Will improved access to capital dampen the need for more agricultural land? A CGE analysis of agricultural capital markets and world-wide biofuel policies

ABSTRACT

This paper analyses the consequences of enhanced biofuel production in regions and countries of the world that have announced plans to implement or expand on biofuel policies. The analysis considers biofuel policies implemented as binding blending targets for transportation fuels. The chosen quantitative modelling approach is two-fold: it combines the analysis of biofuel policies in a multi-sectoral economic model (MAGNET) with systematic variation of the functioning of capital and labour markets.

This paper adds to existing research by considering biofuel policies in the EU, the US and various other countries with considerable agricultural production and trade, such as Brazil, India and China. Moreover, the application multi-sectoral modelling system with different assumptions on the mobility of factor markets allows for the observation of changes in economic indicators under different conditions of how factor markets work.

Systematic variation of factor mobility indicates that the 'burden' of global biofuel policies is not equally distributed across different factors within agricultural production. Agricultural land, as the pre-dominant and sector-specific factor, is, regardless of different degrees of inter-sectoral or intra-sectoral factor mobility, the most important factor limiting the expansion of agricultural production. More capital and higher employment in agriculture will ease the pressure on additional land use – but only partly. To expand agricultural production at global scale requires both land and mobile factors adapted to increase total factor productivity in agriculture in the most efficient way.

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Will Improved Access to Capital Dampen the Need for More Agricultural Land?

A CGE analysis of agricultural capital markets and world-wide biofuel policies

M. Banse, A. Rothe, A. Tabeau, H. van Meijl and G. Woltjer[*]

1. Introduction

Since 2001, a rapid growth of biofuel production has been observed, driven by high crude oil prices, as well as by growing interest in reducing Greenhouse-Gas-Emissions (GHG). High oil prices encouraged innovations to reduce crude oil consumption and triggered governments all over the world to stimulate the production and consumption of biofuel. To assure a certain level of reduction of GHG emissions, mandatory targets, e.g., in terms of binding blending targets, have been established. These quantitative measures set targets for the share of renewable fuels (biofuel) in fuel consumption. Mandatory, but also voluntary, requirements are currently imposed for liquid biofuel in many major world economies except for Russia, Sorda et al. (2010).

The consequences of biofuel policies on agricultural markets and GHG emissions have been analyzed in numerous papers. The extensive overview of such studies can be found in Rajagopal and Zilberman (2007). As Rajagopal and Zilberman point out, most of these studies focus on simulating the impact of renewable fuel mandates either at national or at global level. The majority of these studies, however, analyze either the impact of the 2009 EU Directive on Renewable Energy (DRE) or the consequences of the 2007 US Energy Independence and Security Act (EISA) or both; e.g., OECD (2008), Al-Riffai et al. (2010), Banse et al. (2008), Hertel et al. (2010).

However, none of the studies simultaneously assess the global consequences of biofuel policies in those countries mentioned above. This is an important shortcoming because regions not covered by these analyses, but implementing biofuel targets, are often very important producers and exporters of agricultural commodities. The important question is: how will biofuel programs in these countries affect agricultural land use in these countries, their future exports in agricultural commodities and how will the world prices of these products respond? These papers also show significant direct and indirect land use changes as a consequence of rapid increase in biomass demand. In most papers impact on other important production factors such as agricultural labour and capital have been noted in the margins. This paper, therefore, addresses how an improved access to capital affects agricultural production and consequently helps to reduce the pressure on land use as a consequence of obligatory biofuel mandate implementation at global scale.

This paper explicitly examines the joint effect of obligatory biofuel mandates in the EU, the US, Canada, Brazil, the Rest of South America, India, and South-East Asia on land, food production, total GHG balance, trade and prices of agricultural commodities. We will also

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look at how these policies will influence biofuel production in regions where biofuel targets are voluntary, e.g., China, Japan, Australia and New Zealand.

1.1 Biofuel policies

The wide range of policy instruments is used to encourage and support biofuel production; FAO (2008), Rajagopal and Zilberman (2007), Sorda et al. (2010). Since biofuel production is not profitable in all countries, with the exception of Brazil, it has to be supported to become competitive. This is done by applying such policy instruments as subsidies and tax exemptions. Other forms of support include the policy measures influencing the biofuel supply chain directly or indirectly via subsidies for technological innovation, production factors subsidies, government purchases and investments in infrastructure for biofuel storage, transportation and use. Also, tariff barriers for biofuel are often implemented to protect domestic producers. These policy measures stimulate biofuel production but do not assure meeting a production level required to, e.g., meet certain GHG emission reduction targets. Therefore, many countries set targets - biofuel blending mandates - for the share of renewable fuels (biofuel) in fuel consumption.

The mandatory but also voluntary requirements are currently imposed for liquid biofuel in all major world economies except for Russia. In the EU, the US, Canada, Brazil, Argentina, Colombia, India, Thailand, Indonesia and the Philippines, the mandatory requirements for both ethanol and biodiesel are introduced. Paraguay and Ecuador employ an ethanol mandate and Uruguay and Thailand a biodiesel mandate. The targets are differently formulated in different countries. In the EU, the US, Canada, Brazil, Argentina, Colombia, India, Thailand, Indonesia and the Philippines, mandatory requirements for both ethanol and biodiesel have been introduced. Paraguay and Ecuador employ ethanol mandates and Uruguay and Thailand apply biodiesel mandates. In these countries the targets are set at different levels. In the EU, 10% biofuel in transport in 2020 are obligatory; by 2022 36 billion gallons of fuels from renewable energy must be used in US transportation, while Canadian mandates apply for 5% renewable content in gasoline by 2010 and 2% renewable content in diesel fuel and heating oil by 2012. In the remaining countries targets are mainly set for E10 and B5[1] in 2010 which are supposed to increase over time to E10+ and B20+, respectively. For instance, the Brazilian target for 2013 is E25 and in Indonesia the mandatory level of biofuel consumption is supposed to increase to E15 and B20 by 2025. Also China, Japan and Australia set non-binding targets for biofuel production.

1.2 Effects of biofuel mandates: literature overview

The consequences of biofuel policies on agricultural markets and GHG emissions have been analyzed in numerous papers. The extensive overview of such studies can be found in Rajagopal and Zilberman (2007). As Rajagopal and Zilberman point out, most of these studies focus on simulating the impact of renewable fuel mandate at a national or global level. The majority of these studies analyses the impact of the EU Directive on Renewable Energy (DRE) of 2009 or US Energy Independence and Security Act of 2007 (EISA). The first one implements a minimum binding target of 10% biofuel in transport by 2020. According to the second one, 36 billon gallons of renewables must be used in transport fuel by 2022. Below, we present the global results of biofuel mandates implementation presented in selected studies.

The OECD (2008) assessment of biofuel policies analyses the impact of DRE and EISA using the OECD/FAO AGLINK-COSIMO partial equilibrium model of domestic and international markets for major temperate-zone agricultural commodities. It assumes that next to the first,

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[1] E# describes the percentage of ethanol in the ethanol-gasoline mixture by volume, e.g., E10 stands for fuels with 90% gasoline and 10% ethanol. B# describes the percentage of biodiesel in the biodiesel-diesel mixture by volume; for example, B5 stands for diesel fuel with 95% ('fossil'-)diesel and 5% biodiesel.

also a second, generation of biofuel will be produced in the EU and in the US in the simulation period 2013 - 2017. Therefore, it specifies lower targets for the first generation of biofuel than in DRE and EISA. For instance, in the absence of second-generation biofuel, the EU 2020 biofuel share is reduced to 8%, of which 6.67% will to be reached by 2017. Under these assumptions, the OECD projects that DRE and EISA implementation will result in increase of total ethanol production by 17% and total biodiesel production by about 75% average in 2013-2017 compared with the baseline projection where biofuel policies are not considered. However, the first generation of biofuel will be responsible only for about 11% of ethanol and 50% increase of biodiesel production. The additional production of first-generation biofuels results in extra demand for feedstock commodities which pushes up prices for these commodities and creates additional demand for land. The most pronounced world price increases are projected for coarse grains (3%) and for vegetable oils (14%). Global crop area increase associated with the first generation of biofuel production is equal to about 3.6 million hectares (0.4% increase compared with the baseline) from which about 1.1 million hectares (0.12% increase compared with the baseline) results from DRE.

An IFPRI study, see Al-Riffai et al. (2010), commissioned by DG Trade of the EU-Commission applies a modified version of a global computable general equilibrium model MIRAGE. It assesses effect of DRE implementation and assumes binding target of 5.6% first generation biofuel used in transport in EU by 2020. According to the simulation results, the DRE causes a global increase of ethanol and biodiesel production by 7.6% and 5.1% compared to the reference scenario. Globally, the biofuel mandate leads to an increase in agricultural land use by 0.03% equivalent to 0.8 million hectares. The calculated emissions balance implied by the European mandate is positive and amounts 13 million tons CO_2 equivalent. Sensitivity analysis carried out under different mandatory blending (from 4.65 to 8.6%) shows that saving GHG emission effect is decreasing when the level of the mandate increases since higher blending target results in more pressure on land and consequently use of less efficient land in the agricultural production.

Both assessments presented above calculate quite small direct and indirect land use effects of EU and US biofuel mandates. In contrast, the study by Banse et al. (2008), Dehue and Hettinga (2008) report prepared for the Gallagher Review and the Netherlands Environmental Assessment Agency report by Eickhout et al. (2008a) provides much higher estimates of the agricultural land requirements of the EU mandate. Numbers for the respective studies are about 50, 20-30 and 19-31 million ha. At the same time, Banse et al (2008), using CGE model LEITAP, projects similar increase of the biofuel feedstock prices as OECD (2008). Also a study by Mulligan et al. (2010) shows that crop area changes for a marginal change in demand for particular biofuels produced by different models differ significantly.

Why are projections in land use changes so different in different studies? Edwards et al. (2010) analyzed reasons for these differences and point out that "The major factors causing dispersion of model results are: by-product effects, how much yields increase with price, and how much crop production is shifted to developing countries." The same factors seems to be the underlying causes of the differences in land use changes as an effect of biofuel mandate implementation in different studies. Another reason for these wide-spread results are differences in the assumptions of available land for agriculture. If one assumes a large amount of potential agricultural land, growing land demand for biofuel crops will neither lead to a significant increase in land price nor to a boost on food prices.

As already mentioned most studies mentioned above have a strong focus on land use change changes and do not consider the possibility to intensify the land use by increasing use of capital. Reducing the pressure on land use is one of the main challenges to guarantee the increase of agricultural production for an increasing demand for food, feed, fuel and fibre. Therefore, the analysis presented here shows how an improved access to capital affects agricultural production and consequently helps to reduce the pressure on land use as a consequence of obligatory biofuel mandate implementation at global scale.

2.   Quantitative Approach

This paper explicitly examines the joint effect of obligatory biofuel mandates in the EU, the US, Canada, Brazil, Rest of South America, India, and South-East Asia on land, food production, total GHG balance, trade and prices of agricultural commodities.

2.1   Database

The analysis is based on version 6 of the GTAP data, Dimaranan (2006). The GTAP database contains detailed bilateral trade, transport and protection data characterizing economic linkages among regions, linked together with individual country input-output databases which account for intersectoral linkages. All monetary values of the data are in $US millions and the base year for version 6 is 2001. This version of the database divides the world into 88 regions. The database distinguishes 57 sectors in each of the regions. That is, for each of the 88 regions there are input-output tables with 57 sectors that depict the backward and forward linkages amongst activities.

The initial data base was aggregated and adjusted to implement two new sectors – ethanol and biodiesel – representing biofuel policy in the model. These new sectors produce two products each; the main product and byproduct. The ethanol byproduct is Dried Distillers Grains with Solubles (DDGS) and biodiesel byproduct - oilseed meals (BDBP).

Finally, we distinguish 45 regions, 26 sectors and 28 products. The sectoral aggregation includes, among others, agricultural sectors that use land (e.g., rice, grains, wheat, oilseed, sugar, horticulture, other crops, cattle, pork and poultry, and milk), the petrol sector that demands fossil (crude oil, gas and coal), and bioenergy inputs (ethanol and biodiesel) and biofuel production byproducts. The regional aggregation includes all EU-15 countries (with Belgium and Luxembourg as one region) and all EU-12 countries individually except for the Baltic countries which aggregated to a single region, with Malta and Cyprus included in one region, and Bulgaria and Romania aggregated to a single region. Outside the EU the analysis covers all important countries and regions from an agricultural production and demand point of view.

The extensions with regard to the capital demand have been already outlined in Shutes et al. (2012). The specification of the capital market has been improved through the introduction of capital vintages, sector specific capital or allowing for different types of investment good. Here we implement a sensitivity analysis on the parameters which determine the capital market modelling in MAGNET for the substitution elasticities between capital and other factors as well as the parameters that govern the movement of capital between agricultural and non-agricultural markets.

2.2   MAGNET model

The economic model is the MAGNET (Modular Applied GeNeral Equilibrium Tool) model which is a multi-regional, multi-sectoral, static, applied general equilibrium model based on neo-classical microeconomic theory; see Woltjer and Kuiper (2013). It is an extended version of the standard GTAP model, Hertel (1997) and builds on the LEITAP model, see Nowicki et al. (2009 and van Meijl et al. (2006).

The core of GTAP and MAGNET models is an input–output model, which links industries in a value added chain from primary goods, over continuously higher stages of intermediate processing, to the final assembling of goods and services for consumption. Extensions incorporated in MAGNET model includes an improved treatment of agricultural sector (like various imperfectly substitutable types of land, the land use allocation structure, land supply function, substitution between various animal feed components), agricultural policy (like production quotas and different land related payments) and biofuel policy (capital-energy substitution, fossil fuel - biofuel substitution). On the consumption side, dynamic CDE expenditure function was implemented which allows for changes in income elasticities when purchasing power parity (PPP)-corrected real GDP per capita changes. In the area of factor

markets modelling, the segmentation and imperfect mobility between agriculture and non-agriculture labour and capital was introduced.

This paper mainly refers to options to modify a) the mobility of factors *within* one sector and b) *between* different sectors. The first option will affect the degrees of substitutability between different inputs in the sectoral production function while the second option will model how easy one factor, e.g. capital applied in agriculture can be transferred to sectors outside agriculture.

Due to the fact that the production technology builds on the assumption of a CES function the standard demand function (qf) for the input i in any sector j and region r can be described by the following equation:

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qf(i,j,r) = - af(i,j,r) + qo(j,r) - ao(j,r)
      - ESUBT(i,j,r) * [pf(i,j,r) - af(i,j,r) - ps(j,r) - ao(j,r)];
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The input demand is determined by the level of output qo(j,r), the output price ps(j,r) for commodity j and pf(i,j,r) as the price for input i. The parameters af(i,j,r) and ao(j,r) describe the input augmenting technical progress and the change in total sectoral productivity, respectively. The CES-elasticity is defined by ESUBT describing how a change in input price pf(i,j,r) affects the demand for different inputs limited by the substitutability between different inputs. Thus, the intra-sectoral factor mobility is mainly determined by the choice of the parameter ESUBT. For this paper show how a systematical variation of ESUBT will affect the composition of sectoral input demand between.

Intersectoral factor mobility refers to the speed in which factors move between sectors in response to changes in relative returns. Keeney and Hertel (2005) motivate the introduction of segmented factor markets by four observations: the role of off-farm factor mobility in farm incomes, co-movements in farm and non-farm wages, steady off-farm migration and persistent rural-urban wage differentials (Keeney and Hertel, 2005, p6-7). The model includes a variant with a CET function that Keeney and Hertel use and a variant where an econometrically estimated dynamic mobility equation of capital and labour between agricultural and non-agricultural markets is modelled. Capturing these features better represents agricultural factor markets in MAGNET and improves long-term projections by accounting for off-farm factor movements such as labour migration with a substitution of agricultural labour by new invested capital.

Two types of factor markets for mobile factors are implemented in MAGNET: un-segmented, segmented with mobility between the two sectors governed by a CET function. The un-segmented variant follows standard GTAP. The segmented market with CET function variant follows GTAP-AGR as presented by Keeney and Hertel (2005).

The separation of agricultural and non-agricultural markets leads to separate market clearing conditions and different factor prices in the two markets. The segmented factor markets module links to the rest of the model through input or endowment prices (pf) and the factor market clearing condition. The endowment price is defined as the market price for the factor endowment plus any taxes on factor use. As there are two markets for factors in the segmented market (agriculture and non-agriculture), the endowment price is defined as the agriculture market price plus taxes in the agricultural market and as the non-agriculture market price plus taxes for the non-agricultural market. The market price for each factor (pm) is therefore a weighted average of the agricultural market price (pmagr) and the non-agricultural market price (pmnagr).

The standard GTAP factor market clearing condition is replaced with two market clearing conditions in the segmented factor market module: one for agriculture and one for non-agriculture. The market supply of each factor is therefore equal to the demand for each factor across all industries *within* each market. The total supply of each factor is the sum of the supply of each factor in the agricultural and non-agricultural factor markets.

Although there are two distinct markets for mobile factors in the segmented factor markets module, capital can still move between the two markets. Indeed, extra capital needed in the non-agricultural sector must be pulled from the agricultural sector and vice versa. The movement of factors between agricultural and non-agricultural markets is determined by changes in relative prices and an elasticity of transformation (CET function). Figure 1 provides a graphical illustration of two different CET functions with a higher elasticity of transformation presented by CET^2 and a lower one for CET^1.

Figure 1. Segmentation of agricultural and non-agricultural capital markets

Under CET^1 the same shift in relative prices for capital in non-agricultural sectors and capital in agricultural sectors from pm'_{agr}/pm'_{nonagr} to pm''_{agr}/pm''_{nonagr} will lead to different responses in the transformation of non-agricultural capital into agricultural capital. With a higher elasticity of transformation, here represented by CET^2 demand for capital in agricultural will expand by $pf^2_{agr} - pf^0_{agr}$ while under a lower level of capital mobility (represented by a lower level of elasticity of transformation) the expansion of capital use in the agricultural sectors will be much smaller.

In the absence of available data on the underlying barriers to factor mobility, Keeney and Hertel (2005) introduce a CET function in GTAP-AGR to 'transform' agricultural capital into non-agricultural capital. This option in MAGNET follows the set up in GTAP-AGR as documented in Keeney and Hertel (2005). The transformation of factors between the two markets is governed by the elasticity of transformation. The transformation elasticity is set at -1 for all factors and regions in the first instance and modified under the systematical sensitivity analysis.

To model biofuel use in the fuel production, we adapt the nested CES function of the GTAP-E model, Burniaux and Truong (2002) and extended it for the petrol sector (Figure 2). To introduce the substitution possibility between crude oil, ethanol and biodiesel, we model different intermediate input nets in the petrol. The nested CES structure implies that biofuel

demand is determined by the relative prices of crude oil versus ethanol and biodiesel including taxes and subsidies.

Figure 2. The (bio-) petrol industry nested production structure
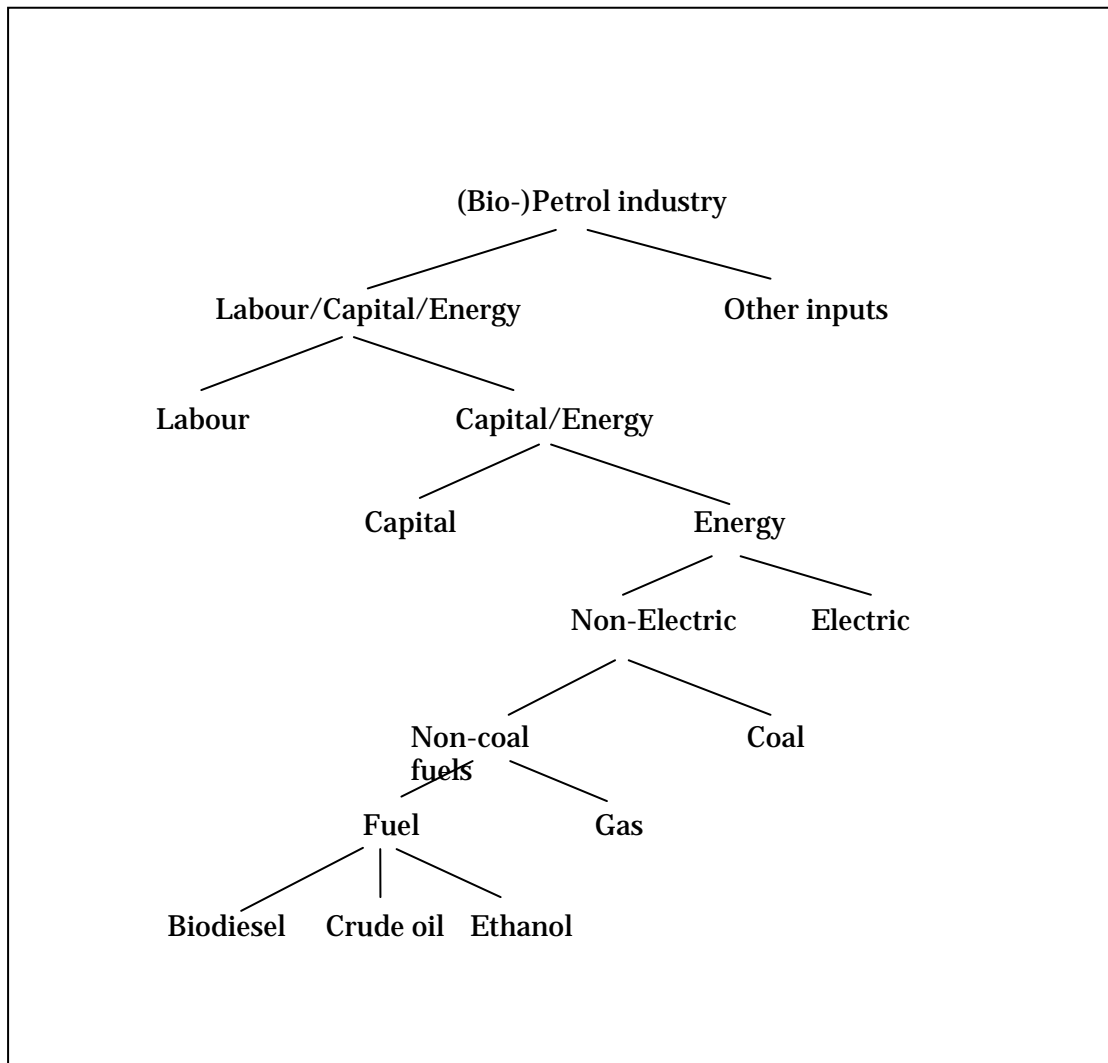
The feed byproducts of biofuel production (DDGS and BDBP) are demanded only by livestock sectors in MAGNET. This demand is generated through the substitution process in the feed nest in the livestock sector. In order to model substitution between different feed components and feed byproducts of biofuel production, we use two-level CES nest describing the substitution between different inputs in the animal feed mixture production (Figure 3). The top level describes the substitution possibility between concentrated feed and its components and grassland (i.e., roughage). The lower level intermediate describes the composition of different types of feed commodities (cereal, oilseeds, byproducts and other compound feed).

Figure 3. The animal feed nested structure
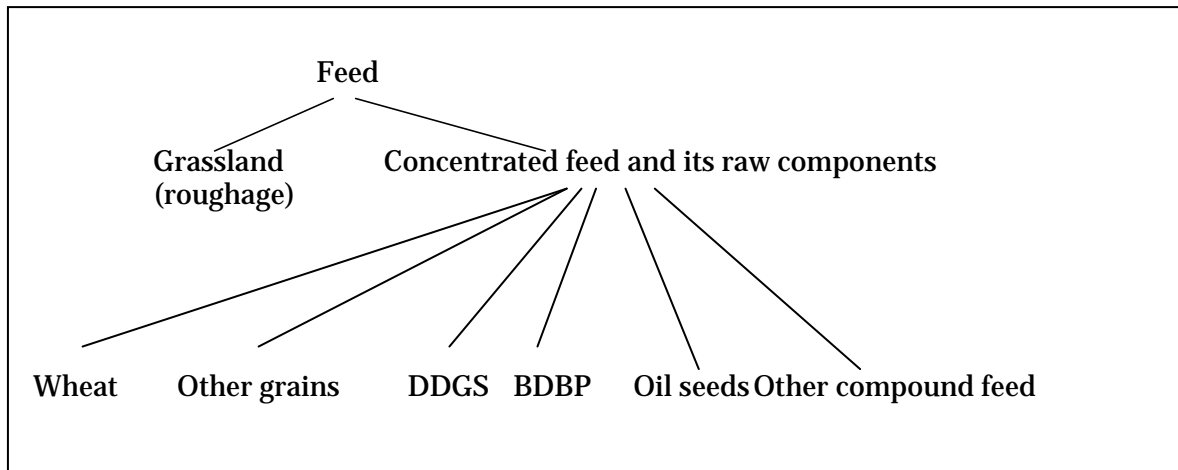
3. Scenario results

3.1 Scenario description

While the main focus on the analysis is on the option to reduce the land use changes under an improved access of agricultural sectors to the capital markets, the main driver in the paper is the introduction of binding biofuel mandates in different regions and countries. The scenario setting is built on a reference scenario (NoBFM) which assumes no mandatory use of biofuel consumption in any part of the world. In addition, we run a single biofuel-policy scenario experiment:

- Glob-BFM Scenario with mandatory biofuel mandate implemented for the EU and the US together with the following countries Canada, Brazil, Argentina, Colombia, Paraguay, Ecuador South Africa, India, Indonesia, Thailand, Philippines.

Based on this setting we use the Glob-BFM as the reference to see how a) an improved substitutability of agricultural land with capital and b) an improved access of agriculture to capital markets ease the pressure on global land use changes induced by world-wide biofuel policies.

3.2 Scenario setup

In the biofuel mandate scenario, we fixed the share of biofuels in fuel used in transportation in 2020. To achieve this policy target, a subsidy on bioenergy inputs in the petrol sector increases endogenously to make bioenergy inputs competitive with crude oil inputs. Since this policy instrument is assumed to be 'budget-neutral', these input subsidies are financed by an endogenous user tax on petrol consumption which generates the required funds for the biofuel input subsidies.

The following section will present the results for the reference scenario which does not assume any enforced mandatory blending target. Due to limited space, the impacts of biofuel policies are presented only at the aggregated regional and commodity level.

To show the impact of an improved mobility of capital within and across sectors we applied the following scenarios:

1. CES-CAP: a systematical variation of the **CES elasticity for capital** in the agricultural sectors by -75%, -50%, +50% and +100% relative to the initial level;

2. CET-ALL: a systematical variation of the **CET elasticity for capital and labour** between agricultural and non-agricultural sectors by -75%, -50%, +50% and +100% relative to the initial level and

3. CET-CAP: a systematical variation of the **CET elasticity for capital only** between agricultural and non-agricultural sectors by -75%, -50%, +50% and +100% relative to the initial levels.[2]

The variation of the CET elasticity for all factors (capital and labour) and for capital only should help to identify the impact of an improved inter-sectoral mobility of capital relative to an improved mobility of both capital and labour together. It should be mentioned that for the scenarios analyzing a systematical variation of the CES and CET elasticities each variant of the model have been run twice: one without binding biofuel targets and a second counter-factual with binding biofuel targets under the same level of CES and CET elasticities.

3.3 Scenario results

As already mentioned in Chapter 1, the main goal is to illustrate the impact of changing factor mobility. However, the next two figures show the impact of a world-wide implementation of biofuel policies on world agricultural prices and land use to give a first glance on the underlying 'scenery'.

Figure 4. Change in real world prices, in percent, 2020 relative to no binding biofuel mandates
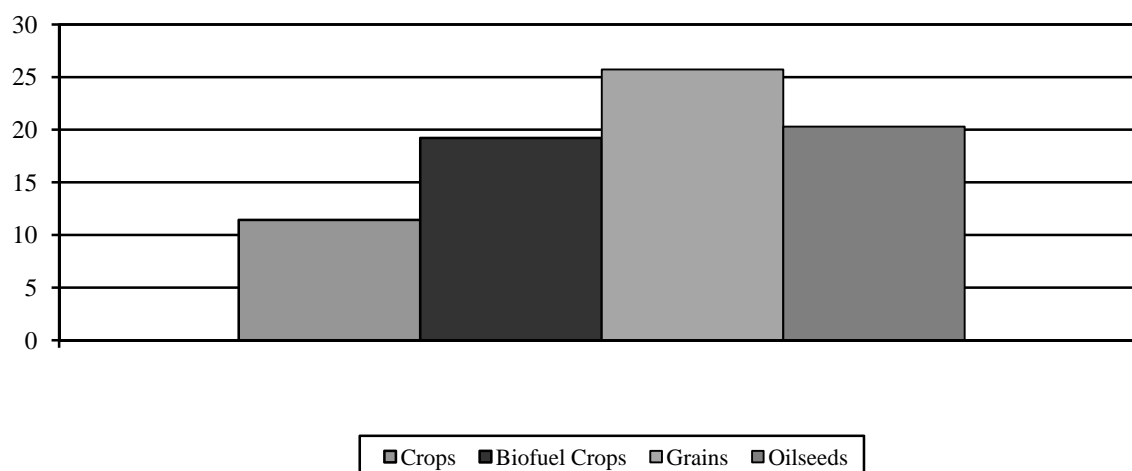
Source: Own calculations.

World prices of agricultural products tend to increase with enhanced biofuel consumption as a consequence of biofuel policies. This is especially the case for those products which are directly used as biofuel crops. Figure 4 presents the changes in real agricultural prices relative to a situation without (binding) biofuel policies. Under biofuel mandates international grain and oilseed prices increase by more than 25% relative to the no biofuel scenario.

At the aggregated level total agricultural production increases in the reference and the policy scenario. In all regions, mandatory blending also leads to a moderate increase in total primary agricultural output, Table 1. Compared with the situation without biofuel policies, the strongest relative increase in agricultural output takes place in the EU and the US itself (EU&US). Here biofuel crop production increases by almost 29% after implementing binding biofuel targets. But also the other regions (Rest-Mandat) where mandatory biofuel policies are implemented face an intensification of agricultural production.

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[2] The results for a variation in the CET elasticities for the capital market only are presented in tables A-1 − A-3 in the annex.

Looking at different biofuel crops, Table 1 presents the results for changes in oilseed production which strongly expands under the policy scenarios. Oilseed production in the EU&US region increases by almost 40% under binding biofuel mandates.

Table 1. Change in agricultural production, in %, 2020 relative to no binding biofuel mandates

|	World	All BioF Reg.	EU&US	Rest-Mandat	NoBioF-Reg.
Primary Agriculture	1.4	1.2	2.4	0.2	1.7
Biofuel Crops /1	17.1	18.7	28.6	13.1	13.8
Grains	33.6	37.0	36.9	38.1	27.5
Oilseeds	19.8	19.8	39.8	13.5	19.5

Remarks: All BioF Reg covers all regions listed above with the two subsets 'EU&US' and 'Rest-Mandat'. All other regions that do not apply binding biofuel policies are aggregated under the aggregate 'NoBioF-Reg.'.

/1: This aggregate summarizes total average production change of sugar beet/cane, cereals and oilseeds.

Source: Own calculations.

These production developments lead to a similar pattern of land use developments (Figure 5). Land use increases in all regions compared with no binding biofuel mandates. In the EU and the US, the slight decline in agricultural land use in the reference scenario almost reverses under the EU&US-BFM scenario. As already seen in previous figures, the main drivers in the expansion of agricultural production and land use are the biofuel policies in the EU and the US but also in other regions of the world. With mandatory biofuel policies implemented at global scale agricultural land use increases by around 4.5%.

Figure 5. Change in agricultural land use, in %, 2020 relative to no binding biofuel mandates
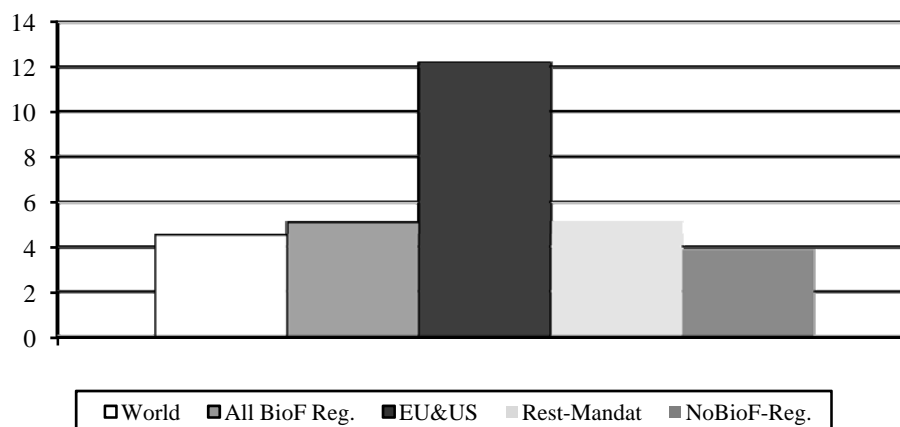
Remarks: For explanations of the regional aggregation see remarks for Table 1.
Source: Own calculations.

These results should illustrate the general tendencies after biofuel mandates have been implemented at global scale in different countries and regions. The following graphs show how the significant impact on agricultural markets in term of price changes, production and land uses might alter, if capital becomes more mobile at intra-sectoral, i.e. within the agricultural sector with a higher substitutability between capital and other factors and at inter-sectoral level, i.e. between the agricultural and the non-agricultural sectors with a higher (factor-) price responsiveness to changes in the ratio capital use within agricultural and the non-agricultural part of the economy.

Similar to the presentation of the general outcome of the implementation of biofuel polices we show the impact on the world agricultural prices.

*Figure 6. CES Elasticities: Change in real world agricultural prices, in %, 2020 relative to standard CES elasticity values under Glob-BFM Scenario*
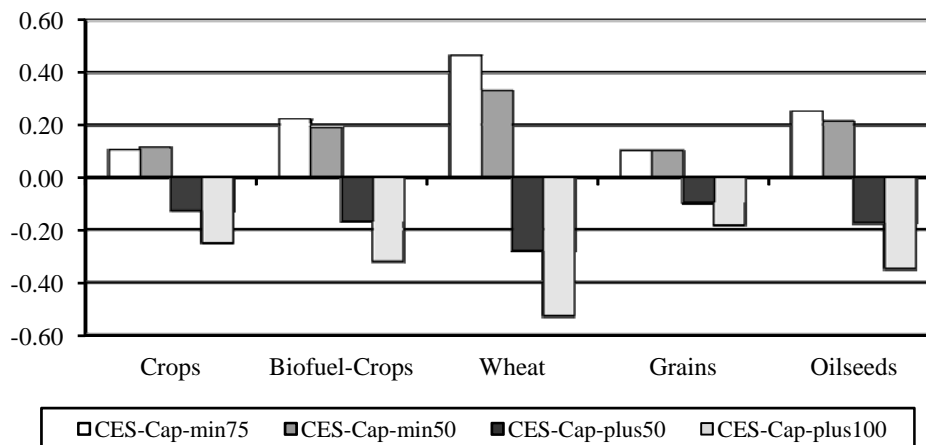
Source: Own calculations.

A variation of intra-sectoral mobility of capital, due to change in the CES elasticity of capital in the production function has only limited impact on world agricultural prices. With lower CES elasticities which imply a stickier and 'slower' change in the composition of factor use under changing factor prices, world prices of crops used for biofuel production are slightly higher. With higher CES elasticities wheat prices will around 0.5% lower compared with the standard elasticity setting in the Glob-BFM scenario (Figure 6).

Figure 7. CET Elasticities: Change in real world agricultural prices, in %, 2020 relative to standard CET elasticity values under Glob-BFM Scenario
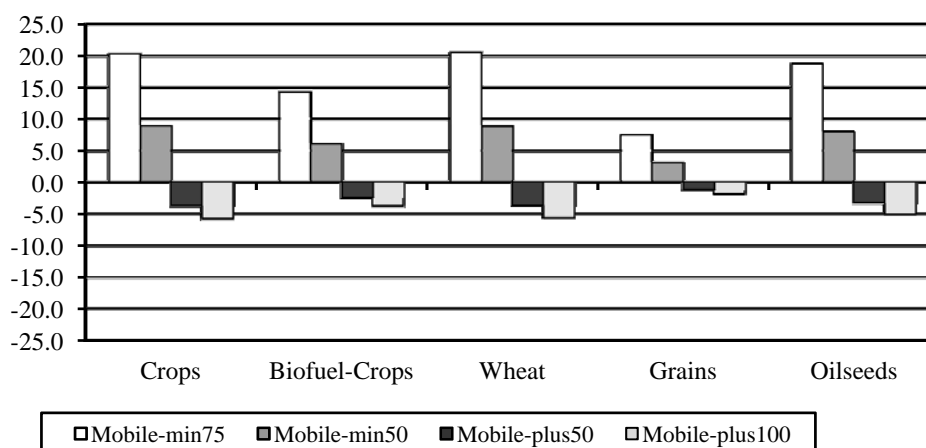
Source: Own calculations.

If we assume an increase in inter-sectoral mobility of factors between agricultural and non-agricultural sectors, the impact of world agricultural prices become more evident. With lower inter-sectoral factor mobility we see that for all arable crops used for biofuel production world prices are much higher compared with the standard CET elasticity values under the Glob-BFM scenario (Figure 7). Under CET elasticities which are 75% lower compared to the

standard assumptions world prices for wheat are more than 20% higher. Higher inter-sectoral factor mobility will dampen the increase on world prices and with CET elasticities twice as higher compared to the standard setting wheat prices will be more than 5% lower compared to the standard assumptions under the Glob-BFM scenario.

How do these results correspond to the changes in agricultural production? Under a lower inter-sectoral we observe a higher level of agricultural prices than under the standard assumption. The following Figure 8 shows the impact of a systematical variation in the CET elasticities on the level of agricultural production. The higher level of prices under the lower inter-sectoral mobility is mirrored by higher agricultural production level which is at first sight a little bit counter-intuitive. Lower-intersectoral mobility means lower use of labour and capital compared to the standard scenario outcome. This is, however, only a part of the full picture! In agriculture land is sector-specific and acts as the limiting factor to agricultural production. With higher prices land rents also increase and it become profitable to expand land use, see Figure 9. Under lower factor mobility agricultural production becomes more land-intensive and less labour/capital-intensive. Hence land use increases dramatically at global scale.

The asymmetric figure of price change, i.e. higher increases in prices/production under low factor mobility and relatively lower decreases in prices/production under higher factor mobility is due to the sector-specificity of land in agriculture where for most arable crop products land rents are the largest part in total value added and the mobile part of labour and capital gains only a relatively small share in total value added in arable crop production.

Figure 8. CET Elasticities: Change in world agricultural production, in %, 2020 relative to standard CET elasticity values under Glob-BFM Scenario
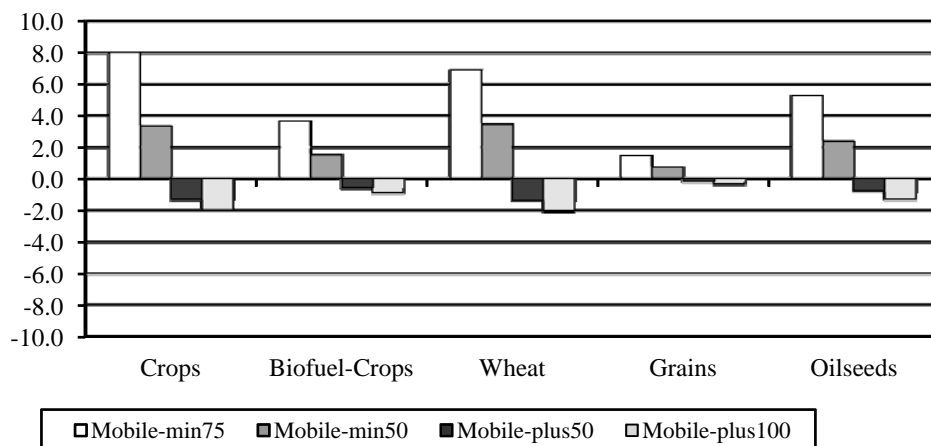

Source: Own calculations.

With lower inter-sectoral factor mobility agricultural land use expands as a consequence of biofuel mandates implemented a global scale by almost 290 mill. ha which is equivalent to 5.4% of global agricultural land use. Higher inter-sectoral factor mobility will ease the pressure on expanding agricultural land use and around 80 mill. ha will used less compared with the standard assumption of factor mobility. Here employment and capital use in agricultural increases. If the inter-sectoral factor mobility is altered for capital only, effects become much smaller, (see right hand side in Figure 9).

Figure 9. CET Elasticities: Change in agricultural land use, in mill ha, 2020 compared with standard CET elasticity values under Glob-BFM Scenario
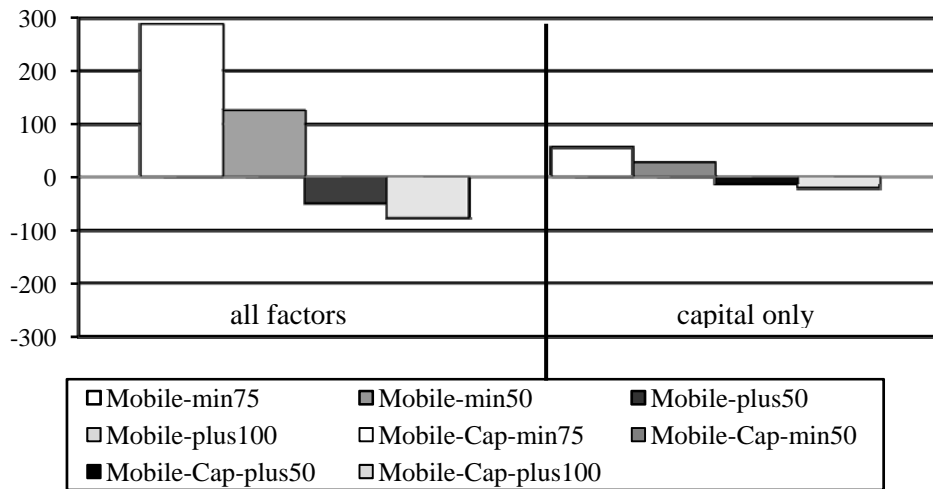
Source: Own calculations.

4.   Conclusions

This paper shows the consequences of different degree of factor mobility in agricultural production under the assumption of an enhanced biofuel production in those regions and countries of the world which have implemented biofuel policies in terms mandatory blending targets of transportation fuels. The chosen quantitative modeling approach is the multi-sectoral economic MAGNET model with a systematical variation of the inter-sectoral and intra-sectoral factor mobility.

The simulation results of the model show that biofuel policies have a pronounced impact on the markets for grains, oilseeds and sugar, but a rather limited impact on the production level of aggregated primary agricultural output. At the global level, the EU and US biofuel policies contribute to the increasing demand for biofuel crops. But other countries, such as Brazil, Canada, India, Thailand, Philippines and South Africa, that also introduced mandatory biofuel targets contribute to an even higher extent to increasing world prices for agricultural products driven by food use for fuel.

With increasing agricultural output total agricultural area is projected to increase by 5%, while production of biofuel crops increases by around 19% indicating a more intensive production of biofuel crops at the global level. Even the strong increase in crop production in countries implementing biofuel policies exceeds domestic supply, and the imports of these biofuel crops from other parts of the world which do not implement biofuel policies are projected to increase significantly.

The analysis shows that apart from direct effects of an enhanced demand for bioenergy on production and land use, the indirect effects of biofuel policies dominates. Additional production of biofuel crops within and outside countries with voluntary and mandatory biofuel policies leads to strong indirect land use changes and associated GHG emissions.

The systematical variation of factor mobility indicates that the 'burden' of global biofuel policies is not equally distributed across different factors within agricultural production. Agricultural land as the pre-dominant and sector-specific factor is regardless of different degree of inter-sectoral or intra-sectoral factor mobility the most important factor and limits the expansion of agricultural production. More capital and higher employment in agricultural will ease the pressure on additional land use – but only partly. To expand agricultural production at global scale requires both land and mobile factors adapted to increase total factor productivity in agriculture in the most efficient way.

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Annex

Table A-1. Change in real world agricultural prices, in %, 2020 for different assumptions on

	Crops	Biofuel-Crops	Wheat	Grains	Oilseeds
CES-Cap-min75	0.10	0.22	0.46	0.10	0.25
CES-Cap-min50	0.11	0.19	0.33	0.10	0.21
CES-Cap-plus50	-0.13	-0.17	-0.28	-0.10	-0.17
CES-Cap-plus100	-0.25	-0.32	-0.53	-0.18	-0.35
Mobile-min75	20.27	14.22	20.51	7.46	18.72
Mobile-min50	8.86	6.03	8.81	3.08	7.99
Mobile-plus50	-3.74	-2.46	-3.66	-1.20	-3.28
Mobile-plus100	-5.81	-3.78	-5.65	-1.83	-5.07
Mobile-Cap-min75	6.09	4.45	6.35	2.24	6.27
Mobile-Cap-min50	2.91	2.10	3.00	1.04	2.99
Mobile-Cap-plus50	-1.37	-0.99	-1.40	-0.48	-1.42
Mobile-Cap-plus100	-2.16	-1.55	-2.20	-0.75	-2.24

Source: Own calculation.

Table A-2. Change in real agricultural production, in %, 2020 for different assumptions on factor mobility, relative to standard elasticity values under Glob-BFM Scenario

	Crops	Biofuel-Crops	Wheat	Grains	Oilseeds
Mobile-min75	8.00	3.64	6.90	1.45	5.26
Mobile-min50	3.33	1.52	3.45	0.72	2.37
Mobile-plus50	-1.33	-0.61	-1.38	-0.18	-0.79
Mobile-plus100	-2.00	-0.91	-2.07	-0.36	-1.32
Mobile-Cap-min75	2.67	1.21	2.07	0.54	1.84
Mobile-Cap-min50	1.33	0.61	0.69	0.36	1.05
Mobile-Cap-plus50	0.00	-0.30	-0.69	0.00	-0.26
Mobile-Cap-plus100	-0.67	-0.30	-0.69	-0.18	-0.53

Source: Own calculation.

Table A-3. Change in agricultural land use, 2020 for different assumptions on factor mobility, relative to standard elasticity values under Glob-BFM Scenario

	in %	in mill. ha
CES-Cap-min75	0.217	11.6
CES-Cap-min50	0.147	7.9
CES-Cap-plus50	-0.114	-6.1
CES-Cap-plus100	-0.202	-10.8
Mobile-min75	5.368	288.0
Mobile-min50	2.335	125.3
Mobile-plus50	-0.937	-50.3
Mobile-plus100	-1.446	-77.6
Mobile-Cap-min75	1.047	56.2
Mobile-Cap-min50	0.507	27.2
Mobile-Cap-plus50	-0.240	-12.9
Mobile-Cap-plus100	-0.391	-21.0

Source: Own calculation.

Comparative Analysis of Factor Markets
for Agriculture across the Member States
245123-FP7-KBBE-2009-3

The Factor Markets project in a nutshell

Title	Comparative Analysis of Factor Markets for Agriculture across the Member States
Funding scheme	Collaborative Project (CP) / Small or medium scale focused research project
Coordinator	CEPS, Prof. Johan F.M. Swinnen
Duration	01/09/2010 – 31/08/2013 (36 months)
Short description	Well functioning factor markets are a crucial condition for the competitiveness and growth of agriculture and for rural development. At the same time, the functioning of the factor markets themselves are influenced by changes in agriculture and the rural economy, and in EU policies. Member state regulations and institutions affecting land, labour, and capital markets may cause important heterogeneity in the factor markets, which may have important effects on the functioning of the factor markets and on the interactions between factor markets and EU policies.
	The general objective of the FACTOR MARKETS project is to analyse the functioning of factor markets for agriculture in the EU-27, including the Candidate Countries. The FACTOR MARKETS project will compare the different markets, their institutional framework and their impact on agricultural development and structural change, as well as their impact on rural economies, for the Member States, Candidate Countries and the EU as a whole. The FACTOR MARKETS project will focus on capital, labour and land markets. The results of this study will contribute to a better understanding of the fundamental economic factors affecting EU agriculture, thus allowing better targeting of policies to improve the competitiveness of the sector.
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Website	www.factormarkets.eu
Partners	17 (13 countries)
EU funding	1,979,023 €
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