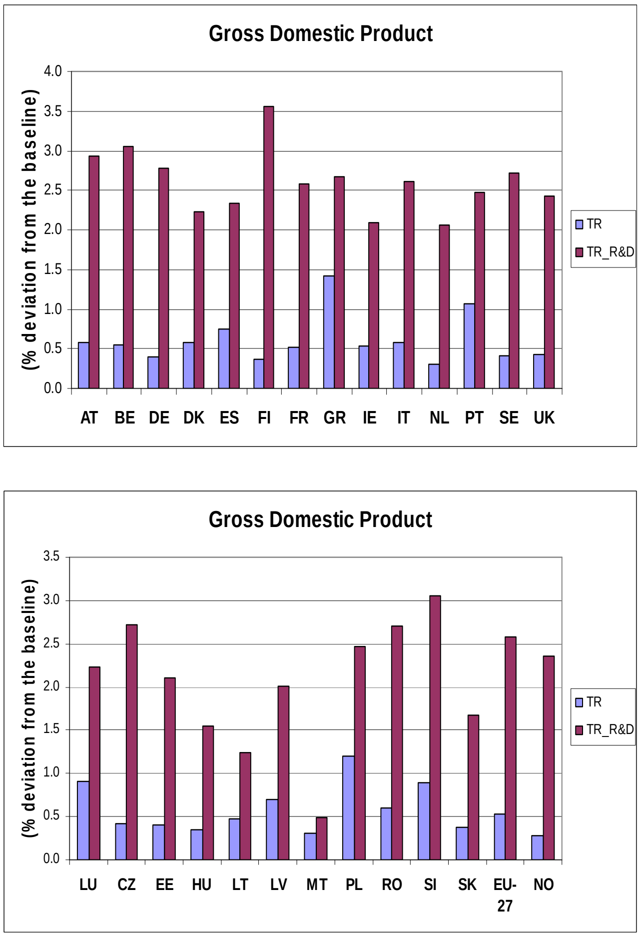


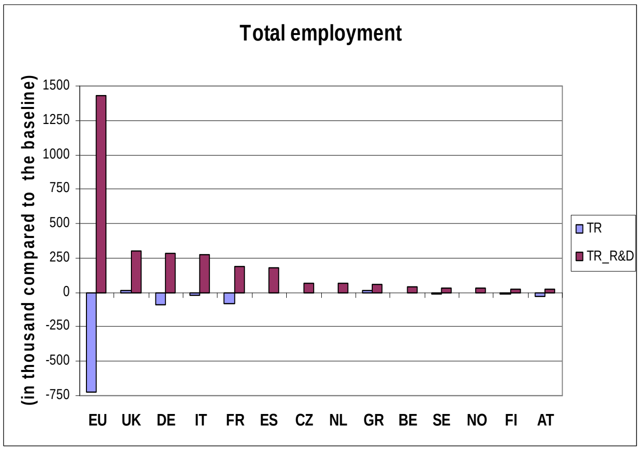
Figure 6a, b: GDP change, deviation from baseline

The net impact of the policy on economic activity depends on the combination of the price and revenue effects. Figure 6 displays the GDP changes in the *"Tax Rebate"* and *"R&D Expenditure"* scenarios. One can see that the CAP financial reform increases GDP by about 0.53% in Europe in 2025 in the *"Tax Rebate"* scenario, that is to say a little more than the funding saved from the CAP. Thus, measured by GDP, the CAP is not an efficient use of tax money, and by reallocating the CAP budget to the rest of the economy economic activity in Europe is stimulated. The largest GDP increase, 1.21%, is found in Poland, and the lowest in the Netherlands (0.30%).

Recycling the money saved from the CAP subsidies to R&D, strongly impacts on economic activity and increases GDP across Europe. The GDP gain reaches 2.57% for the whole EU27, with a maximum of 3.56% in Finland, and a minimum of 0.49% in Malta where R&D activities are very limited. In this scenario, the gains in employment, displayed in figure 7, are also very significant, with 1.4 million additional jobs in

Europe in 2025, against a loss of 0.7 million jobs when the money saved by the CAP is sent back to Member States and not reinvested in R&D.

The important increases in GDP, consumption and employment in the "R&D Investment" scenario widely exceed the losses in the agriculture sector where about 1.8 million jobs are lost in both scenarios. The reduction of farmers revenue of 58 billion euro in 2025 in the two scenarios is should be compared with the increase in GDP of about 56 and 266 billions respectively in the *"Tax Rebate"* and *"R&D Investment"* scenarios.



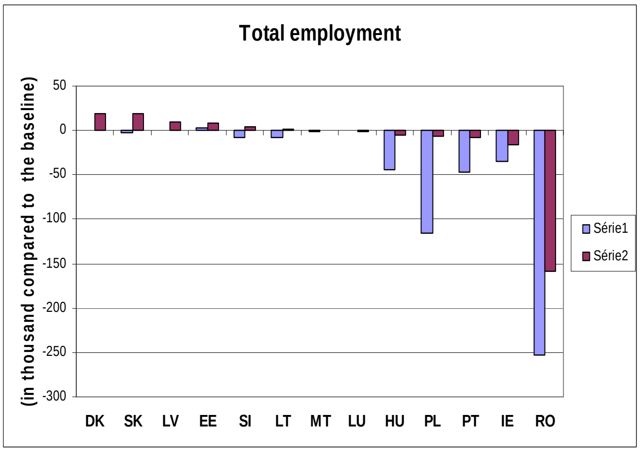


Figure 7a, b: Total employment change compared to baseline

C. Land-Use

The direct impact of the reforms on land use is a reduction of land use in agriculture. There is also second order impacts resulting from the changes in agricultural productivity, which generally reduces land input by increasing yields, and also from changes in land demand from the sectors Tourism, Urbanization and transport infrastructure.

In the baseline scenario, land cover changes show a small expansion of agricultural land in most European countries, particularly in countries producing high value products such as fruits, vegetables and flowers (e.g. Spain, the Netherlands) compared with the present situation. A reduction in agricultural area is foreseen in countries with a strong livestock sector, as shifts in feed composition result in a strong increase in productivity.

Abolishing the CAP leads to land abandonment compared to the baseline, due to decreased agricultural production. Land abandonment happens most in the more marginal, mountainous areas, but also in the Baltic States (Table 3). Globally, the CAP financial reform, by lowering European agriculture production, reduces the land used for agriculture by 2.6% in the Tax Rebate scenario and by 2.5% in the R&D Investment scenario. This small difference is caused by a lower total production in the Tax Rebate scenario, more than offsetting the higher productivity in the R&D Investment scenario.

Table 3 Land-Use Changes in 2025

	Tax Rebate Scenario			*R&D Investment Scenario*		
	Arable Land	*Grass land*	*Total Agr.*	*Arable Land*	*Grass land*	*Total Agr.*
AT	-3.2	-3.5	-3.4	-3.2	-3.4	-3.3
BE	-3.6	-3.8	-3.7	-3.5	-3.7	-3.6
CZ	-2.2	-2.4	-2.3	-2.2	-2.3	-2.2
DE	-3.1	-3.4	-3.2	-3.1	-3.3	-3.2
DK	-1.5	-1.5	-1.5	-1.4	-1.5	-1.4
EE	-9.5	-9.4	-9.5	-9.5	-9.3	-9.5
ES	-3.4	-3.7	-3.5	-3.4	-3.6	-3.5
FI	-3.1	-3.2	-3.2	-3.0	-3.0	-3.0
FR	-3.2	-3.4	-3.3	-3.1	-3.3	-3.1
GR	-4.1	-4.3	-4.2	-4.0	-4.2	-4.1
HU	-1.3	-1.3	-1.3	-1.2	-1.3	-1.3
IE	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
IT	-3.2	-3.4	-3.3	-3.2	-3.4	-3.2
LT	-4.4	-4.4	-4.4	-4.3	-4.3	-4.3
LU	-1.6	-1.7	-1.7	-1.6	-1.7	-1.7
LV	-4.4	-4.5	-4.4	-4.3	-4.3	-4.3
MT	0.0	0.0	0.0	0.0	0.0	0.0
NL	-1.8	-1.8	-1.8	-1.7	-1.8	-1.8
PL	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
PT	-4.3	-4.6	-4.5	-4.2	-4.5	-4.3
RO	0.0	-0.1	0.0	0.0	-0.1	0.0
SE	-3.6	-3.8	-3.7	-3.5	-3.6	-3.6
SI	-6.5	-7.0	-6.9	-6.4	-6.8	-6.7
SK	-2.2	-2.2	-2.2	-2.1	-2.2	-2.2
UK	-1.0	-1.1	-1.1	-1.0	-1.1	-1.0
EU	-2.6	-2.6	-2.6	-2.5	-2.5	-2.5

The response of agricultural land cover to the two counterfactual scenarios is quite diverse among countries. For example, in Estonia the land abandonment response to the CAP reform is very strong because — due to the high land availability — land abandonment does not lead to significantly lower land prices. With reference to figure 2, Estonia is positioned on the rather flat mid or left part of the land supply curve. The UK, on the other hand, is on the steep right part of the land supply curve, so that small land abandonment leads to a significantly reduced land price.

The distribution of the agricultural area decrease over arable land and grassland is quite equal. This can be explained by the fact that of the three area determining factors – total production, agricultural prices, and land rental prices – only the prices are affected by the reform.

While agricultural land use declines due to CAP reform, the forest area is showing a net increase of 1% in both the *"Tax rebate"* scenario and the *"R&D investment"* scenario in 2025 (figure 8). The net expansion of the forest area is mainly due to reduced deforestation rates, because agriculture requires less land with CAP reform. Land abandonment does not contribute much to the forest area expansion in 2025, but may become more important later in time.

Financial reforms generally result in an increase of wood removals across the EU, but the effects are rather small (figure 9; 0.2% in the *"Tax rebate"* scenario and 0.45% in the *"R&D investment" scenario"* for the EU). Increasing removals are due to an increasing demand for industrial roundwood and fuelwood for bio-energy production; the demand for fuelwood especially increases in the *"R&D investment"* scenario.

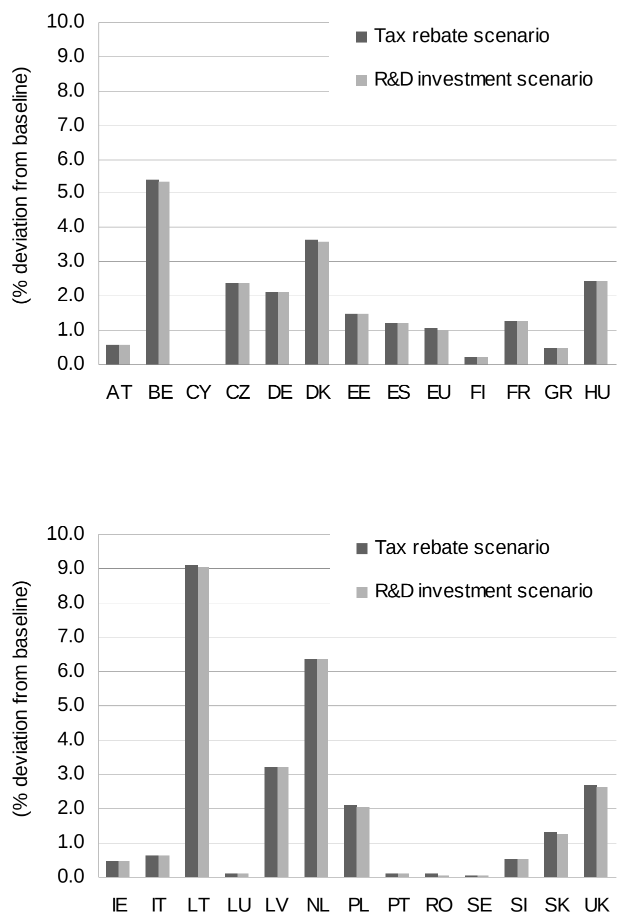


Figure 8a, b: Changes in forest area, deviation from baseline

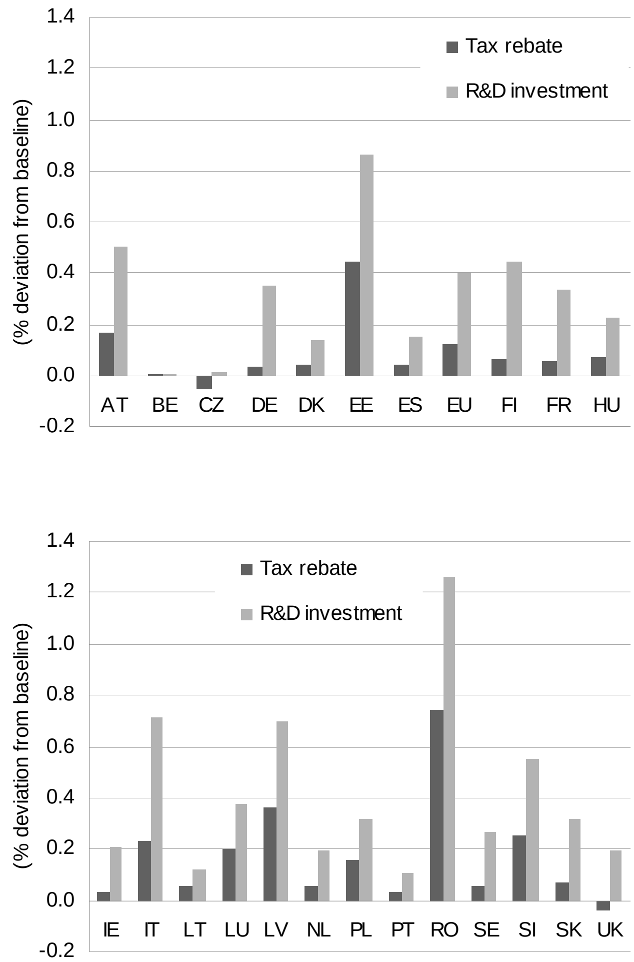


Figure 9a, b: Changes in roundwood removals, deviation from baseline

IV. CONCLUSIONS

The policy reforms considered here lead to increased GDP in the EU, and most certainly so if the same amount of tax money is instead invested in general R&D. The analysis thus confirms what general economic intuition suggests, namely that if no external effects of agriculture are considered, then the CAP is an inefficient use of tax money. Furthermore, increased spending on R&D is an efficient use of money. However, one must bear in mind that an efficiency analysis based solely on GDP is very partial, because it neglects any positive or negative external effects that may be associated with agriculture and other sectors — it is in fact the public good character of public research that makes public spending there efficient. Nevertheless, the GDP changes computed here can serve as an indication of the cost of the CAP, i.e. as a measure of how much the European Union pays for the sum of all such external effects.

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