Determinants of the Export Demand of U.S. Distillers Dried Grains with Solubles

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The production and utilization of distillers dried grains with solubles (DDGS), a co-product of corn ethanol, have surged since the Energy Policy Act of 2005 in the United States. On average, one metric ton of DDGS can supply the equivalent protein and energy content as feeding approximately 1.22 metric ton ration consisting of a combined 1.03 metric ton corn and 0.19 metric ton soybean meal (Hoffman and Baker, 2011). Thus, the feed consumption of DDGS in the U.S. has grown more than threefold from 2004/05 to 2014/15 (USDA ERS, 2016). Meanwhile, U.S. DDGS exports have expanded at a much faster rate than domestic feed consumption, increasing from less than one million metric tons (mmt) in 2004/2005 to 11.5 mmt in 2014/2015 (USDA ERS, 2016). The surge of DDGS sales has presented an opportunity to expand U.S. agricultural trade and become increasingly important for the ethanol industry.

Despite the increasing importance of DDGS to U.S. agricultural and biofuel sectors, there is limited literature on what drives the exports of U.S. DDGS and the expected growth of exporting U.S. DDGS to other countries in the future. A commonly used approach to understanding the determinants of the trade flows of agricultural commodities among different countries is the gravity model. The gravity model has been used to evaluate the effects on the trade flows of agricultural commodities with regional free trade agreements or monetary union (e.g. Zahniser et al., 2002; Sarker and Jayasinghe, 2007; Glick and Rose, 2002); changes in tariffs and non-tariffs barriers (e.g. Jayasinghe et al., 2010; Bao and Qiu, 2012; Dreyer and Fedoseeva, 2016); and changes in exchange rates between trading countries (e.g. Kandilov, 2008; Sheldon et al., 2013). A gravity model approach could explain how country size and transaction costs impacts DDGS trade flows between U.S. and its trading partners.

The objective of this study is to identify the determinants of U.S. DDGS exports through a gravity model. To our knowledge, this is the first study to identify the determinants of U.S. DDGS trade in the literature. This information could help the stakeholders of U.S. agricultural, the biofuel sectors, and U.S. trade policy agreements make decision to boost DDGS sales. A commodity-specific gravity model was applied to U.S. DDGS exports to 29 countries from 2000 through 2013.

Following Sheldon et al. (2013) and Hatab et al. (2010), the country-pair fixed effects were applied to control for country-specific influences on trade flows. The distance variable was then dropped as it would have been collinear with the country-pair fixed effects. A reduced-form of gravity equation that explains the determinants of U.S. DDGS exports is defined as:

(1) $$X_{1jt} = Exp(\beta_0 + \beta_1(\ln E_{1t}) + \beta_2(ln(1 + z_{1jt})) + \beta_3(lnA^D_{1t}) + \beta_4(lnA^W_{jt}) + \beta_5(ln\, r_{j1t}) + \beta_6(bt_{1jt}) + \beta_7(I_{1j})) + \mu_{1jt},$$

where X_{1jt} is the quantity of DDGS exported from the U.S. (country 1) to country *j* (*j* = 2,…,30) in the year *t* (*t* = 1,…, 14) in metric tons (mt); $\beta_0, \ldots, \beta_7$ are coefficients to be estimated; E_{1t} is U.S. ethanol production; z_{1jt} is the *ad valorem* tariff applied to DDGS by country *j* to U.S. DDGS exports; A^D_{1t} represents the market size of DDGS use in the U.S., using variables defined in specification 1, 2, and 3 (i.e. livestock stock, red meat consumption and red meat production respectively); A^W_{jt} represents the market size of DDGS use, using variables defined in specification 1, 2, and 3; r_{ijt} is the real exchange rate in country *j* with respect to U.S.; bt_{jt} is a dummy variable recording a notification of technical barrier of trade from country *j*; I_{1j} represents country-pair fixed effect, and μ_{1jt} is the error term.

The Pseudo-Poisson maximum likelihood (PPML), proposed by Santos Silva and Tenreyro (2006), has been used to estimate the gravity model to address the heteroskedasticity in the error term and zero values for the dependent variable. Also, PPML performs well in small samples (Westerlund and Wilhelmsson, 2011). Furthermore, Fally (2015) shows that the gravity model estimated using PPML approach with fixed effects of trading countries (exporters and importers) is consistent with the approach imposing "multilateral resistance" indexes proposed by Anderson and van Wincoop (2003). Since the gravity model in equation (1) was estimated in a level-log form, the coefficients of the continuous explanatory variables are the exports elasticities of each variable. For the dummy variable, the percentage change in exports was calculated as the exponential of the coefficient minus one, multiplied by 100.

Results suggest that U.S. DDGS exports were impacted by U.S. ethanol production, *ad valorem* tariff, technical barriers to trade, and demand for DDGS, such as stock of cattle, red meat production or consumption, in the importing countries. Demand for DDGS in importing countries was the most influential factor to U.S. DDGS exports. Specifically, a 1% increase in demand for DDGS in importing countries leads to about 3% increase in U.S. DDGS exports. Thus, U.S. DDGS exports in the outlook is closely related to the annual growth of red meat production or stock of cattle.

The U.S. ethanol production, as a proxy of the supply of DDGS, is also an elastic factor to U.S. DDGS exports. However, ethanol production in the U.S. is projected to be stable in the next few years as the U.S. has reached the mandate of corn-based ethanol production proposed by U.S. Environment Protection Agency. Lower crude oil prices may also prevent a greater expansion on the production of corn-based ethanol and DDGS. Therefore, the effect of U.S. ethanol production on DDGS exports may not be as strong as it was in the following years.

Our findings also suggest that technical barriers to trade adversely impacted the exports of U.S. DDGS to a great extent, which was larger than the influence of tariff. The E.U. used to be the dominant export market for U.S. DDGS between 1995 and 2000 with a share of over 80%. However, as a result of regulations on genetically modified grains and their co-products in 2004, DDGS exports to the EU declined rapidly and its share of U.S. DDGS exports plunged to only 4% in 2015. Similar strategy was applied by China in 2016 due to its domestic overstock issue of corn, and DDGS exports to China dropped from over six mmt in 2015 to likely about two mmt in 2016. Policy makers should make an earnest effort to negotiate with major international buyers of DDGS, such as China, to mitigate the further damage of trade policy distortions on DDGS exports.

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