

Modelling Endogenous Technical Change for Food Security (625278 METCAFOS)

IEF Final Publishable Summary Report

1. Research background and objectives: How to make projections of food security less of a "black-box"

Food security is one of the largest challenges facing mankind in the next half century. It is expected that food production needs to double by 2050, yet the possibilities of agricultural land expansion are limited. Thus, investments in agricultural research and development (R&D) will play an important role to stimulate productivity. This is especially the case in developing countries, where cereal yields are still far below the global average level.

Though it is well-known that R&D investments play a key role in increasing agricultural productivity, they are usually neglected in major economy-wide models, which are used for assessing long-term scenarios. In these models it is still assumed that yield growth is the "manna from heaven". This situation weakens the ability of the global models to guide policy makers in defining long-term food security strategies.

This Marie Curie Project METCAFOS aims to improve the projections of agricultural production, prices and food security towards 2050. It does so by explicitly accounting for the link between R&D investments and agricultural productivity in a state-of-the-art Computable General Equilibrium (CGE) model called MAGNET (www.magnet-model.org).

2. Methodological approach

STEP 1: Empirical estimations of the impact of R&D investments on productivity

In the first part of the project, we assessed in an empirical way if and to what extent there is a link between R&D investments and productivity. We looked into data about 11 OECD countries over a time frame of 20 years (1987-2007). This empirical assessment contributes to the scant empirical evidence on the speed, sources and direction of technical change on the sector level. The obtained elasticities of R&D investments are consistent with the CGE modelling framework used in MAGNET. The results showed that R&D investments had statistically significant effects on the productivity in manufacturing and services sectors, with the highest impact found in the high-tech manufacturing and transport, storage and communication sectors.

STEP 2: Agricultural productivity is linked with R&D investments within a global CGE model

A new, specific R&D module was built in the global CGE model MAGNET. We assumed that public R&D in agriculture stimulates productivity of land as it will be leading to land-augmenting technical change. This is because public R&D in agriculture is mostly targeted at major improvements of seeds and varieties, in the style of the Green revolution. The model takes into account a substantial time lag before R&D investments are reflected in increased productivity. In industrialized countries, basic research prevails, so R&D lags are longer and R&D returns are higher than in developing countries, where a more applied nature of research prevails. R&D stocks built from R&D investments are linked with productivity coefficients of the production function. This assures that agricultural sector benefits "freely" from public R&D investments, though the government pays for the expenditures.

STEP 3: Baseline food security projections with R&D driven productivity and policy simulations

The R&D-driven yield and food security developments resulting from the simulations run with the MAGNET model were compared with projections based on exogenous yields that grow according to experts' opinion and trend analyses (e.g. productivity growth rates developed by the IPFRI model IMPACT). The latter are mainly used in key global impact assessment models and analyses. We carried out various policy simulations on alternative R&D spending patterns and set up a scenario with no agricultural R&D investments at all. Finally, the relation between bio-economy and food security was studied. For this, we ran a simulation that assessed the role of public agricultural R&D investments in avoiding negative food security effects resulting from bioenergy policy.

3. Main results

With current R&D spending patterns, sub-Saharan Africa regions will face a major deterioration in food access, a dimension of food security

With R&D-driven land productivity, food prices are expected to decline in most regions. This is in line with the projections based on yields obtained by expert opinion and trend analyses. However, for certain regions such as sub-Saharan Africa, these expert-led predictions might be too optimistic with regard to productivity growth. This bias becomes mostly notable in the development of agricultural and food prices, as especially land becomes scarce due to lower yield growth which is reflected in an increase in land prices. Since unskilled wages in agriculture will not keep up with the growth of food prices, a deterioration of living standards of rural households can be expected in this region. Despite international technology transfer and knowledge spillovers, developing countries have only limited benefits from international R&D spill-overs. The available knowledge is often not very useful to these countries, because production structures and agro-ecological zones are different and less effective as the absorption capacity of new knowledge is lower.

Tripling agricultural research intensity in sub-Sahara Africa will have positive nutritional benefits

Given that in sub-Saharan Africa the existing agricultural R&D intensity ratios are well below the developed countries, many R&D strategy documents call for doubling their intensities. The policy simulations in our model showed that doubling the R&D intensity will soften the land constraint and slow down growth of food prices in sub-Saharan Africa (for instance in Western Africa, prices might increase by 38% instead of 74% between 2010-2050). This can prevent a deterioration of households' living standards that is otherwise expected. The positive benefits of R&D policies are also reflected in nutritional consumption. Doubling R&D shares would bring a gain of 100 – 150 kcal per day and with triple shares, households in Eastern Africa could consume even 200 kcal per day more over the period of 2010 – 2050, which represents an almost 20% increase compared to a situation without R&D. Moreover, the R&D costs of additional calories are notably lower here than in Latin America.

Investments in agricultural R&D are a potentially effective strategy to avoid undesirable land use change and food security effects of large scale use of biomass

Bioenergy and food security bring important societal benefits, yet they might yield conflicting outcomes. In our model exercises, we tried to avoid and reduce the undesirable effects of bioenergy on food security by increasing the agricultural productivity through agricultural R&D investments. Globally, the costs of agricultural R&D represent only about 10% - 16% of the biomass price. Moreover, there will be additional positive food security effects that will accrue only 10 – 20 years after the implementation of bioenergy plantations. This shows that R&D investments in agriculture are a potentially effective and low-cost strategy to avoid undesirable land use change and food security effects caused by the large-scale use of biomass from energy crop plantations. Yet, early planning and timing of bioenergy policies with investments in R&D in agriculture are essential.

4. Socio-economic impacts of METCAFOS:

It has been shown that doubling research intensity of agricultural R&D investments in sub-Saharan Africa and other developing regions is a cost-effective policy that can contribute significantly to food security. The policy recommendations from this project are thus largely directed towards higher support of national R&D investments in developing regions. As the most limited factor of production will clearly become agricultural land, it will be crucial that R&D investments focus more on land-augmenting technologies, such as new seeds. In addition, the benefits of international R&D transfer to agricultural sectors of developing countries are limited, so these countries will have to rely more on domestic R&D efforts. To implement this and to benefit more from international knowledge spillovers, building research capacities and infrastructure in addition to training qualified laborers are strategies that are necessary and required.

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