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On the upsurge of U.S. food prices revisited

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ABSTRACT

The objective of this study is to empirically examine the effects of changes in exchange rate, commodity price and energy price on five U.S. food prices — cereal/bakery, meats, dairy, fruits/vegetables and beverages. The Johansen cointegration analysis and a vector error-correction (VEC) model are applied to monthly data for the 2001–2010 period. Results show the existence of stable long-run relationships among the selected variables. We also find that energy and commodity prices have influenced U.S. food prices mainly through changes in prices of cereal/bakery, meats and dairy. Finally, exchange rate is found to have been a significant factor influencing U.S. food prices. The Energy Independence and Security Act of 2007 is one of main driving forces for the recent food price inflation, which has affected negatively consumers, especially low income households, in the United States.
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1. Introduction

During the period 2006–2008, U.S. consumers had experienced the rapid spike in food prices not witnessed for almost two decades. The Consumer Price Index for all food (food CPI), for example, increased by 5.0% between 2007 and 2008, the highest increase since 1990. Prior to this period, the food CPI in the U.S. had never increased above the average annual rate of 4.0% over the past 15 years. As a result, the food CPI increased much faster than the Consumer Price Index for all items (overall CPI) (3.3%). This sharp upward trend in U.S. food prices had mainly been led by increases in prices for cereal/bakery (7.3%), meats/poultry (5.0%), eggs (21.5%) and dairy products (7.7%).

A large body of literature has analyzed the so-called 2006–08 price surge in the U.S. food markets (for example, Abbott et al., 2008; Hanrahan, 2008; Headey and Fan, 2008; Herndon, 2008; Lipsky, 2008; Mitchell, 2008; Rosegrant, 2008; Schnepf, 2008; Trostle, 2008). These studies have typically attempted to identify the causations of the sharp hikes in U.S. food prices. The results from these studies generally suggest that, among other things, rising energy prices (i.e., crude oil prices), increased farm commodity prices (due mainly to significant growth in ethanol production) and the weak U.S. dollar have been the important factors driving up the rise in food prices. Trostle (2008), for example, shows that the U.S. dollar's global weakness has helped U.S. major commodities become more competitive on export markets, thereby enhancing foreign demand for U.S. commodities and hence prices. In addition, Mitchell (2008) finds that the rapid increase in crude oil prices has significantly increased the competitiveness of ethanol, which in turn has pushed up demand for farm commodities (i.e., corn) and thus prices.

One common feature of the studies reviewed above is that they have mostly used descriptive statistics, graphical methods and simulation methods at best in tackling the issue. In other words, relatively little attention has been paid to conduct econometric work on this topic. To our knowledge, Baek and Koo (2010), and Lambert and Miljkovic (2010) are perhaps the only two published articles that have introduced an econometric technique to empirically quantify the impacts of market factors on U.S. food prices. Using a cointegrated vector autoregression (CVAR) model, for example, Baek and Koo (2010) find that commodity price, energy price and exchange rate have significant impacts on U.S. food prices. Using the same econometric method, Lambert and Miljkovic (2010) show that commodity prices and food industry wages have played key roles in influencing U.S. food prices during the 1970–2009 period, but energy prices have not. One deficiency of these studies, however, is that they have commonly used aggregate food prices (i.e., food CPI) in linking food price inflation and market factors.[3] Given that the impacts of market factors (i.e., prices of energy and commodities and exchange rate) on food prices vary depending on different food products, their empirical findings may suffer from aggregation bias

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[3] Unlike Lambert and Miljkovic (2010), we have excluded industry wages from the final model. It is because agriculture is known as one of the most capital intensive industries in the U.S. economy; hence, changes in industry wages may have little impacts on U.S. agricultural prices. In addition, the USDA recently reports that the increase in the 2006–2008 food prices is primarily the result of high energy prices. Thus, it seems sufficient enough to include energy prices as a key factor in the model.

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of data, thereby resulting in a misinterpretation of the dynamics of food prices in response to changes in the market variables.[4]

In this study, we take one step further and attempt to quantify the effects of various market factors on U.S. food prices within the context of disaggregating price series for food in the United States. A special attention has been given to the assessment of dynamic linkages between changes in prices of energy and agricultural commodities and exchange rate, and changes in prices of five major food groups such as cereal/bakery, meat, dairy, fruits/vegetables and beverages. To achieve this objective, we use Johansen's maximum likelihood cointegration analysis and vector error-correction (VEC) models as Baek and Koo (2010) did. The cointegration approach takes into account data nonstationarity and allows us to explore the dynamic relationships among a group of variables without imposing a priori structural restrictions on the model (Sims, 1980). It is hoped that this careful study should lead to a better understanding of the 2006–08 food price surge in the United States. The remaining sections present theoretical framework, empirical methodology, data, empirical findings and concluding remarks.

2. Theoretical framework

To illustrate theoretical relationships among five major food groups, prices of energy and agricultural commodities, and exchange rate, the individual consumer's demand for food group j, which maximizes consumer utility subject to its budget constraint, is first defined as:

$$D_j^i = f\left(P_j, Y\right) \tag{1}$$

where D_j^i is individual i's demand for food group j — in this study, for example, $j =$ cereal/bakery, meat, dairy, fruit/vegetable and beverage; P_j is the price of food group j; and $Y$is the individual's disposable income. An aggregate demand for food group j in a region is a product of the individual demand for food group j and the population in the region:

$$D_j^r = D_j^i \times POP^r \tag{2}$$

where D_j^r is the aggregate demand for food group j in region r; and POP^rdenotes the region's population.

We then define the total supply of food group j in a region, which is largely determined by agricultural goods and fisheries available for food production in the region.

$$S_j^r = f\left(P_j, AF\right) \tag{3}$$

where S_j^r is the aggregate supply of food group j in region r; and AF is agricultural and fishery products produced for food products in the region. It is important to emphasize that, since total agricultural and fishery products produced are generally used for food production, biofuel production and exports, agricultural products used for food production can be defined as the total agricultural production (AP) minus the sum of agricultural and fishery products used for production of biofuel and exports as follows:

$$AF = AP(CP) - AT(CP, ER) - G(CP, ENP) \tag{4}$$

where AT represents exports of agricultural and fishery products, which is defined as a function of the price of agricultural commodity (CP) and relevant exchange rate (ER); and Grepresents agricultural and fishery products used for non-food purpose, mainly biofuel production and depend on the price of agricultural commodity (CP) and the price of energy (ENP). Accordingly, AFcan be specified as a function ofCP, ENP and ER.

Finally, Eqs. (2)–(4) and the market equilibrium conditions for the demand for and supply of each food group yield the following relationship:

$$P_j = f(CP, ENP, ER, Y). \tag{5}$$

Since the U.S. government has mandated the renewable fuel standard at 10% of gasoline used under the Energy Independent and Security Act (EISA) of 2007, biofuel production is sensitive to the price of energy (ENP). As the price of energy increases, biofuel production will increase and also increase prices of food since agricultural products are used for biofuel production rather than food production. Exchange rate (ER) is also sensitive to food prices, because U.S. exports of agricultural products are strongly related to the value of the U.S. dollar against the importer's currency. Similarly, agricultural commodity prices (CP) are highly correlated with food prices. The relationship between the prices of the food groups (P_j) depends upon whether they are complementary or substitute. It should be pointed out here that, since a small portion of individual household income is used for food in the U.S., we drop disposable income from our empirical modeling.

3. Empirical methods

The Johansen cointegration approach (Johansen, 1995) starts with an unrestricted vector autoregression (VAR) of z_t involving up to k lags:

$$z_t = \sum_{i=1}^{k} \Phi_i z_{t-i} + \Psi w_t + \alpha + \mathrm{u_t} \tag{6}$$

where z_t is a $(1 \times n)$ vector of jointly determined (endogenous) variables – in this study, $z_t = [CEL_t, MET_t, DRY_t, FRU_t, BEV_t]$; w_t is a vector of exogenous variables – in this study, $w_t = [ER_t, ENP_t, CP_t]$; α is a vector of constant term; and u_t is a vector of normally and independently distributed error term. CEL_t, MET_t, DRY_t, FRU_t and BEV_t represent cereal/bakery, meat, dairy, fruit/vegetable and beverage, respectively. ER_t, ENP_t and CP_t represent exchange rate, energy price and commodity price, respectively. Because the right-hand side of each equation in Eq. (1) consists of a common set of regressors including lagged and predetermined variables, ordinary least squares (OLS) is efficient to estimate each equation (Harris and Sollis, 2003). It is should be pointed out, however, that, if variables in z_t are nonstationary, then OLS regression among the series results in a spurious regression problem (Wooldridge, 2006). To avoid this problem, Engle and Granger (1987) show that, even in the case that all the variables in a model are nonstationary, it is possible for a linear combination of integrated variables to be stationary; in this case, the variables are said to be cointegrated and hence the problem of spurious regression does not arise. Accordingly, the first requirement for the use of the Johansen approach is that the variables must be nonstationary.

Eq. (6) can be reparameterized using the lag operator (L;$\Delta = 1 - L$) as follows:

$$\Delta z_t = \sum_{i=1}^{k-1} \Gamma_i \Delta z_{t-i} + \Pi z_{t-k} + \Psi w_t + \alpha + u_t \tag{7}$$

where $\Gamma_i = -(I - \Phi_1 - \ldots - \Phi_i)$, (i = 1, …, k - 1) and $\Pi = -(I - \Phi_1 - \ldots - \Phi_k)$. The system specified this way contains information on both short-run and long-run adjustments to changes in z_t, via the estimates of Γ_i and Π, respectively. That is, $\Pi = \alpha\beta'$, where α represents the speed of adjustment to equilibrium and β' is a matrix of long-run coefficients such that the term $\beta' z_{t-k}$ represents up to $(n - 1)$ cointegration relationships in the system (Johansen, 1995). Eq. (7) is said to be cointegrated of rank r, if Π has a rank r. If Π has a rank 0

[4] It is worth mentioning that in the early 2011, *Journal of Policy Modeling* published a special issue containing several papers that analyzed the agri–energy–food price nexus (see Sieber and Dominguez, 2011). Schade and Wiesenthal (2011), for example, investigate the interrelationship between commodity prices (e.g., oil and feedstock prices) and biofuel using the Monte Carlo method. However, these papers focus on the European agricultural markets.

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