Introducing endogenous technical change, Research and Development and a Stock of Knowledge in a CGE model and the GTAP database

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The role technology plays has become more preponderant in a context where concerns related with climate change and growth are among the priorities of a sustainable development agenda. Furthermore, although it is a key element in explaining growth and also one of the instruments proposed to deal with climate change, it may also be influenced by climate policy. Different kinds of environmental, economic and energy models for the analysis of mitigation policies have been gradually evolving from considering technological change as an exogenous element to include it as an endogenous mechanism following ideas of theories such as endogenous growth, innovation and learning by doing.

In a brief literature revision, some common elements can be identified as the most important and interconnected concepts related with Endogenous Technical Change (ETC): i) A stock of knowledge and human capital that drives growth, ii) Investments in Research and Development (R&D), iii) Technology Learning, iv) Technology diffusion, and v) Technology Spillovers.

Regarding the inclusion of ETC in a modelling framework it is necessary to consider the modelling approach and the corresponding endogenous specification. On the one hand, there are two general type of modelling methodologies. The first is the bottom-up approach which contemplates more detail in technologies and is based on engineering concepts being mostly partial equilibrium or energy system models; while the second one is the top-down approach based on economic concepts and with a higher degree of aggregation as in integrated assessment (IAM), computable general equilibrium (CGE) or macro econometric models. On the other hand, when considering the specifications for ETC the main focus could be broadly classified either on R&D and the accumulation of a knowledge stock, or also on learning curves.

CGE models offer a more detailed description of an economy with several sectors and regions, and, although they may lack of a detailed bottom up system; they offer a more exhaustive information about intersectoral and international flows which constitutes a potential advantage for endogenous technical progress deriving from technology, knowledge and trade spillovers since they can include not only energy R&D but also R&D for the rest of the sectors in the model.

The main contribution of the paper is to introduce an ETC specification in a global computable general equilibrium model in order to analyze the different implications of selected policies, including trade, R&D policies or also technology transfers. According to a literature review, a reasonable alternative is to include a knowledge capital stock which is also the product of investment in R&D. Although there are some challenges regarding the integration of additional data related to R&D and a stock of knowledge, the corresponding benefit is the possibility to provide details about the interaction between sectors including spillovers from trade or R&D.

Different data sources have been considered to include R&D activities and the related stock of knowledge in the GTAP database. Gross expenditure on Research and Development from UNESCO and the World Development Indicators are the starting point and reference for countries expenditures on R&D. The sectoral breakdown has been obtained using as a main reference the ANBERD database which presents detailed information on business enterprise R&D by industries for OECD countries. Finally, expenditure on R&D has been considered using data from the International Energy Agency (IEA), Research and Development Budget - Edition 2009. In addition, UNESCO data allows for the differentiation among Business Enterprise R&D, Government R&D and Private R&D.

Combining all those data sources we have been able to produce an extended dataset contemplating a global database which includes a stock of knowledge for every GTAP 7 region with the corresponding R&D services in the form of a new endowment used by all sectors of the database. The mentioned stock of knowledge has been computed following the perpetual inventory method according to a reclassification of the R&D expenditures initially taken into account as intermediate consumption in the original database, which now are considered as investments in R&D through the use of an additional endowment. An implication of this reclassification is that GDP is increased according to the use of the new R&D factor introduced following the existing literature considerations.