Holistic approach to assess the impact of green Investments using the MAGNET model

Provisional paper - draft

1. Introduction

The Paris Agreement, adopted by 196 Parties, aims to limit global warming to well below 2, preferably to 1.5 degrees Celsius. In this context, the European Union has launched its new growth strategy, which aims to transform the EU into a resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050. Given the ambitious goals put forward, there is a need to evaluate the ex-ante impacts of a potential investment boost in low-carbon economy (green investments).

Being a multi-region multi-sector global CGE model with a GTAP core and various modules, MAGNET has been well equipped to conduct long-term ex-ante analyses of economy-wide impacts across economic, social and environmental dimensions. In case of investments driven economic development, special insights in sector specific investment allocation, their financing and productivity effect is required.

This paper provides an overview of the methodological developments implemented in the MAGNET model to improve the modelling of investments. Using green energy sectors as an example, we simulate a set of exploratory scenarios to investigate the effects of increasing sector-specific investments under different assumptions of financing and productivity effects associated with these investments. The main methodological steps involve the application of recursive dynamic features augmented with sector-specific investment allocation and including technology learning effects that are endogenized within the model as a result of both learning by doing and learning by research.

The results show that the financing alternatives play an important role in determining the potential GDP effects of the investment boost, with significant spillover effects across different regions of the world. According to the expectations, technology learning plays an important role in fostering green transition when clean energy sectors become more competitive and replace the traditional sources of energy. Positive spillover effects are also noted within the economy, as stimulating green sectors increases demand and production of primary agriculture as an important provider of the biomass resources for green transition.

2. Methodology

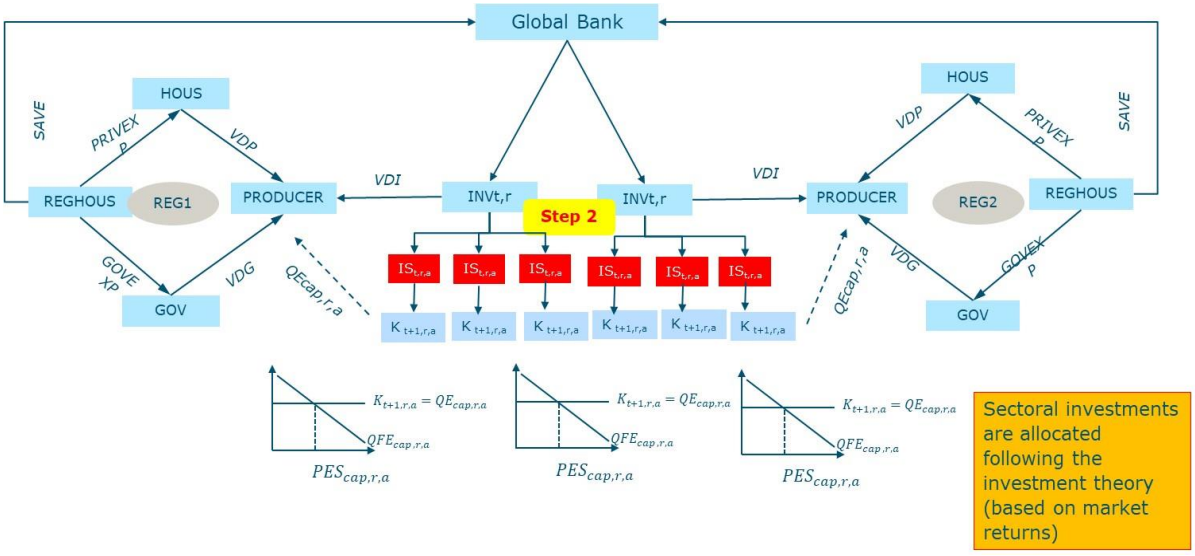
This section provides the description of the methodological approach.

2.1 Investment allocation according to Tobin Q approach

Until now, investments were only regionally specific and no distinction was made with respect to the sectoral allocation. In order to introduce green investment shocks, it is necessary to treat

investments as sector-specific. Different investment allocations per sector will also result in different capital stock growth rates with repercussions on productivity. Figure 2 illustrates the new investment mechanism - now there are sector-specific investments and sector-specific capital stocks. This has repercussions on the capital market – in each individual sector-specific capital market is a price clearing mechanism that equalizes capital demand with capital supply (Figure 5). The key issue in converting regional investments and capital stocks to sector-specific is to choose the mechanism of investment allocation.

Figure 1: Schematic representation of sector-allocation of investments (Step2)



Various options in the literature exist to introduce sector-specific investment allocation. In the GAMS-based CGE models, a Tobin-Q investment allocation approach prevails. In the global GTAP model, investments are normally not sector-specific (this holds also for the dynamic GTAP extensions). In the study of Pant (2012), investment allocation mechanisms of the famous global models such as MONASH, GTAP and GTEM are explained and a new approach is outlined that can improve some imperfections in the existing models. In the MONASH CGE model, sector investment allocation is determined by the intersection of an investment demand and an investment supply function modelled by an S-shape curve. The specific shape of the investment supply function assures that capital stock would always oscillate between the bounds of minimum rate of growth necessary for replacing depreciated capital stock, a historical normal capital growth rate and a maximum attainable growth of capital stock. The MONASH approach has several advantages but it is not further considered in this paper due to the requirements for parameters and data, namely the trend growth rates based on historical capital stock, upper bounds for capital growth, the normal rates of return, etc.

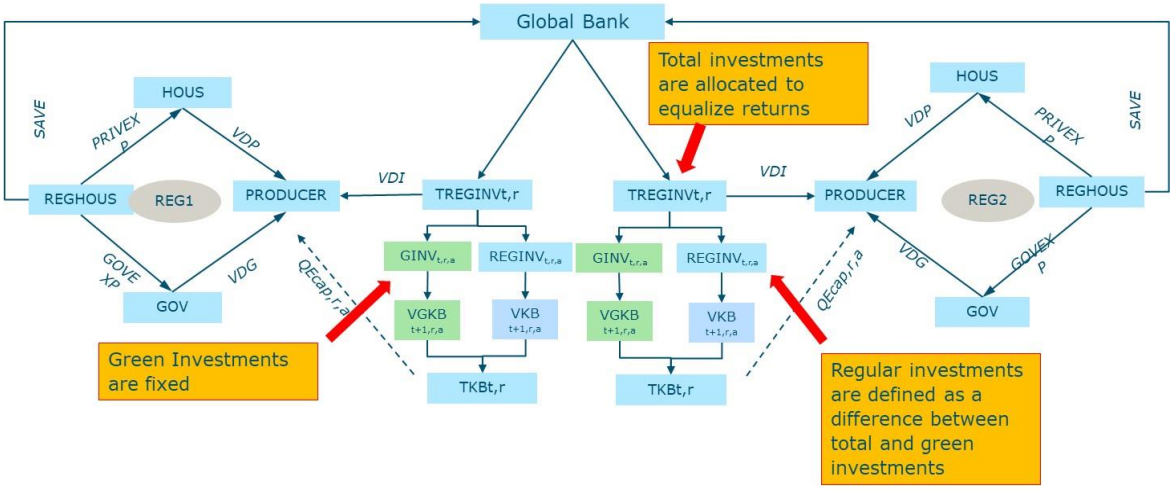
The GTEM CGE model only models regional investment allocation based on a reduced form function with various macroeconomic variables as drivers, therefore it is by no use for this paper.

Our investment allocation options are therefore further reduced to two approaches that are implemented in this project. The first approach is the Tobin Q approach and the second approach is based on an GTAP-style equalization of rates of return applied on a sectoral level. We focus only on Tobin Q as this approach is the one used in the investment scenarios.

2.2 Incorporation of exogenous green investment shocks

The following step in modifying investment behaviour in MAGNET is to include an exogenous component corresponding to exogenous investment budget. Thus, certain part of investments is determined exogenously and the remaining part is still allocated according the private returns (Figure 2). The total amount of investments (summing green and other) creates a demand for total investment goods in the economy. Both green and other investments are cumulated to form green and other capital stock. The total amount of capital stock enters consequently the production function and leads to higher volume of production.

Figure 2: Schematic representation of Investment Mechanism in a recursively-dynamic version (Step1)



2.3 Modelling technology learning in MAGNET

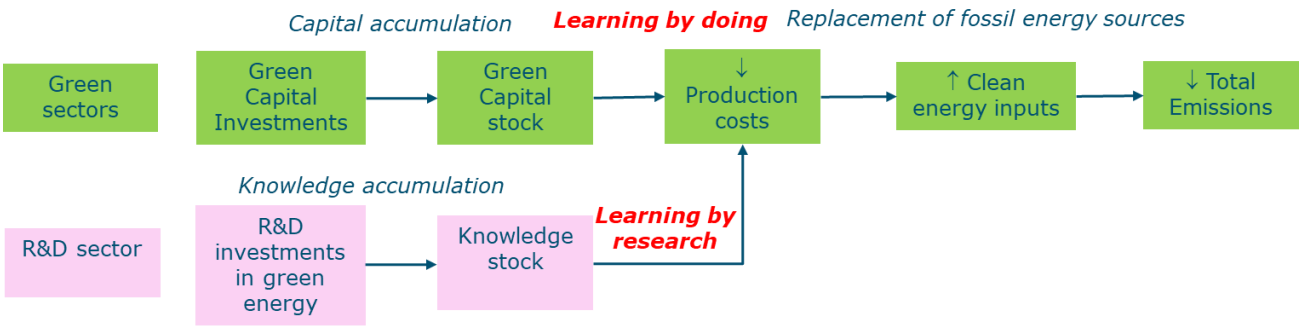
Until now, MAGNET model enables to relocate investments between the sectors to achieve a productivity effect called *capital deepening*. Thus, the favoured sectors may grow quicker because of their faster capital stock accumulation. If the exogenous investments are allocated

to sectors with lower carbon footprint, this will already partially contribute to the green transition.

There are however more impulses needed in the economy to stimulate green transition. This is achieved by productivity gains coming from *technology learning*. The most commonly recognized forms of technology learnings are learning-by-doing and learning by research. Figure x demonstrates the linkages of technology learning. We distinguish green sectors which achieve productivity gains from learning-by-doing by investments in capital stock and R&D sector which creates productivity gains in green sectors by learning-by research. Thus, green sectors become more productive (use less inputs) from two sources of technology learning. As a result of that, production costs decline and green sectors become more competitive compared to fossil sectors. As consequence, clean energy inputs substitute fossil energy inputs in energy mix. At the end of this chain, there is a decrease of total emissions.

For learning-by-doing, this process is fully endogenized, as it depends on the accumulation of capital stock in the green sectors. Even without additional increase in "green" investments, productivity of green sectors grow because of their usual investments. The additional investment boost then increases further their advantage. As for the learning by research, this process can be both endogenous and exogenous, depending on how we determine R&D investments – either exogenously by following a given governmental R&D budget plan, or they are targeted to a certain constant R&D intensity (a ratio of R&D investments to output of the green sectors), in which case they are endogenous.

Figure 15: Introducing productivity effects of Green investments in MAGNET



Technology growth models are in line with the endogenous growth theory of Paul Romer which contrasted the original assumptions of technological change as an exogenous source of productivity growth. The endogenous change models intend to understand the importance of cost reductions for technologies used in one industry and the spillover effects to other industries and geographic regions.

The most common model used in the energy literature to forecast change in technology cost is the "one-factor learning curve" or "experience curve" (Rubin et al., 2015).

2.4 Modelling R&D investments in energy technology in MAGNET

In order to implement R&D investments from energy technology in MAGNET, various steps must be carried out:

- Obtain historical flows of R&D investments needed to build knowledge stocks:
- Choose an appropriate form of building knowledge stocks (R&D lags and depreciation rates)
- Calibrate base year value of knowledge stocks
- Implement equations of knowledge stock accumulation in MAGNET

3. Implementation of MAGNET model in investment scenarios

3.1 Calibration of sectoral capital stock and investment in the base data

3.2 Description of baseline assumptions

3.3 Description of scenarios

4. Scenario results

5. Conclusions