FACTOR MARKETS

Comparative Analysis of Factor Markets for Agriculture across the Member States

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Lindsay Shutes, Andrea Rothe and Martin Banse

Factor Markets in Applied Equilibrium Models

The current state and planned extensions towards an improved presentation of factor markets in agriculture

ABSTRACT

This paper describes how factor markets are presented in applied equilibrium models and how we plan to improve and to extend the presentation of factor markets in two specific models: MAGNET and ESIM. We do not argue that partial equilibrium models should become more 'general' in the sense of integrating all factor markets, but that the shift of agricultural income policies to decoupled payments linked to land in the EU necessitates the inclusion of land markets in policy-relevant modelling tools. To this end, this paper outlines options to integrate land markets in partial equilibrium models.

A special feature of general equilibrium models is the inclusion of fully integrated factor markets in the system of equations to describe the functionality of a single country or a group of countries. Thus, this paper focuses on the implementation and improved representation of agricultural factor markets (land, labour and capital) in computable general equilibrium (CGE) models. This paper outlines the presentation of factor markets with an overview of currently applied CGE models and describes selected options to improve and extend the current factor market modelling in the MAGNET model, which also uses the results and empirical findings of our partners in this FP project.

FACTOR MARKETS Working Papers present work being conducted within the FACTOR MARKETS research project, which analyses and compares the functioning of factor markets for agriculture in the member states, candidate countries and the EU as a whole, with a view to stimulating reactions from other experts in the field. See the back cover for more information on the project. Unless otherwise indicated, the views expressed are attributable only to the authors in a personal capacity and not to any institution with which they are associated.

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Factor Markets in Applied Equilibrium Models

The current state and planned extensions towards an improved presentation of factor markets in agriculture

Lindsay Shutes, Andrea Rothe and Martin Banse*

Factor Markets Working Paper No. 23/February 2012

1. Introduction

It must sound a bit strange for most modellers to integrate factor markets in partial equilibrium models and still keep them 'partial'. It is a special feature of general equilibrium models to have factors markets integrated in their systems of equations to describe the functionality of a single country or a group of countries. This working paper maintains a distinction between partial and general equilibrium models, even with factor markets integrated in partial equilibrium models.

2. Integrating factor markets in partial general equilibrium models

2.1 General concept

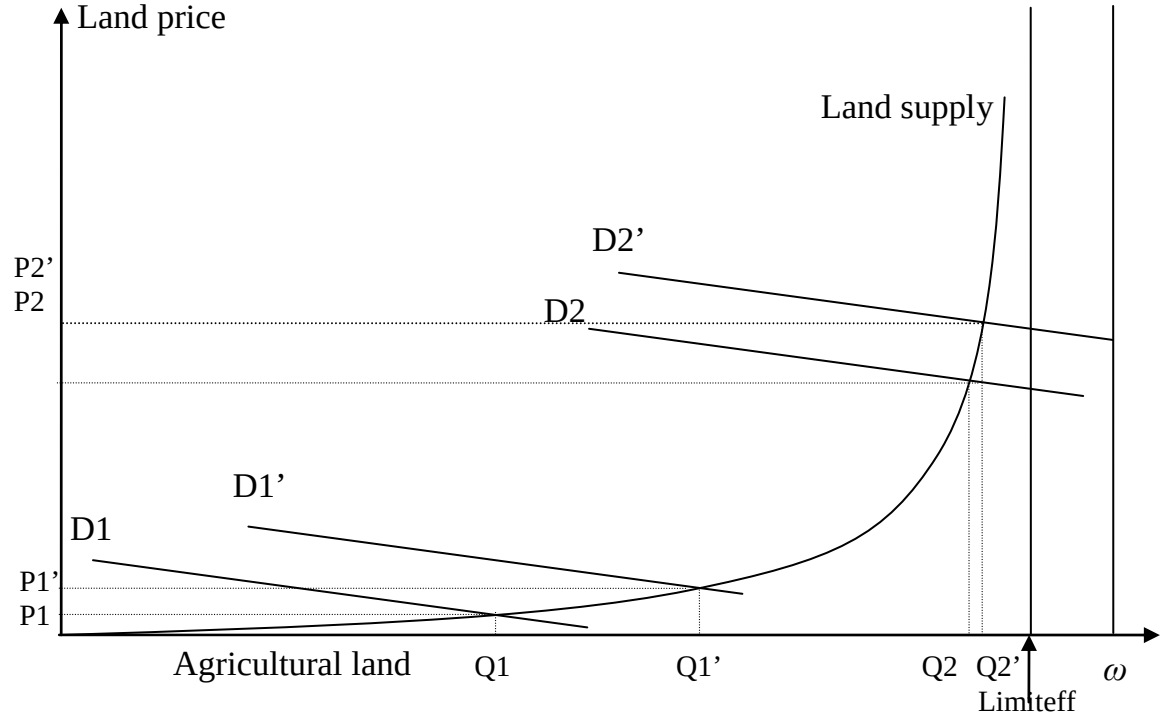
The shift of agricultural income policies to decoupled payments linked to land in the EU necessitates the inclusion of land markets into a policy relevant modelling tool. Many existing partial equilibrium models present crop supply as a function of yield and agricultural area, see CAPSIM, AGLINK, AgMEMOD and ESIM. In all of these models, area allocation is determined by own and cross commodity prices. However, the presentation of the land market itself is often modelled in a very simplistic way without modelling a 'real' land price which adjusts to guarantee market clearing on land markets. Only CAPSIM – as a partial equilibrium model – uses an endogenous land price while other partial equilibrium models use scaling techniques to ensure that total land demand does not exceed land supply.

In general equilibrium models such as MAGNET (an extended version of GTAP known formerly as LEITAP) or GOAL, land markets are endogenous to the model and rental prices for land adjust such that total available area is not exceeded nor undershot.

However, while land markets are usually endogenous to CGEs, they are not included in most partial equilibrium models. So far, this has also been true for ESIM and CAPRI. However, in the course of research for the underlying work a land market module has been included. It is largely based on an approach used by van Meijl et al. (2006), who modelled land supply in an extended GTAP version. Although this approach has been applied to a CGE model, it also fits in the general framework of ESIM when amended by technical and theoretical model specifications. The underlying approach and its implementation in ESIM is described below.

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Figure 1. Land supply curve determining land conversion and land prices



Source: Own composition, following van Meijl et al. (2006).

The basic idea of the land market module in ESIM relies on a land supply curve, which specifies the relation between land supply and the price for land in each region. Thereby, a distinction between rental and purchase prices is not relevant. Land supply to the agricultural sector can be influenced by urbanisation, which is a very common situation in EU member states, and by conversion of non-agricultural land into land that can be used for agricultural purposes (van Mejil et al., 2006). The latter case occurs in some of the NMS only (see below). In addition, also political measures, e.g. obligatory set-aside restrictions, have a direct influence on land supply. Figure 1 illustrates the land supply curve.

The design of the land supply curve is based on the idea that the most productive land is first taken into production. Additionally, the physical limit of taking additional land into agricultural production is considered.

If the difference between land, which is used for agricultural land, and the overall endowment of land resources, which could potentially be used by farming activities, is large, an increasing demand for agricultural land would lead to a conversion of non-agricultural land into agricultural land (van Meijl et al., 2006). Such a situation is depicted at the flat part of the land supply curve in

Figure 1. Here, an increase in demand for land by farmers, which could, for example, result from an increase in the overall price level for agricultural products, shifts the land demand function from D_1 to the D_1'. Though a significant amount of land is additionally taken into production, which is represented by the shift from Q_1 to Q_1', land prices increase only moderately from P_1 to P_1'. Thereby, the increase in land prices reflects the costs of bringing additional land into production. In contrast, if overall land endowments are scarce and there is not much room left to bring additional land into production, an increase in demand for agricultural land leads to significant increases in land prices, while the agricultural area is extended only slightly. Such a situation is depicted on the steeper part of the land supply curve. While land prices increase considerably from P_2 to P_2', agricultural land is extended from Q_2 to Q_2' only.

2.2 Model specification

The mathematical specification of the land supply function as well as the interactions between land supply and land demand are not identical to the specifications made by van Meijl et al. (2006). This can be traced back to fact that the model structure of the CGE model, which is the basis of the approach chosen by van Meijl et al. (2006), is different from the structure of a partial equilibrium model like ESIM. Accordingly, mathematical specifications regarding the inclusion of the land market in ESIM rely partly on own considerations, while the basic idea regarding the features of the land market function are taken from van Meijl et al. (2006).

In ESIM, the shape of the land supply (LS) curve is modelled according to the following equation:

$$LS_{cc} = Limiteff_{cc} - \alpha_{cc} / (\beta_{cc} + LP_{cc})$$

where

$Limiteff_{cc}$ is the effective total amount of land, which can potentially be used for agricultural production,

α_{cc} is a parameter determining the bend of the land supply curve,

β_{cc} is a parameter determining the bending of the land supply curve,

LP_{cc} is the land price.

Limiteff is endogenous to the model and is determined as follows:

$$Limiteff_{cc} = \omega_{cc} * \theta_{cc} - Oblset_{cc}$$

where

ω_{cc} is the total amount of land, which can potentially be used for agricultural production, which includes currently used agricultural land, fallow land plus obligatory set-aside area,

θ_{cc} is the rate, by which ω changes each year over the whole simulation period due to urbanisation or conversion of land into potentially usable agricultural area,

$Oblset_{cc}$ is the obligatory set-aside area, which depends on the grandes cultures area and the set-aside rate set out each year.

The following paragraph describes, which mathematical specifications, mechanisms, and equations ensure the equilibrium on the land market by the adjustment of land prices.

Assume again an increase in the overall price level for agricultural products. As mentioned above, this leads to an increase in overall demand for agricultural area given the area allocation function as specified in previous ESIM versions (Banse et al., 2005):

$$Area_{cc,cr} = \exp\begin{pmatrix} \ln areaint_{cc,cr,j} + \sum_j \left(\varepsilon_{cc,cr,j} * \ln PI_{cc,j}\right) + \lambda_{cc,cr} * \ln capc_{cc} \\ + \mu_{cc,cr} * \ln wag_{cc} + \varsigma_{cc,cr} * \ln med_{cc} \end{pmatrix}$$

where

$areaint_{cc,cr,j}$ is the area intercept,

$\varepsilon_{cc,cr,j}$ is the elasticity of area allocation with respect to prices,

$\lambda_{cc,cr}$ is the elasticity of area allocation with respect to capital costs,

$\mu_{cc,cr}$ is the elasticity of area allocation with respect to wages,

$\varsigma_{cc,cr}$ is the elasticity of area allocation with respect to costs of intermediates.

However, in order to ensure that total land demand does not exceed total land supply, and in order to meet the overall equilibrium condition on the land market, which requires that

$$LS_{cc} = \sum_{cr} Area_{cc,cr} \quad ,$$

the land price increases. This, in turn, compensates the stimulating effect of increasing product prices on area demand to some extent, since the land price has been introduced as one argument into the land allocation function, which is now re-specified as:

$$Area_{Cr,C} = \exp\begin{pmatrix} \ln area\,\mathrm{int}_{cc,cr,j} + \sum_j \left(\varepsilon_{cc,cr,j} * \ln\left(PP_{cc,j} + DP_{cc,j}\right)\right) + \lambda_{cc,cr} * \ln capc_{cc} \\ + \mu_{cc,cr} * \ln wag_{cc} + \eta_{cc,cr} * \ln med_{cc} + \sigma_{cc} * \ln LP_{cc} \end{pmatrix}$$

where

$\sigma_{,cc}$ is the area allocation elasticity with respect to the land price.

Due to limited data availability, it was not possible to estimate area allocation elasticities. Therefore and in contrast to all other input elasticities, the area allocation elasticity with respect to the land price is the same for all kinds of area uses. We applied a rather low elasticity value which reflects a rather 'sticky' behaviour for agricultural land markets. However, it should be mentioned that this assumption has consequences for the functioning of the land markets and needs further research. The approach of determining this elasticity, however, corresponds to the determination of the labour, capital, and intermediate elasticities. A description of the determination of these elasticities follows in Banse et al. (2008).[1]

In order to calibrate the parameters of the land supply function, β has been assumed to be proportional to the total land supply in each country. The parameter α has been calibrated in such a way that it reproduces the base data for land prices, total land supply, and effective total amount of land, which can potentially be used for agricultural production. Most land prices have been taken from European Commission (2007) and Latruffe & Le Mouel (2006), who provided a comprehensive overview of the land markets in various member states of the EU. Due to a lack in data availability, however, some land prices rely on own estimations. Table 1 shows the levels of land prices assumed for the analysis in this work. Though ESIM does not distinguish between rental and purchase prices it should be mentioned that these figures represent rental rates.

It is striking that for the time of the base period, i.e. prior to EU enlargement and implementation of the MTR reform, rental prices in the EU-12 are far below average prices in EU-15 members. However, in both groups of member states significant differences among countries exist. Romania and Bulgaria are expected to have the lowest land prices within the group of EU-12 member states. Land prices in Hungary, Poland, and the Czech Republic are three to four times higher.

As shown in Table 1, among the group of EU-15 members the highest prices for agricultural land exist in the Netherlands (€370) as well as in the Mediterranean countries (€300 to €355) except France (€123), where the prices are the lowest. The high level of rental prices in the latter countries might occur due to the existence of irrigation systems on a number of

[1] It should be mentioned that the approach of land modelling is similar for all member states. Possible market imperfections that might limit the functioning of land markets are only reflected in the parameters of the functional form.

agricultural areas, which have been installed by landowners and are provided for tenants. Another or additional explanation might be that the costs of irrigation are included in the rental prices. The reason for the high level of land prices in the Netherlands may be the large number of fruit and vegetable-producing farms as well as the overall scarcity of land.

Table 1. Land rental prices in EU member states in the base period (in €/ha)

Austria	200		**Latvia**	10
Belgium/Luxembourg	185		**Romania**[1]	10
Denmark	290		**Slovenia**[1]	25
Finland	150		**Lithuania**	12.5
France	123		**Bulgaria**[1]	10
Germany	200		**Poland**	40
Greece	455		**Hungary**	45
Ireland[1]	200		**Czech Republic**	30
Italy	377		**Slovakia**	25
Netherlands	370		**Estonia**[1]	12
Portugal[1]	300			
Spain	400			
Sweden	140			
United Kingdom	199			

[1] Authors' own estimations.

Source: European Commission (2007), Latruffe & Le Mouel (2006), Swinnen & Vranken (2008) and own estimation.

In case of the underlying modelling approach it is assumed that potentially available land, expressed by the asymptote *limiteff*, is the sum of the agricultural land currently used for production purposes and fallow land, which is neither obligatory nor voluntary set-aside land. The asymptote ω additionally includes obligatory set-aside area. Data for fallow land are obtained by Eurostat (2011) and FAO (2011). Table 2 illustrates the amount of total land demand, i.e. the amount of land that is actually used for agricultural production, and the amount of land that could potentially be used for agricultural production (*limiteff*). In addition, the rate, by which ω is assumed to change year by year, is shown.

The table illustrates that in all countries of the enlarged EU additional land reserves exist, which could be converted into agricultural land. In the EU-15, approximately 4.6 million ha, and in the NMS (EU-12), about 3.6 million ha, could additionally be taken into production. In both groups of countries unused land amounts to approximately 5.5% of the maximum available agricultural area. These figures indicate lower land reserves than published in van Meijl et al. (2006), who assume that more than 10% of the maximum available area is not used for production purposes. The calculation of the land reserve for this study is based on recently published data by EUROSTAT which explains this difference. Among individual countries, however, significant differences exist. With respect to EU-15 members, the highest shares of unused land reserves are observed in the Scandinavian countries of Sweden and Finland (9.4% and 6.0%, respectively). In the member states of high population density, i.e. most of all the Netherlands and Belgium/Luxembourg, unused land reserves amount to less than 5% of the maximum available area. According to recent time series obtained from Eurostat (2008), the total available area in most EU-15 members is assumed to remain constant over time or to decrease by up to 1.6% per year. An increase in total available agricultural area is assumed for Sweden and Finland only.

Table 2. Total land demand, potentially available land, and yearly change in area

	Total land demand (million ha)	Limiteff (million ha)	Gap in land demand /limiteff (% of limiteff)	Change in ω (in % p.a.)
Austria	3,140.8	3,253.5	3.6	-0.10
Belgium/ Luxembourg	1,406.0	1,469.4	4.5	0.00
Denmark	2,660.9	2,690.7	1.1	-0.20
Finland	2,077.0	2,202.1	6.0	0.30
France	2,6671.1	28,089.8	5.3	-0.40
Germany	16,390.4	1,7450.2	6.5	-0.50
Greece	1,956.5	2,063.8	5.5	0.00
Ireland	3,820.7	3,826.3	0.1	0.00
Italy	11,769.5	1,1967.7	1.7	0.00
Netherlands	1,735.1	1,759.2	1.4	0.00
Portugal	1,020.9	1,097.1	7.5	-1.60
Spain	16,621.2	17,318.4	4.2	-1.00
Sweden	2,784.5	3,045.5	9.4	0.30
United Kingdom	10,626.0	11,088.9	4.4	-0.10
EU-15	102,680.5	107,322.6	4.5	-0.37
Latvia	1,133.0	1147.5	1.3	-0.40
Romania	13,096.6	14,107.6	7.7	0.00
Slovenia	4,78.4	491.7	2.8	0.00
Lithuania	2,292.3	2,531.9	10.5	0.00
Bulgaria	4,398.9	4,946.3	12.4	-0.50
Poland	15,154.7	16,547.7	9.2	-0.50
Hungary	5,437.6	5,653.1	4.0	0.50
Czech Republic	4,113.8	4,191.0	1.9	0.20
Slovakia	2,212.9	2,283.1	3.2	0.00
Estonia	722.3	785.6	8.8	0.00
EU-12	49040.5	52685.7	7.4	-0.14

Source: Eurostat (2011), and FAO (2011).

The situation in the NMS corresponds closely to the situation in their Western partner countries. The share of unused land reserves in most countries lies between 1.3% in Latvia and 12.4% in Bulgaria. The average decrease in maximum available agricultural area is somewhat lower for total EU-12 on average than for the EU-15 on average (-0.14% compared to -0.37%). Within the group of EU-12, total area is assumed to decrease in Latvia, Bulgaria and Poland, while it increases in Hungary and the Czech Republic.

3. Implementation of factor markets in computable equilibrium models – A general overview

3.1 Introduction

In addition to the representation of factor markets in partial equilibrium models, the implementation of agricultural factor markets in computable equilibrium models (CGE) is also of interest. In the first part, a general description of factor market implementation in CGE models will be given. The current state of factor market modelling in GTAP and the MAGNET model is described in the next section. Thereafter an overview of the different ways in which factor markets are implemented in other existing CGE models is included.

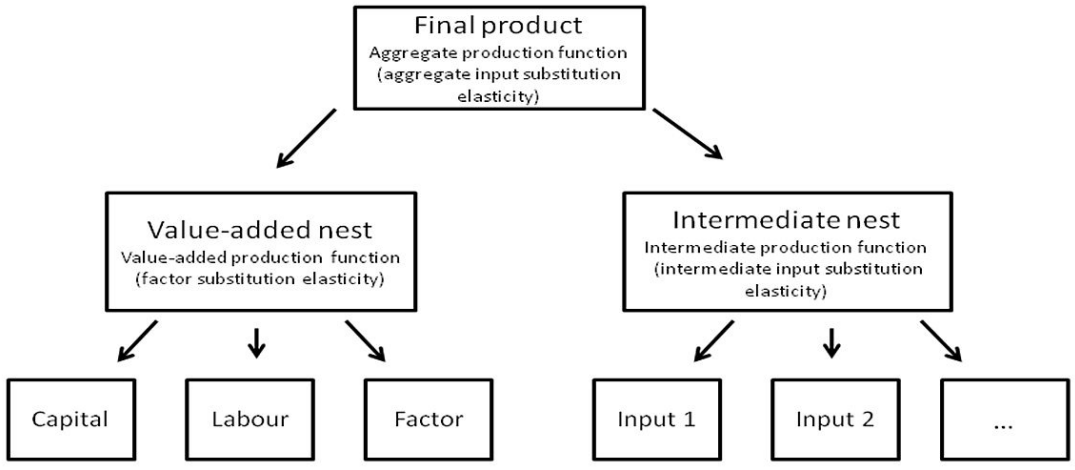
The production of goods and services in a market economy requires factors and inputs. The factors of production are labour, land and capital and other primary resources, which producers combine with other intermediate inputs to make goods and services. Each of these goods and services has a market price, which is determined by the interaction of supply and demand. Every market is assumed to clear at this set of prices. In a regional CGE model, production creates demand for value-added factors and goods and services used as intermediate inputs. The implementation of factor markets in CGEs with regard to demand and supply will be described in the following part.

3.2 Factor demand

The neoclassical theory represents the specification of production in national CGE models. Therefore factor demands depend upon output and relative prices.

Production activities use intermediate inputs and primary factor inputs such as land, capital and labour. Technology defines how these inputs are combined in the production process. The physical relationship is defined by nested production functions. Figure 2 shows a technology tree for a standard CGE model. There are two levels of the production process: in the lower level are the value-added nest and the intermediate input nest. The second level presents the combination of the value-added and intermediate nest for the final product.

Figure 2. Technology tree for nested production functions



Intermediate input demand

In standard CGE models, the use of intermediate inputs follows the Leontief fixed proportion production function. As the ratio of inputs does not change, the elasticity of intermediate input substitution elasticity is zero.

Value-added (factor) demand

Primary factors enter the production process in a manner allowing factor substitution. Factor demand is specified though a value-added production function, such as the Cobb-Douglas production function or constant-elasticity-of-substitution (CES), which describes the substitution of production factors in a sector. The assumption that the producer is a cost minimiser, leads him to choose the cost minimal factor ratio. In case of relative price changes, he will substitute the relative expensive factor for the cheaper factor.

The standard factors of production are labour, land and capital. However, in CGE models it is possible to disaggregate these factors, for example into skilled and unskilled labour, cropland and grassland and so on. A higher level of disaggregation enables the model to do more specific analyses of the effects of economic shocks.

Combination of factor and inputs

To produce the final good, the producer has to combine the intermediate inputs with the bundles of factors. The way of realization is described in an aggregated production function in which the two bundles can be substituted appropriate to the aggregate input elasticity. This final process is regarded as a Leontief fixed proportion technology, which represents the non-substitutability between intermediate and primary inputs.

3.3 Factor supply

This section describes the supply side and equilibrium conditions for the factor markets.

In CGE models, market behaviour for primary factors is analysed from both short-run and long-run perspectives. In the short run, capital is assumed to be fixed by sector while labour is assumed to be mobile between sectors and regions. In the long run, both capital and labour are mobile between sectors and regions. Total available land is assumed fixed in both the short and long run.

The standard assumption in a static CGE framework is a fixed supply of a nation's factor endowment. The effects of changes of the factor endowment of a nation can be analysed through economic shocks, for example an increase of labour supply because of migration or a decrease of capital because of investments in another nation. These shocks cause a change in the nation's productivity and also distributional effects. The increase of the factor supply can affect increases on its wage or rent.

The mobility of factors describes their ability to move to other sectors in a country or between countries, because of different wage rates or capital rents. Factors are **fully mobile** if they are assumed to switch among sectors until differences in wages and rents disappear. Full factor mobility can be regarded as a realistic view of capital and labour markets in the medium or long run, because transition costs become less important over a longer period of time. Factors can also be considered as **partially mobile**. In this case transition costs are so high, that differences in wages and rents only cause some workers or equipment to move to other employment. Under this assumption, factor movements are smaller than in the case of full factor mobility. Factor mobility can also be **sector-specific**, which means that in the short run, some factors are immobile. This assumption is often made in the case of capital, which is bound to existing machinery and equipment. The wage or rent of the sector-specific factor can differ across the sectors, but there will be no movement.

Alongside factor mobility, changes in factor productivity can also influence the supply of factors.

Factor productivity is defined as the level of output per unit of factor input. An increase of factor productivity means that the same input can create more output.

A change in the productivity of all factors in one industry by the same amount is called total factor productivity. The change of the productivity of one single factor influences the effective factor endowment. The effective factor endowment considers the quantity and the efficiency of the factor, which can influence the demand and price of this factor.

However, changes in the productivity of one factor can also affect the demand and prices of other factors in three ways:

1.) Higher productivity of one factor will cause a greater use of this factor because of lower effective wages or rents, causing a substitution away from other factors. Changes in productivity will be passed on the consumer. For instance, in the case of higher productivity, the production cost will fall and the price will be lower. That leads to higher demand and production. The demand for all factors will increase in the same proportion as the change in output with constant relative factor prices.

2.) If productivity of one factor increases, the demand for this factor will also increase, because of lower product prices and the higher demand for the product.

3.) Assuming a given output level, the change of the productivity of one factor affects the demand for this factor.

The net effect of productivity change on factor demand is a combination of substitution, output and productivity effects.

In addition, factor unemployment affects the factor supply. The common assumption in CGE models with regard to employment is full employment of all factors. However, this is not a realistic assumption and special factor market closures can be defined. The full employment model closure causes wages and rents to adapt until the fixed supply of the factors is fully employed. The unemployment closure fixes the wages or rents. Economic shocks, like for example higher labour supply because of immigration, also affect the factor supply. In this case the model will adjust until the factor supply and demand are equal at the fixed wages or rents. Unemployment assumptions can lead to changes in a nation's productive capacity and the real GDP.

4. The current state of factor market modelling in MAGNET

The Modular Applied GeNeral Equilibrium Tool (MAGNET, formerly LEITAP) is a global computable general equilibrium model that covers the whole world economy including factor markets. The model has been applied extensively to trade analyses, biofuel assessments and CAP analyses. This section outlines the current state of factor market modelling in MAGNET. Explicit reference is made to the modifications made to the model to better represent agricultural factor markets over and above the GTAP (Global Trade Analysis Project) model which forms the core of the model. The modelling of factor markets has been extended in MAGNET in five key ways; both by incorporating developments from other models such as GTAP-AGR, GTAP-E and GTAP-DYN and through unique innovations. The developments in the MAGNET model better capture the demand and supply of factors and the mobility of factors between sectors. The coverage of factor markets in the GTAP database is first addressed and then each factor market extension is discussed in detail, including the data requirements for the extension. Note that the modular nature of MAGNET allows the factor market in each region to be specified differently with features that pertain to that region.

4.1 Factor market coverage in the GTAP database

The GTAP database includes the use of five factors of production[2] by firms in the production process: land, capital, skilled labour, unskilled labour and natural resources. Payments for the use of factors in the production process is the only source of income to factors and the income is distributed to the private household as the owner and supplier of factors and to the government in the form of direct tax payments via the regional household . There are no flows to domestically owned factors used overseas or foreign-owned factors used domestically recorded in the standard database.

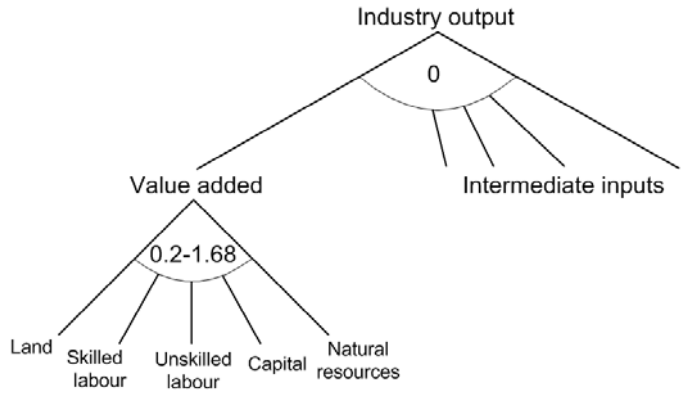
[2] Considered as non-tradable commodities and referred to as endowment commodities in the GTAP literature.

All firms use capital, skilled labour and unskilled labour; however, land is only used by agricultural sectors and natural resources are only used by the forestry, fishing, coal, oil, gas and other minerals sectors. Capital is the only factor that is subject to depreciation.

4.1.1 Flexible structure of factor demand

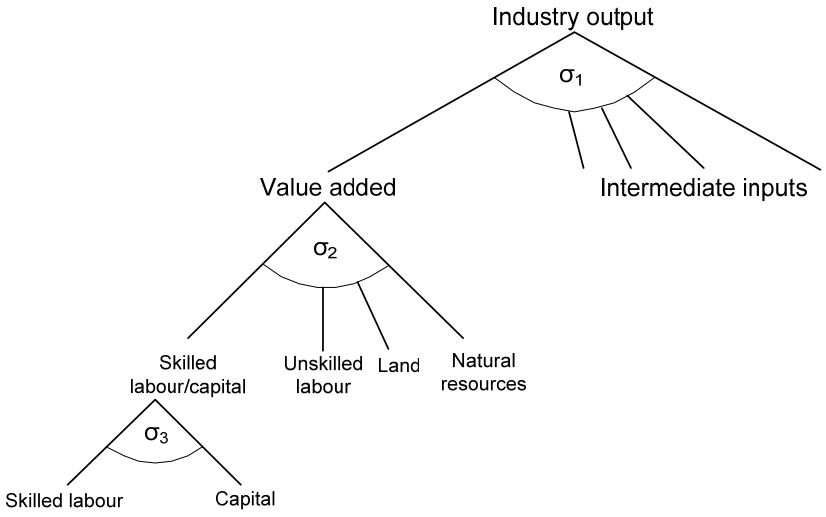
The demand for factor use by each sector is modelled in the standard GTAP model with a two-level CES production nest as shown in Figure 3. At the lower level, aggregate value added is formed through the optimal combination of factors which is then substitutable for all intermediate inputs at the top level of the production nest. Substitution between primary factors is inelastic for the agricultural and extraction sectors (with values of 0.2-0.24) and higher among the other sectors (with values of 1.12-1.68). The elasticity of substitution between aggregate value added and intermediate inputs is set at zero in the standard GTAP version which reflects Leontief technology in which intermediate inputs and value added are combined in fixed proportions to produce the output good.

Figure 3. Factor demand in GTAP



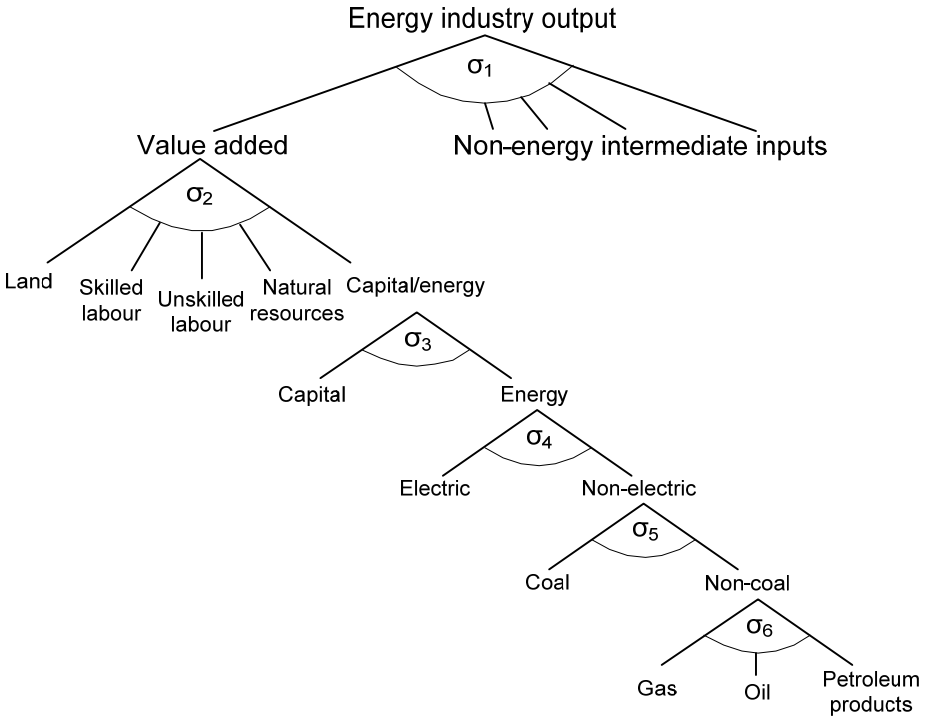
The modelling of the production structure has been extended in two ways in MAGNET. Firstly by allowing substitution between aggregate value-added and intermediate inputs at the top level of the nest using the elasticities of substitution from the GTAP-AGR model. Secondly, in place of the two-level CES production structure in the standard GTAP model, the MAGNET model includes a fully flexible production structure in which the user can specify the production structure for each region and/or sector. Allowing for multiple levels of the production nest overcomes the disadvantage of a fixed production structure in which all pairs of inputs at the same level of the nest have the same degree of substitutability. It may be desirable for example to specify a different substitutability between capital and skilled labour to reflect their complementary (see Figure 4).

Figure 4. Example of factor demand in MAGNET



Furthermore, the flexible production structure in MAGNET also allows for factors to be directly substitutable with intermediate inputs. This may be desirable in scenarios of energy use where capital and energy may be viewed as directly substitutable. The introduction of direct substitution between capital and energy following the GTAP-E structure (Burniaux & Truong, 2002) is shown in Figure 5. Clearly, the advantage of the MAGNET structure of factor demand is its flexibility which allows the model to be tailored to each regions' characteristics and the research question. Such flexibility does however require more data; specifically the elasticities of substitution between inputs at all levels of the nest must be specified as part of the modelling process.

Figure 5. Further example of factor demand in MAGNET



4.1.2 Land supply function

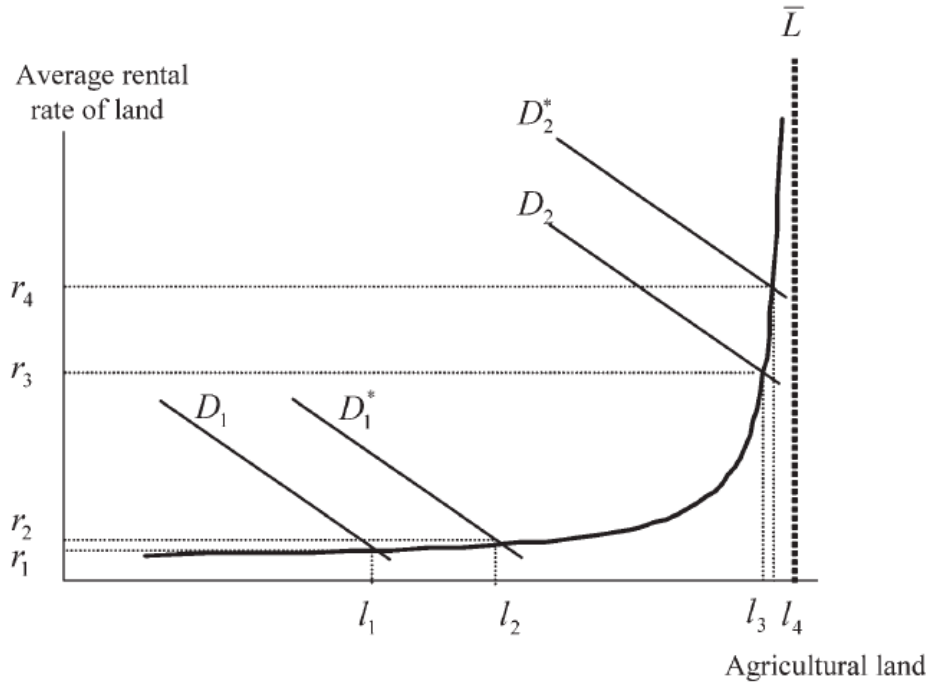
The supply of land, labour and natural resources is fixed in the standard static version of the GTAP model. Also, although the capital stock can grow through investment (net of depreciation), the static nature of the model means that new capital is not brought into use until the next period and therefore the capital stock is also fixed. Unemployment can be introduced into the model by fixing the nominal wage rate and allowing the quantity of labour supplied to change.

The primary development of MAGNET in terms of factor supply is the introduction of a land supply function which allows for more land to be used in agriculture at a higher rental rate up to the maximum amount of land available. The positive relationship between land supply and the land price is based on the assumption that additional land will be more costly to use as either farmers have to use land that is less productive and therefore have higher associated costs or it requires converting land from other uses into land suitable for agriculture, again at higher cost.

The relationship between the average rental rate of land and land supply is specified for each region using three pieces of information: current land use in km², the maximum amount of land available for use in km² and the price elasticity of land supply. Data on current land use and the maximum available land in each region are taken from work done with the IMAGE model based on biophysical data (Eickhout et al., 2007).

An example of the land supply curve is shown in Figure 6, where l_1 is the current land use, $\bar{L}$ is the total land available and forms the asymptote of the function, and the slope of the curve is determined by the price elasticity of land supply. Clearly the proximity of current land supply to maximum land supply has important implications for how changes in demand affect the land price. In land-abundant countries such as Brazil, there is still a large amount of land available, so an increase in demand (from D_1 to D_1^*) can be accommodated with only small increases in rental rates. In contrast, land-constrained regions such as the EU and Japan are already using an amount of land close to the maximum available. A similar increase in demand (from D_2 to D_2^*) can only be met if the rental rate increases a great deal to bring remaining land into the market.

Figure 6. Land supply curve in MAGNET



Source: Banse et al. (2008, p. 125).

Allowing for changes in land supply and rental rates is important when the policy in question will affect the demand for land. Regions that are land-abundant will be able to meet the demand for extra land at lower prices than land-constrained regions which in turn affects the regions' competitiveness.

4.2 Factor supply over time

In addition to allowing factor supplies to change in response to changes in demand as in the case of the land supply function, the dynamic nature of the MAGNET model also allows the supply of factors to change over time. Growth in the labour supply is assumed to follow USDA (US Department of Agriculture) population projections. Capital is assumed to grow in line with baseline GDP growth also from USDA based on World Bank projections[3] to maintain a constant capital-output ratio. The new capital goods are assumed to be created according to a fixed combination of inputs that varies by region and typically includes large shares of construction and machinery and equipment complemented with electricity, trade and business service inputs. The capital good is created from both imported and domestically sourced inputs upon which sales taxes are levied, but without the use of factors. The factor use associated with investment is assumed to already be embodied in the inputs used; there is no extra value added in the creation of the investment good. Investment in the capital good affects the demand for these inputs but does not affect the size of the capital stock as the model is only run for one period. Investment in new capital goods is driven by available savings in the GTAP model.

Factor supply can change through the quantity supplied or the quality supplied where the latter is affected by technological change. Future economic growth is driven by technological change but the assumption about how that change is distributed among inputs is down to the user in MAGNET. The current set up of the model assumes that agriculture grows twice as fast as the service sector and that manufacturing grows 2.65 times as fast. This growth is distributed to bring about labour-saving technical change and some input-saving technical change, thereby improving the quality of the inputs and their effective supply. Land productivity is altered in the baseline in line with FAO projections which indicate increasing land productivity in all regions to 2030.

4.3 Segmented agricultural and non-agricultural factor markets

Factor mobility refers to the speed in which factors can move between sectors in response to changes in relative returns. The modelling of factor mobility has been extended along two dimensions in the MAGNET model. Firstly, through the introduction of segmented labour and capital markets in agriculture and non-agriculture and secondly, through the modelling of land transformation between uses in agriculture, which is discussed below.

Two types of factors are identified in the GTAP model: perfectly mobile factors that can switch freely between sectors leading to an equalisation in the rate of return, and sluggish factors that adjust more slowly leading to different sectoral returns. The user can define which factors are considered to be sluggish and which are perfectly mobile. The transformation of sluggish factors between uses in different sectors is governed by a CET function where the speed of adjustment to changes in relative returns, depends upon the elasticity of transformation. Higher absolute levels of transformation elasticity allow sluggish factors to be released more quickly in response to changes in relative returns. In the standard setup of the GTAP model, land and natural resources are deemed to be sluggish factors with a transformation elasticity of -1 for land and -0.001 for natural resources. Land is therefore more mobile than natural resources but less mobile than labour and capital.

Keeney & 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

[3] http://www.ers.usda.gov/Data/Macroeconomics/#BaselineMacroTables

non-farm wages, steady off-farm migration and persistent rural-urban wage differentials (Keeney & Hertel, 2005, pp. 6-7). The MAGNET model allows for three types of factor markets for labour and capital: unsegmented (GTAP), segmented with movement between the markets determined by a CET function (following the GTAP-AGR model) or segmented markets with dynamic factor markets (where factors migrate between sectors in response to changes in relative returns). Segmented factor markets imply different factor prices in each market and separate market clearing conditions. Currently there are two markets in the segmented factor market module: agriculture and non-agriculture.

The segmented factor markets module links to the rest of the model through endowment prices and the factor market clearing condition. The endowment price is defined as the market price for the endowment plus any taxes on factor use. As there are two markets for factors in the segmented market (agriculture and non-agriculture), the factor 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 is therefore a weighted average of the agricultural market price and the non-agricultural market price. Labour and capital are freely mobile within each sector leading to a single price in the agricultural factor market and in the non-agricultural factor market.

The market clearing condition for the factor market in GTAP 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*. 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, labour and capital can still move between the two markets. Indeed, extra labour or 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 either by changes in relative prices and an elasticity of transformation (CET function) or by changes in relative prices and a speed of adjustment parameter (dynamic factor markets).

In the absence of available data on the underlying barriers to factor mobility, Keeney & Hertel (2005) introduce a CET function in GTAP-AGR to 'transform' farm labour into non-farm labour and farm capital into non-farm capital. This option in MAGNET follows the set up in GTAP-AGR and is documented in Keeney & Hertel (2005). The transformation of factors between the two markets is governed by the elasticity of transformation. Note that the elasticity of transformation within each market is endowment and region specific but not market specific; so the same elasticities apply in both markets. The transformation elasticity is set at -1 for all factors and regions in the first instance.

The dynamic factor market module offers a different way of determining the movement of factors from agriculture to non-agriculture. The module includes an agricultural employment equation,

$$\text{qoagr(i,r)} = \text{DYNAGNAG(i,r)} * \left(\frac{PAENDWM_{i,r}}{PNAENDWM_{i,r}} - 1\right) * 100 * \text{time}$$

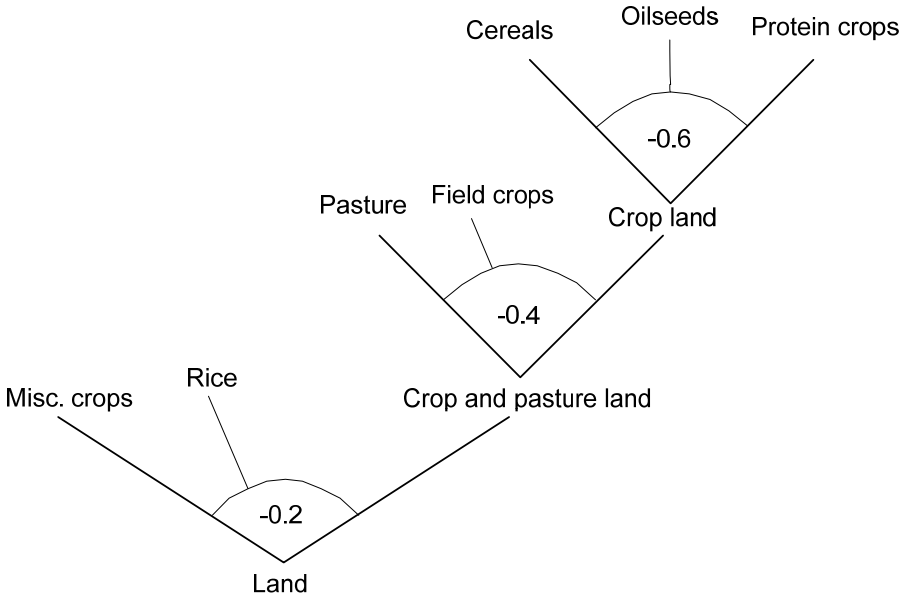
where the percentage change in the quantity of labour or capital (i) used in agriculture (qoagr) in each region (r) is determined by the relative wage between the two sectors, the time period and a speed of adjustment parameter (DYNAGNAG). The initial difference between the agricultural and non-agricultural wage levels is taken as indicative of the reservation wage in agriculture. A value of 0.07 is used for the speed of adjustment between the two markets based on econometric estimation. A full description of the estimation of the agricultural employment equation can be found in Tabeau & Woltjer (2010).

4.4 Land allocation

Land allocation is the second of the MAGNET factor market extensions that pertain to factor mobility. The standard GTAP model identifies only one form of land and allows for that land

to be sluggishly transformed between the agricultural sectors that use the land in response to changes in relative prices. The single tier function used to transform land between different sectors in the GTAP model implies that the degree of transformability is the same between land used in all sectors. In reality, land used to grow crops may be more easily transformed between some land uses than others. For example, transforming the use of land between different crop types is likely to be easier than the transformation from arable land to grazing land. The MAGNET model captures these differences in transformability of land between uses using a three tier Constant Elasticity of Transformation (CET) function following Huang et al. (2004).

Figure 7. Land allocation in the MAGNET model



The process governing land allocation in the MAGNET model is shown in Figure 7. The three-tiered CET structure allows the mobility of land between uses to vary according to how the land is used. Sectors that use land are grouped according to ease of transformability. Land used to grow cereals, oilseeds and protein crops is considered to be most easily transformable between the three uses with a transformation elasticity of -0.6. The aggregated land from these three uses is then transformable with field crop land and pasture land with a lower degree of transformability, -0.4. Finally, aggregate crop and pasture land is transformable into land used to grow rice and other crops (such as vegetables and orchard fruits) with the lowest degree of transformability, -0.2.

4.5 Extensions of factor market modelling in MAGNET

The description of work for the Factor Markets project specifies three types of extensions to factor market modelling. For each factor market, the specification, implementation and links to other models should be improved; where specification refers to demand, supply, mobility and substitutability and implementation refers to parameters and economic data that underlie the modelling of the factor market. The review of CGE models provides ample examples of how factor market modelling could be extended in MAGNET.

A range of possible extensions of factor market modelling in MAGNET are shown in Table 3. The specification of the capital market could be improved through the introduction of capital vintages, sector-specific capital or allowing for different types of investment good. The latter would be interesting to better capture the impact of the wave of investment that accompanies new industries on the capital stock, e.g. the development of an ethanol sector. The implementation of capital market modelling could be improved through better estimation of

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.

The specification of labour market modelling could be extended along many dimensions. An improved modelling of unemployment that incorporates a positive relationship between real wages and the supply of labour is desirable, as is the introduction of a minimum wage and capturing union power in European labour markets. Broader concerns such as migration, population dynamics and human capital accumulation, which are relevant to capturing the impact of the accession of new member states, are also possible extensions for the modelling of factor markets. The implementation of labour markets in the model could be strengthened by improving the substitution elasticities between labour and other factors and the parameters governing the movement of labour between agricultural and non-agricultural markets. Finally, extending the segmented factor modelling to other sectors would also add flexibility to the model and improve the modelling of factor markets in the EU.

The specification of the land market could be extended to explicitly include the competition for land between all sectors of the economy: agricultural, forestry, manufacturing, services. Moreover, the speed at which land is brought into use could be adjusted with a stickiness parameter to reflect the different regulatory frameworks than govern land use in the member states and candidate countries. As with the capital and labour markets, improving the elasticities that govern the demand and supply of land would strengthen the modelling of the land market.

Table 3. Possible extensions to factor market modelling in MAGNET

Factor market	**Specification**	**Implementation**	**Links to other models**
Capital	Vintages Putty-clay Industry-specific investment matrix	Improving elasticity of substitution with other factors. Improving transformation/migration parameter between segmented markets.	CAPRI, AgriPoliS
Labour	Unemployment Extend segmented market specification Minimum Wage Stickiness (union power) Human capital accumulation Migration Population dynamics	Improving elasticity of substitution with other factors. Improving transformation/migration parameter between segmented markets.	CAPRI
Land	Competition for land between all sectors Stickiness (regulatory environment)	Improving elasticity of substitution with other factors. Improving price elasticity of supply estimates.	CAPRI, farm level models

The final selection of improvements in factor market modelling in MAGNET will be taken in conjunction with the other members of the project as the extension work depends on the output of other work packages and their timetable for research. The impact of improving factor market modelling in MAGNET can be tested by comparing the results of the model with and without the extensions; with the expectation that the extended model will better capture the functioning of factor markets in the EU.

5. Factor markets in selected CGE-Models

From the multitude of CGE models, factor market modelling is only reviewed here in six key global models: GTAP and its variants: GTAP-AGR, GTAP-E, GTAP-DYN and G-MIG, GLOBE, the LINKAGE model, at the World Bank, MIRAGE, MAGNET and WORLDSCAN. Given the heavy data requirements needed for a global model, most of the models described here use a common core database: GTAP. In addition, most models are descendants of the GTAP global CGE model.

Table 4. Overview of selected CGE with factor market modelling

Model	Description	Literature
GTAP-AGR	The GTAP-AGR model represents a special purpose version of the GTAP model, designed to capture certain structural features of world agricultural markets that are not well-reflected in the standard GTAP model. GTAP-AGR considers the importance of off-farm factor mobility – particularly for labor – in determining farm incomes. Improvements have been made in the case of characterizing the degree of factor market segmentation between the farm and non-farm sectors as well as improving the representation of input substitution possibilities in farm production. Furthermore farm household are describes as entities which earn income from both farm and non-farm activities, pay taxes and consume food and non-food products based on an explicit utility function.	Keeney & Hertel, 2005
GTAP-E	GTAP-E is an extended version of the GTAP model. In addition, GTAP-E considers carbon emissions from the use of fossil fuels as well as international carbon emission trade. In addition to inter-fuel substitution, the model incorporates a Social Account Matrix (SAM) which provides a full account of the carbon tax revenues and expenditures and a more specific treatment of carbon emission trading.	Burniaux & Truong, 2002
GTAP-DYN	The dynamic model GTAP-DYN is an extended version of the standard GTAP modeling framework, with consideration of dynamic behavior. It includes all the features of the standard GTAP Model, such as consumer demands and inter-sectoral factor mobility, as well as incorporating a new treatment of investment behavior and additional accounting relations to keep track of foreign ownership of capital.	Ianchovichina & McDougall, 2000
G-MIG	G-MIG is based on the global applied general equilibrium GTAP model and database. Adaptions have been made with regard to incorporate the movement of natural persons. Labour is separated into domestic and migrant workers with different substitution elasticities. Furthermore, features of the dynamic GTAP (GDyn) model have been combined with G-MIG to obtain a dynamic migration model	Walmsley et al., 2007
MIRAGE	The multi-region, multi-sector model MIRAGE is a computable general equilibrium model for trade policy analysis. It comprises imperfect competition, product differentiation by variety and by quality, and foreign direct investment, in a sequential dynamic set-up where installed capital is assumed to be immobile. MIRAGE is based on the MAcMaps database	Hedi Bchir et al., 2002

LINKAGE	LINKAGE is a global dynamic computable general equilibrium model (CGE). In its standard version, it is a neo-classical model with both factor and goods market clearing Characteristic is a full range of tax instruments, price markups, multiple labor skills, vintage capital, and energy as an input combined with capital. Trade is modeled using nested Armington and production transformation structures to determine bilateral trade flows. Tariffs are fully bilateral and the model captures international trade and direct and indirect transportation costs. Also tariff rate quotas are implements. A recursive framework is used to drive dynamics, with savings-led investment and productivity. The model incorporates adjustment costs in capital markets and trade responsive endogenous productivity.	van der Mensbrugghe, 2005
GLOBE	GLOBE is a Social Accounting Matrix (SAM)-based global Computable General Equilibrium (CGE) model based on GTAP. GLOBE consists of a set of single country CGE models linked by their trading relationships. Price systems are linearly homogeneous and change in relative prices matter. Each model region has its own numéraire price, the consumer price index (CPI) and a nominal exchange rate.	McDonald et al., 2007
WORLDSCAN	WorldScan is a recursively dynamic general equilibrium model for the world economy, based on GTAP database. WorldScan has been developed to construct long-term scenarios for the global economy and to enable policy analyses in the field of international economics. WorldScan can be adapted to arbitrary sector and country Classifications.	Lejour et al., 2006

5.1 Labour markets

Labour is classified as a mobile factor in the standard GTAP model. As such, labour is free to move between sectors in a country or region in response to changes in relative prices, which leads to an equalisation of the increase or decrease in the wage rate across all sectors. Two types of labour are included in the standard GTAP model: skilled labour and unskilled labour. Each type of labour has its own wage rate determined by the interaction of the supply of labour (usually exogenous) and the demand for labour as a factor of production. Skilled and unskilled labour are substitutable both for the other type of labour and the other factors of production in the formation of the value added composite which in turn is substitutable with composite (domestic and imported) intermediate goods in the production of the output of each sector.

Table 5. Labour market features in global CGE model

Feature	GTAP	GTAP-AGR	GTAP-E	GTAP-DYN	G-MIG	MIRAGE	LINKAGE	GLOBE	WORLDSCAN
Skilled/ unskilled labour	X	X	X	X	X			X	X
Segmented markets (rural, urban)						X	X	X	
Unemployment	X	X	X	X			X	X	X
Farm/ off-farm employment		X				X			
Wage differences farm / off-farm		X							
Minimum wage						X	X		
Farm-owned (value-added) aggregate		X							
Mobility across sectors	X	X	X	X	X	X	X	X	X
International migration					X			X	X
Productivity differences of permanent and temporary labour					X				
Sector specific restriction					X			X	
Wage differences temporary workers / resident workers					X				
Complementarity between skilled labour and capital						X			
Wage bargaining							X		X
Activity specific restriction								X	
Labour supply and unemployment modelled endogenously								X	X

5.2 Capital markets

In standard GTAP, capital can move between industries within a region, but not between regions. The capital flow is immobile in the short run and mobile in the long run. In the standard GTAP-model, investors are represented by a single agent, the global bank. The global bank receives savings from the households and invests this savings. Investments are represented by purchase of a commodity named 'capital goods'. Capital goods are not tradable. Because GTAP is a comparative static model, savings are incorporated as a fixed share of the households' utility function. At the global level, the amount of investments is the sum of savings in each region. Time preferences for investments or influences on the decision of saving levels are not captured. Therefore many attempts have been made to model capital in CGEs. An overview is given in the following table.

Table 6. Capital market features in global CGE model

Feature	GTAP	GTAP-AGR	GTAP-E	GTAP-DYN	G-MIG	MIRAGE	LINKAGE	GLOBE	WORLDSCAN
Mobile between regions				X	X	X	X	X	X
Mobile between sectors	X		X	X	X	X		X	X
Capital mobile between agriculture and non-agriculture		X						X	
Restricted mobility between sectors		X						X	
Farm household modelling		X							
Capital – Energy complementarity/substitutability			X					X	
Dynamic modelling of savings and investments				X	X	X			
Capital accumulation				X		X		X	
Regional capital stocks				X				X	
International assets and liabilities				X				X	
International investment and income flows				X	X			X	
Financial assets				X					
Intrinsic dynamic of physical and financial asset stocks				X					
Putty-clay hypothesis (immobility of installed capital)					X		X	X	
Partial mobility across sectors							X	X	
Semi-putty-clay hypothesis (partial immobility of installed capital)							X		
Vintage capital – old /new capital							X		
Relation between savings and demography									X
Estimated savings function							X		

Exogenous savings rate	X								
Savings were derived from welfare maximisation and consumer decision									X
Regional savings and investment can diverge									X
Regional capital markets – imperfect capital mobility									X
Foreign direct investment incorporated through linkage of regional capital markets								X	X
Influence of transportation and transaction costs on capital flow									X

5.3 Land markets

The standard assumption of land markets in GTAP can be described by a sluggish sector-specific factor, namely land. Land – together with the factor 'natural resource', which is also included in the GTAP data base – is assumed to be immobile across domestic agricultural sectors. The agricultural sectors are the only land-using sectors in the data base.[4] With the assumption of land as sluggish land prices differs across the land using sectors in agriculture. Similar to the standard presentation of land and capital, land use is also presented only in value terms in the GTAP data base as a part of sectoral value added. Land use presented in physical units is not modelled in the standard version of GTAP.

Table 7. Land market features in global CGE model

Feature	GTAP	GTAP-AGR	GTAP-E	GTAP-DYN	G-MIG	MIRAGE	LINKAGE	GLOBE	WORLDSCAN
Only agricultural use	X	X	X	X	X			X	X
Imperfectly mobility between agricultural sectors	X	X	X	X	X	X	X	X	
Regions classification as land-constrained or not						X			
Land mobility across sectors						X	X		
Set aside						X			
Aggregate supply of land responds to changes of the real aggregate land price (logistic function)							X		
Allocation of land responds to the relative land prices across the activities (CET function)	X	X	X	X	X	X	X	X	

[4] Land use in forestry is covered under the factor 'natural resource'.

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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.
Contact e-mail	info@factormarkets.eu
Website	www.factormarkets.eu
Partners	17 (13 countries)
EU funding	1,979,023 €
EC Scientific officer	Dr. Hans-Jörg Lutzeyer