A New Fertilizer Module for the FAPRI Modeling System

Fertilizers have played an important role in recent changes in global agricultural commodity markets. First, the rising demand for agricultural commodities in order to satisfy uses for food, feed, and fuel has increased the focus on the supply side of agricultural commodity markets. In this regard, a better understanding of the use of fertilizers at the world level is crucial because fertilizer use is a key driver of crops supply. Second, these changes in global commodity markets have several environmental consequences that are at the center of attention in the international agricultural community. Because the use of fertilizers has direct and indirect consequences for the environment, an explicit treatment of the fertilizer use in agriculture contributes to a better evaluation of these consequences. For these reasons, it is important to understand how fertilizers respond to the changes in the global economy and how fertilizers interact with the crops for which they are used.

To this end, a new fertilizer module—called the WorldNPK model—has been recently introduced and linked with the FAPRI model. There are three main benefits of developing a model that makes an explicit treatment of fertilizer use in agriculture. First, there exists general interest in fertilizer application rates and fertilizer demand projections at the nutrient, country, and crop levels. Second, this constitutes an improvement to the existing FAPRI model since it gives a more realistic specification of the equations governing crop supply. Third, the new model improves FAPRI’s ability to evaluate policies that affect commodity markets, and it allows for the analysis of policies implemented within the fertilizers sector.

The WorldNPK model covers individually three macronutrients: nitrogen (N), phosphorous (P), and potassium (K). It covers the following crops: wheat, corn, rice, barley, sorghum, oats, rye, soybeans, rapeseed, sunflower seed, oil palm, cotton, sugarcane, and sugar beet. The countries covered mirror the FAPRI coverage, such that for each crop, the most relevant countries in terms of production, consumption, or trade are explicitly modeled. The remaining countries are modeled, for each crop, within a regional aggregate. The model incorporates the latest available data on fertilizer use by crop from internationally recognized sources such as the International Fertilizers Industry Association (IFA), Fertilizers Europe, the Ministry of Agriculture of India, and the Food and Agriculture Organization of the United Nations.

The fertilizer model interacts with the FAPRI model by providing each crop yield equation with a term of fertilizer cost of production. This allows us to distinguish the impacts on yields of fertilizer use from the effects of other variable inputs. In the crop yield equation, a term for each nutrient (N, P, and K) is calculated as the product of a fertilizer application rate in kilograms per hectare (that is crop and country specific) and a domestic fertilizer price in local currency per kilogram (that is country specific). Each fertilizer application rate that enters the yield equation changes in each iteration of the model, a change that is consistent with variation in yields relative to the previous year. This consistency is given by the elasticity of yields with respect to fertilizer application rates weighted by the share of fertilizers in the total variable cost of production, so that only a portion of the yield change is assigned to changes in fertilizer
application rates. These elasticity coefficients come from the estimation of an underlying production function at the world level using yield data and nutrient application rates data from a cross-section of the countries covered by the model.

The interaction between the WorldNPK model and the FAPRI model allows the projection of fertilizer application rates at the nutrient, crop, and country levels. Also, fertilizer demand projections at these levels are also reported, which are a function of the fertilizer application rates and the harvested areas projected by FAPRI.

FAPRI’s ability to provide the most comprehensive projections for policy analysis is improved with the development of the fertilizer module. Policies that directly affect fertilizer markets, such as input taxes or subsidies, quantity use restrictions, and trade restrictions, can now be explicitly formulated and evaluated. The effects of these policies on global agricultural markets can be evaluated directly by the FAPRI model, and their effects on greenhouse gas emissions can be evaluated by the Greenhouse Gas in Agriculture Simulation Model, GreenAgSiM (see a description in the Special Features, “Greenhouse Gas Model”). Also, any other policy affecting commodity markets, such as input and output price shocks, biofuels mandates, and land-use change, can now be evaluated with regard to its impacts on the world fertilizer markets.

**Outlook**

World fertilizer use in 2011/12 is projected to be 179 mmt, composed of 104 mmt of N fertilizers, 42 mmt of P, and 33 mmt of K. This increase of 2.29% relative to the 2010/11 crop season reflects the expansion of the world’s agricultural frontier by 1.60% and also the more intensive use of fertilizers at the world level in most commodities (with the exception of soybeans, sorghum, sunflower, and sugarcane). All commodities except soybeans experience an increase in fertilizer consumption from 2010/11 to 2011/12. While world soybean area increases, it is offset by a decrease in the per hectare N and K application rates. On the other hand, commodities such as sorghum, sunflower, and sugarcane, whose fertilizer application rates also decrease, observe higher fertilizer consumption because of a more-than-proportional increase in their crop area.

China, India, the U.S., and the EU-27 countries account for more than two-thirds (65%) of the world’s fertilizer consumption in agriculture. China, the world’s top consuming country, followed by the U.S., is characterized not only by large crop areas but also by an intensive use of fertilizers, which is comparable to (and even higher than in the cases of wheat, sunflower seed, peanuts, cotton, sugarcane, and sugar beet) those of the U.S. and EU-27 countries. India, on the other hand, is the third-largest consumer given its larger crop areas but with its more moderate fertilizer application rates. China’s fertilizer use increases by 1.37% in 2011/12, driven by higher fertilizer application rates for most commodities; however, the lower areas for most crops are not enough to drag down total fertilizer consumption. Fertilizer use in India marginally increases, by 0.8%, as a result of a generalized extensification (except in the case of wheat) and more intensive use of fertilizer per hectare (except for cereals). Fertilizer use in the U.S. increases by 2.93%, dominated by higher use of fertilizers in corn, wheat, and sorghum because of expanded area and fertilizer application rates.
The majority of the commodities (wheat being the exception) show a sustained increase in their demand for fertilizers over the projection period (from 2011 to 2025). In the cases of corn, barley, peanuts, palm kernel, cotton, and sugar beet, this is driven by an increase in both the crop area and the fertilizer application rates. However, for soybeans and sugarcane, while the world area increases, the fertilization rates at the world level decrease because of a shift of crop area toward countries with relatively lower application rates per hectare (in the case of soybeans), or because of a more rapid increase in the cropping areas of those countries with relatively lower application rates per hectare (in the case of sugarcane).