WORLD PRICE RESPONSES TO RICE PRODUCTION AND TRADE SHOCKS: A SYSTEM DYNAMICS PERSPECTIVE AND EARLY WARNING IMPLICATIONS

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INTRODUCTION
From the end of 2007 to the middle of 2008, the world prices of major grains abruptly and drastically surged to unprecedented levels. The trading price of rice in particular rose much more quickly than other grains, such as wheat and maize, tripling within this very short period in the spring of 2008. The price increase was not due to crop failure or a particularly tight global rice supply situation. Instead, trade restrictions by major suppliers, panic buying by several large importers, a weak dollar, and record oil prices were the immediate causes of the rise in rice prices. The 2007-08 rice price increase followed price spikes for major agricultural commodities such as wheat, corn, and soybeans. The primary cause of the rise in prices for these commodities from 2006-08 was recognized as a combination of causes including rising global incomes, dietary changes, increased use of biofuels, tight grain supplies, and increased participation in futures markets by nontraditional investors. Because rice which is critical to the diet of about half the world’s population is produced and consumed as a staple in many developing countries, the rapid increase in global prices had a detrimental impact on those rice consumers’ well-being. Although rice prices have dropped more than 40 percent from their April 2008 highs, they remain well above pre-2007 levels (Slayton, 2009). Numerous articles concerning this unexpected food crisis have been published since 2008. Most of the literatures discuss the causes of price surge, the impact of the price surge, and the policy implications to prevent future crises (Timmer, 2008). As for the causes of the rice price spike, there seems to be a common understanding that export bans or restrictions by major rice exporters, such as India and Vietnam, and the panic purchase by major importers, such as the Philippines, pushed the price to this height (Headey, 2011). The short-term behavior of world rice prices throughout the 2008 crisis looks like an overshoot (from a relatively stable condition) to a very high level, followed by a rapid decrease to partially recover and stay around a relative high level. Unexpected price surges have been modeled in a few papers (Timmer, 2008; Lagi et al., 2011), using ‘supply to storage’ models but considering the single stock of food for the whole world to show the stock depletion mainly due to speculation in several forms. Another paper (Headey, 2011) is focused on trade shocks using ‘back of the envelope’ calculation for discrete import and export transactions within the year of 2008 to illustrate how high the price surge can be under the assumption of low consumption and low production elasticities of price. The purpose of this modeling exercise is to build a System Dynamics model in order to generate and explain dynamic behaviors of world rice price in response to exogenous shocks such as production and trade shocks since, to our knowledge, there is no such model developed yet.

MATERIALS AND METHODS
The rice system in the global trading context is modelled in our study to consist of two aggregate groups of countries: (1) rice-exporting countries and (2) rice-importing countries. The top rice-importing countries include Thailand, Vietnam, India, Pakistan and the US; and the top rice-importing countries in Asia include the Philippines, Indonesia, and Malaysia. As rice can be storable, the global rice is considered to be stored mainly in the two aggregate stocks: one in exporting countries and another in importing countries. These two stocks are coupled through shipment that is delivered from exporting countries to importing countries.
So, we deal with the generic stock management problem but at the world level of aggregation. The management problem for either stock is structured explicitly by considering the two coupled parts: (1) the stock and flow structure of the system and (2) the decision rules used by the management to control the flows. In addition, there are other two specific stocks included in between – export stock and goods in-transit. Such inclusion is necessary for determining world rice price and dealing with delivery delay, respectively. The rice stock will be modelled first for exporting countries, followed by importing countries, then combined to represent a supply chain with the export stock inserted to be based for the hill-climbing search-based world price setting (Sterman 2000) which in turn transmits to domestic markets to change local consumption and production, hence closing the master loop between the supply change for world trade and pricing. The interactions between the supply chain of physical stock sub-systems and world trading prices are modelled to bring export and import into balance (or to the desired level of stock coverage) through responses to prices of local productions and consumptions. It is very interesting to note here that the same decision-making heuristic of anchoring and adjustment is applied in the stock management decisions (in both exporting and importing countries) as well as in the world price setting process. The data currently used for model testing and analysis are based on world rice statistics (production, consumption and trade) to represent the situation just before the crisis in 2008. The model is initially set in equilibrium, then disturbed from month 4 and run for about 4 years to generate short-term dynamics, by possible changes in production, consumption and inventory. Note that we assume no change in population (hence normal demand) in the short-run.

RESULTS AND DISCUSSION

Control flows are technically employed for both outflows and inflows in exporting and importing countries respectively, to account for production surplus or deficits in addition to stock adjustments. Likewise, standard anchor-and-adjustment heuristics are also systematically used to be based for making decisions on desired supply for export, desired demand for import, as well as on setting indicated world trading prices. Several types of delays are considered including delivery delay associated with the goods in transit, and stock adjustment times to bring these stocks in line with their desired levels.

It is found that the prices are responsive to temporary shocks of production or consumption, or even a step increase in desired food stock, but recovered after some period of time. In the case of long-term shocks of production or trades (or export restrictions), world prices, however, may create undesirable overshoot patterns and then recover partially. Systematic assessment and continuous monitoring of these shocks in terms of their sources and magnitudes will provide important insights for developing an early warning system for food price volatility. Such sources must include top exporters and importers with magnitudes of potential supply for exports as well as demand for imports in response to various types of shocks.

CONCLUSION

World prices of staple food are known to be volatile mainly because of concentration of its production base together with a high level of domestic protection, especially for rice, resulting in market thinness for world trade, hence being susceptible to any shocks. The main purpose of this paper is to develop a System Dynamics model to capture a supply chain of flows of rice as staple food from exporting to importing countries and its interactions with world trading prices in order to generate world price dynamic patterns created by various shocks ranging from production to consumption, stockpiling and trade shocks. It is found that
the prices are responsive to temporary shocks of production or consumption, or even a step increase in desired food stock, but can be recovered after some period of time. In the case of long-term shocks of production or trades (or export restrictions), world prices, however, can create undesirable overshoot patterns and then recover only partially. The model will be used effectively for developing an early warning system for food price volatility.

**BENEFIT(S) TO INDUSTRY**

The model developed in this study along with preliminary research findings serve as important starting points for understanding rice price dynamics. Based on this, systematic assessment and continuous monitoring of production, inventory and international trade shocks in terms of their sources and magnitudes will provide more important insights for developing an early warning system for food price volatility.

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