



# Policy induced price volatility transmission: Linking the U.S. crude oil, corn and plastics markets



Jingze Jiang<sup>a,\*</sup>, Thomas L. Marsh<sup>b</sup>, Peter R. Tozer<sup>b</sup>

<sup>a</sup> Department of Business and Economics, School of Business, Edinboro University of Pennsylvania, Edinboro, PA 16444, USA

<sup>b</sup> School of Economic Sciences, Washington State University, Pullman, WA 99164, USA

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## ABSTRACT

Policy changes and the evolution of green technology have induced new linkages in commodity markets. In this research, we study a representative market system, the U.S. crude oil, corn and plastics markets affected by policies promoting corn-based energy and corn-based bioplastics production. A vector error correction model (VECM) is estimated to study price transmission among markets in the United States, especially price volatility spillover effects. We find that plastics prices and corn futures prices move together in the long run, but that the crude oil futures prices are weakly exogenous to this system. We identify significant bidirectional volatility transmission between the corn futures and plastics markets, which brings new challenges to stakeholders in both markets. Moreover, we demonstrate that EISA 2007 has strengthened linkages between the corn futures and crude oil futures markets. In addition, changes in the linkages across the three markets are associated with the fuel ethanol–gasoline consumption ratio. The potential application of these findings for policy makers and risk managers is discussed.

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## 1. Introduction

Policy changes and the evolution of green technology have induced new linkages in commodity markets. Examples include policies and programs promoting biotechnology development and expansion of biofuel production (Wu et al., 2011). The plastics market is no exception. The use of corn-based bioplastics, which may be more degradable, is increasing due to growing concerns about pollution from non-degradable conventional plastics (Begemann, 1997; Vickner, 2013).<sup>1</sup> Stricter regulations on plastic waste disposal have also driven consumers away from conventional plastics in search of environmental friendly materials (Calcott and Walls, 2000). Many auto companies, such as Toyota and Mazda, already use bioplastics for interior design (DeMorro, 2014; Miel, 2015). The

largest bioplastics manufacturer, Nature Works LLC, reports an average annual sales growth of 20% (Plastics News, 2015). Leaversuch (2002) suggests that the demand for biodegradable polyesters is growing by approximately 30% per year.

The plastics industry is the third largest manufacturing industry in the United States and a multi-billion dollar industry. Plastic products are pervasive and in high demand around the world from injection molding to 3D printing. In 2012, about \$373 billion worth of goods were shipped by United States plastics manufacturers and the plastics industry created a \$13.1 billion trade surplus. In fact, there are nearly 16,000 facilities in the United States that directly create 900,000 jobs (American Chemistry Council, 2015; Plastics Industry Trade Association, 2014, 2015; U. S. Department of Labor Bureau of Labor Statistics, 2015).

Conventional plastics are primarily petrochemical products that utilize oil and natural gas as major feedstock and fuel (Speight, 2010). In 2010, about 3% of the petroleum used in the United States, or 190 million barrels of liquid petroleum gas (LPG) and natural gas liquids (NGL), was used in the production of plastic products. Of those 190 million barrels, around 99% was used as feedstock and the rest consumed as fuel (Energy Information Administration, 2013). More than 40% of the cost of manufacturing plastics is hydrocarbon feedstock (Vickner,

\* Corresponding author at: 234 Hendricks Hall, 235 Scotland Road, Edinboro University of Pennsylvania, Edinboro, PA 16444, USA. Tel.: +1 814 732 1441.

E-mail address: [jjiang@edinboro.edu](mailto:jjiang@edinboro.edu) (J. Jiang).

<sup>1</sup> Typically plastics are high molecular weight polymers, which are mixed with other substances for the purpose of performance improvement and cost reduction. The term “plastics” defines a wide range of synthetic or semi synthetic organic amorphous solid materials that are used for the industrial products manufacture.

2013). Therefore, increasing uncertainty in crude oil market likely affects the plastics industry (Chang, 2013).

The Energy Policy Act of 2005 (EPA 2005) listed developing bio-products, including biomaterials, as substitute products for petroleum-based feedstock that may enhance economic security and stability. Subsequently the Energy Independence and Security Act of 2007 (EISA 2007) was signed into law, which attempted to achieve greater energy independence and security. Further development of bio-products, such as bioplastics, is also considered a crucial means to achieve the goals identified in EISA 2007. In particular, corn-based bio-products may alter uncertainty from energy markets transferred into the plastics sector.

Corn-based ethanol production supports the ethanol manufacturing industry in the United States (Tyner, 2008). In 2007, the United States Department of Agriculture's (USDA) 2005 baseline expected an increased amount of corn grain to supply biofuel production. This would increase from 0.339 quads of biofuel in 2010 to 0.361 quads of biofuel in the United States by 2015 (Daniel et al., 2007). This increase is attributable in part to energy policies in the United States. Wu et al. (2011) studied the crude oil and corn markets from 1992 to 2009, and McPhail (2011) analyzed it from 1994 to 2010. They concluded that the EPA in 2005 strengthened the linkage between crude oil and agricultural commodity markets.

It is important to assess market linkages, because it can assist stakeholders in those markets to improve pricing efficiency, and to better understand the assimilation of market signals as well as structural rigidities of prices (Apergis and Rezitis, 2003). However, limited studies have examined the price transmission between the plastics and crude oil markets (Masih et al., 2010; Vickner, 2013). Furthermore, there is little or no economic research on the empirical linkages between the plastics and corn markets, nor on the linkages between the crude oil, corn, and plastics markets. Therefore, the current analysis fills an important gap in the research literature. In addition, because there is the limited number of futures markets for a plastics producer,<sup>ii</sup> finding significant volatility spillover between the plastics and corn futures markets could potentially identify cross-hedging relationships not previously understood in these markets.

To address these gaps we investigate the long-term relationships between crude oil futures, corn futures, and plastics prices in the United States from summer 2006 to spring 2014; as well as price volatility spillover effects across these markets. In addition, we examine the effect of EISA 2007; which created opportunities to expand the development of biofuel production in the United States, but of which the impact across markets has not been fully studied. Finally, we identify the impact of the gasoline-ethanol consumption in gasoline on the linkages across plastics, and corn and oil futures markets.

To measure the linkages among markets, two approaches can be considered. One is a long-term equilibrium relationship, and the other is short-term price changes. In order to model the long-term equilibrium relationship, we test for cointegration relationships among plastics, crude oil futures and corn futures prices, applying a vector error correction model (VECM). Previous economic research has analyzed long-term relationships between crude oil and corn prices, and has established identifiable links between oil, ethanol, and corn prices by applying a VECM (Birur et al., 2009; Mueller et al., 2011; Saghalian, 2010; Serra et al., 2011). Therefore, in part of our research, we focus on a long-term equilibrium analysis that includes the plastics market.

Short-term price changes are represented by price volatility or volatility spillover. Price volatility figures prominently in agricultural commodities pricing (Apergis and Rezitis, 2003; Buguk et al., 2003; Wu et al., 2011), industrial operation (Elyasiani et al., 2011) and public

policy decisions (Ray et al., 1998). This is because increased price volatility results in greater costs for risk management procedures (Trujillo-Barrera et al., 2012). Although plastics manufacturers have been buying oil-related financial instruments at an increased rate to hedge oil-price risk (Regnier, 2007), the effectiveness of such risk management strategies and opportunities for cross-hedging have not been studied. Moreover, overlooking the newly-developed volatility spillover, to or from the corn futures market, can also be interpreted as risk transmission from changing market relationships (Asche et al., 2003), in turn impacting the efficiency of risk management procedures (Apergis and Rezitis, 2003; Buguk et al., 2003).

In this study, we follow Ng (2000) and Wu et al. (2011) and fit the data with a vector autoregressive conditional heteroscedasticity (ARCH) model. The ARCH model first introduced by Engle (1982) is widely applied to study volatility (Brooks, 2008; Greene, 2008; Hamilton, 1994). Furthermore, evidence of volatility spillover in the financial market is well-documented (Baele, 2005; Bekaert and Harvey, 1997; Christiansen, 2007; Glosten et al., 1993; Ng, 2000), and the ARCH model is demonstrated to be suitable for modeling the volatility spillover. Christiansen (2007), who estimated the generalized ARCH (GARCH) model for US bonds, regional European bonds and local European bonds markets, found statistical evidence of risk transmission in the United States and European bond markets. Several others have applied either vector ARCH or GARCH models to analyze volatility transmission between crude oil and corn markets (Du et al., 2011; Wu et al., 2011) and all identified volatility transmission from these two markets.

We further extend the analysis with three different parameterizations for the volatility spillover coefficients: constant; event-dummy; and time-varying (Christiansen, 2007; Ng, 2000; Wu et al., 2011). The different models are developed to analyze the effect of EISA 2007 and fuel source changes on volatility spillover. In the event-dummy spillover model, we focus on the impact of EISA 2007. The EISA 2007 follows EPA 2005 and emphasizes the importance of developing clean renewable fuels<sup>iii</sup> and biotechnology. However, while others have studied the impact of the EPA 2005, the impact of the EISA 2007 has not been addressed (McPhail, 2011; McPhail and Babcock, 2012; Natanelov et al., 2011; Wu et al., 2011). Our research shows that risk from the crude oil futures market became more closely linked to risk in the corn futures market after the introduction of EISA 2007. Furthermore, results reveal that EISA 2007 also induces bidirectional volatility transmission between the corn futures and plastics markets. Although the significant volatility spillover effects are found in both constant and event-dummy models, we assume the spillover does not vary over time in either the full sample or in the sub-samples of the analysis. Therefore, we further relax the assumption of constant spillovers by allowing the spillover effect to vary with an underlying factor. We argue that the share of biofuel in total fuel consumption changes in the United States may be associated with the strength of change in linkages across the United States plastics, and corn and oil futures markets. Hence, we constructed the time-varying spillover model by allowing the gasoline-ethanol consumption ratio to drive changes in spillover parameters over time. We find with increasing ethanol percentage in gasoline consumption, there is increasing volatility transmitted from the oil market to the corn futures market. In addition, the bidirectional volatility transmission between corn futures and plastics markets is also evident in the time-varying model.

<sup>ii</sup> The plastics producers usually hedge the risk by buying oil futures, since the only plastics related future is HDPE High Density Polyethylene Futures which was not available until the end of August in 2014.

<sup>iii</sup> U.S. Government Printing Office, 2008. Senate Hearing 110-362 Retrieved from <http://www.gpo.gov/fdsys/pkg/CHRG-110shrg42123/html/CHRG-110shrg42123.htm> (Last accessed May 15, 2015).

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