The implications of irrigation as a planned adaptation measure on an economy wide context

Notwithstanding its key role in food production, the economic relevance of agriculture varies widely across countries. In OECD economies, it currently accounts for less than 1.6% of overall economic output and employs less than 6% of the labour force. By contrast, in many least developed countries, more than 25% of gross domestic product (GDP) is derived from agriculture, and in some countries more than 50% of workers are employed in the sector.

Agricultural activities depend on specific climate conditions such as temperature, CO_2 concentration, precipitation, water availability, as well as frequency and intensity of extreme weather events. It is thus expected that they will be particularly sensitive to future climate change leading to changes in agricultural productivity, level and regional distribution of food production. Therefore, there is a need to implement specific adaptation measures to cope with the negative effects of climate change. In this context, irrigation activities could play a key role, especially in developing countries. However, given that irrigation activities require specific resources, it is also necessary to include several economic aspects in the analysis. Among these aspects it is important to consider irrigation costs and the interaction of irrigation activities with the rest of the economy. Also important are the repercussions in domestic and international markets following expected productivity shocks, as well as the mitigation of impacts which could be provided by adaptation measures. These elements offer the basis to pose the following research question: Which are the economic implications of irrigation as a measure of planned adaptation for the agricultural sector, considering indirect economy wide effects as well as international trade?

To address this question we use a multi-country and multi-sector recursive dynamic Computable General Equilibrium (CGE) model which takes into account international trade flows. In addition, we extend it with specific features to include irrigation as a planned adaptation measure. This comprises enhancing the model, and its database with information on rainfed, irrigated land, and irrigation services. These modifications allow us not only to assess impacts of climate change with an improved model, but also assess the contribution of irrigation as a specific adaptation action.

The economic impact literature proposes two different approaches to address climate change and adaptation on the agricultural sector: partial and general equilibrium analyses. The former uses partial equilibrium models to take into account equilibrium conditions only for selected crops, and disregarding possible interactions with the rest of the economy by fixing prices in all other economic activities. The latter instead uses CGE models which consider price interaction across markets and show explicitly several linkages between different activities of the economic system. According to these features, CGE models allow to analyse both direct and indirect effects of a specific economic context. Hence, they have been largely used to assess the impact of climate change and autonomous adaptation. However, few global CGE models explicitly consider water resources in the agricultural sector. Furthermore, when the role of irrigation as a planned adaptation strategy is analysed, it is treated as an exogenous variable rather than an endogenous decision based upon cost efficiency considerations (e.g., Berrittella et al., 2006; Calzadilla et al., 2013; Koopman et al., 2015).

The main innovative feature of the modified CGE model is related to agricultural production. Farmers can decide to use both rain-fed and irrigable land, substituting one for the other according to their relative costs. Irrigable cropland is usually more valuable because it requires better conditions in terms of slope, drainage, texture, soil depth, etc. (FAO, 1997). Furthermore, irrigation services based on capital and infrastructure are demanded by farmers to use irrigated land. Hence, irrigated land is not only more productive, but also more costly because the value of land is higher, and due to the required irrigation services associated to capital, operational and maintenance costs. While these modifications regard the demand for irrigable land, it was also necessary to modify the land supply structure. Land owners can allocate land between pasture and cropland. Moreover, within cropland it is also possible to convert rainfed land into irrigable land which can be offered to farmers at a higher price.

However, it is of most importance to understand the ability of the model to mitigate the initial negative impact expected in a climate change scenario. If the model is successful in reducing the impact or even increasing crop output, then it can prove to be a useful tool to analyse climate change impacts and adaptation in agriculture. We run a straightforward test by applying a negative shock to each one of the crops in each country, one at a time to avoid intersectoral and international trade effects. In addition, we run the model deactivating the cropland conversion from the supply side, which provides a “No Adaptation” scenario and allows estimating the additional contribution of adaptation in the model. When each crop is affected by a reduction in land productivity (both rainfed and irrigated land) farmers demand more irrigated land to compensate for the negative impact. In the No Adaptation scenario, there is an increase in price due to the rigidity in land conversion while in the Adaptation scenario, crop output is slightly higher while prices increase less than in the No adaptation case.

These test results apply only when one crop in one region is affected, but climate change is a worldwide phenomenon. If climate change would affect negatively agricultural productivities, the demand for irrigation would increase to cope with those impacts. However, the interaction between changes in productivities by type of crops may have different results depending on future impacts. The initial endowment of irrigated land as well the type of agriculture (capital, labour or land intensive) will determine the final economic outcome.

We apply this modelling framework to different scenarios of climate change highlighting effects on the demand for irrigation, land as well as the price and production of agricultural commodities; and finally on country GDP. To better address uncertainty at sectoral, and regional level we use simulations from five crop models from the AgMip project also for different climate scenarios (Elliott et al., 2015; Rosenzweig et al., 2014; Villoria et al., 2014).

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