An assessment of the relationship between the high fructose corn syrup and the soft drink markets in the United States

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Abstract

This study analyzes the market of high fructose corn syrup (HFCS) in the United States and its linkages with soft drink market. For that, it develops a system of demand and supply equations for both the HFCS and soft drinks markets, which is estimated through Two Stage Least Squares methods. The results show that soft drinks are the main driver behind the growing demand for HFCS. In addition, negative news on HFCS (the association of HFCS consumption and obesity) has a negative effect on the growth of demand for soft drinks; however, per capita advertising on soft drinks has a positive effect on the growth of demand for soft drinks and more than offsets the effect of negative news. A vector error correction model is also estimated and reveals a long-term relationship between the per capita quantity consumed of soft drinks and HFCS. Lastly, consumption of soft drinks is found to Granger-cause consumption of HFCS.

Key words: high fructose corn syrup, sugar, soft drinks, supply, demand.

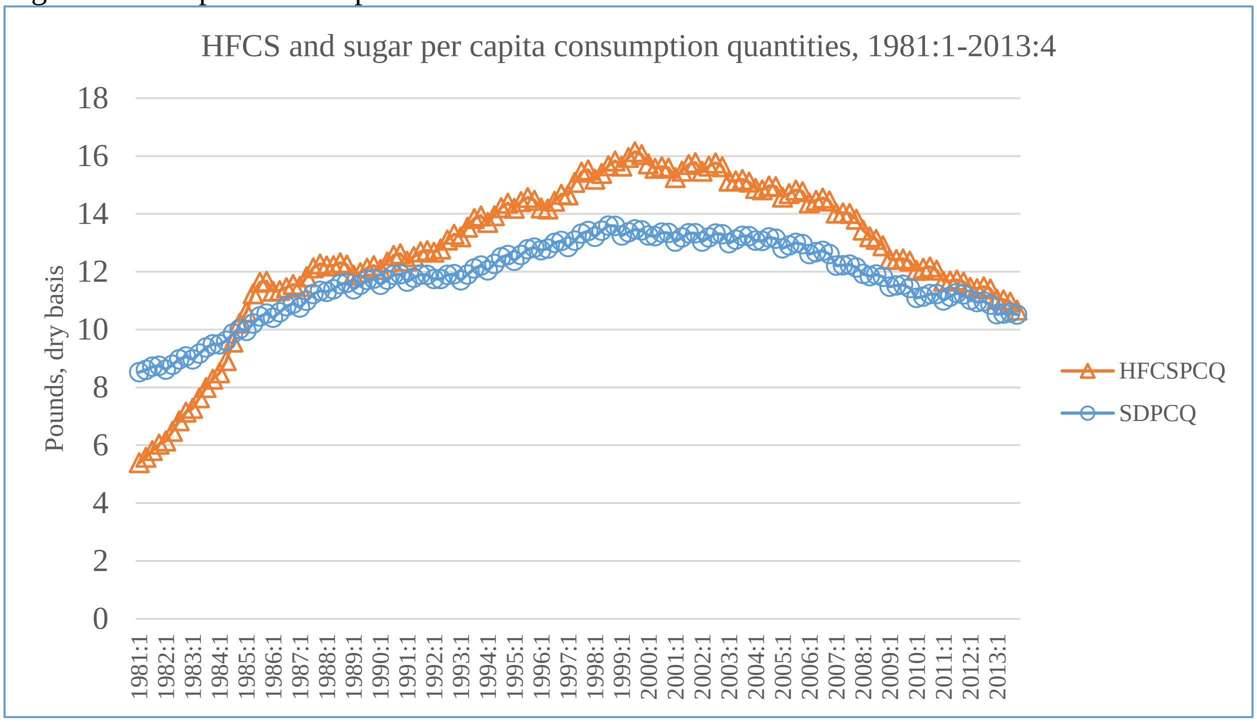
Introduction

The United States is the world's largest producer of high fructose corn syrup (HFCS), and ranked fifth in term of sugar production. On the other hand, the United States is the second largest consumer of caloric sweeteners in the world, which includes HFCS (Korves, 2011). U.S. food processors have replaced sugar with HFCS as sweetener in many final goods such as beverages and processed food products. The substitution has been mainly driven by lower prices of HFCS relative to sugar prices, which has allowed beverage and processed food manufacturers reduce costs.

In the early 1970s, there was a shock to the world supply of sugar that affected the U.S. soft drinks industry. During that period, the wholesale price of refined sugar increased from 12.4¢/lb in 1973 to 56¢/lb in December of 1974. Consequently, in December 1974, the Coca-Cola Company started replacing 25 percent of the sucrose in its Fanta soft drink with HFCS-42 (Bode, Empie, and Brenner, 2014). Other companies followed Coca-Cola and started replacing between 25 percent and 50 percent of sucrose with HFCS-42 (Forrestal, 1982). However, food processors recognized that HFCS-42 was not the best substitute for sucrose in soft drinks manufacturing. Thus, the industry increased the concentration of fructose in HFCS-42 to 55 percent and developed a new sweetener called HFCS-55 (Blanchard, 1992). The new HFCS-55 was introduced to the market in 1978 (Corn Annual, 1996).

In 1979, yet another shock to the world supply of sugar impacted the U.S. soft drinks industry, with the price of the U.S. wholesale refined sugar increasing from 21¢/lb. in 1979 to 52¢/lb. in October 1980 (Bode, Empie, and Brenner, 2014). As a response to these price increases, in 1980, Coca-Cola and Pepsi started replacing between 25 percent and 50 percent of sucrose with HFCS-55 in soft drinks manufacturing. In 1984, this replacement reached the 100 percent (Perdegrast, 1993). In the case of HFCS-42, it has become a substitute for sugar in the production of baked products, but it has also been used as sweetener in the production of beverages. Korves (2011) reports that the USDA estimated that 2.9 million tons of HFCS-42 were used in 2010 in the production of food and beverages. Figure 1 shows per capita consumption of HFCS and soft drinks for the period 1992:01-2013:12, and it reveals that rises and falls in consumption of HFCS are associated with changes in soft drinks consumption. This initial graphical analysis suggests a close relationship between the HFCS and the soft drinks markets. It is important to note that there has been a decline in the consumption of these two products that started in the late 1990s.

Figure1. Per capita consumption of HFCS and soft drinks.



Note. Authors' calculation using data from USDA/ERS, Beverage Digest, Advertising Age, Business News, and American Beverage Association.

In an economic analysis of the HFCS market that assumed a 25-percent market share ceiling for HFCS use, Carman (1982) pointed out this relationship and suggested that the potential use of HFCS in beverage products would be 100 percent and that the potential use of HFCS in processed food products would be 75 percent. Evan and Davis (2002) report that soft drinks, as final goods that use HFCS, have the strongest effect in a derived demand analysis for HFCS. However, these studies do not analyze the HFCS and the soft drinks markets in conjunction. More recently, White (2014) concludes that, of the total HFCS and sugar delivered to the different food industries in the United States, the beverage sector uses 72 percent of HFCS and nine percent of sugar. The processed foods sector uses 10 percent of HFCS and seven percent of sugar. Given the importance of HFCS as an input, shocks to the soft drinks or processed food markets will likely affect the HFCS market.

To our knowledge no research has analyzed the interactions between the HFCS and the soft drinks markets. This study seeks to contribute to the literature on the economics of the HFCS market by developing and estimating a simultaneous system of supply and demand equations for both the HFCS and soft drinks. In order to assess the validity of these findings and test the linkages between the demands for these two products, times series econometric analysis will be also employed.

The objectives of this research include: (1) assessing how changes in the soft drinks sector impact the demand for HFCS; (2) testing for a long-term relationship between the demand for soft drinks and HFCS; (3) analyzing the effects of soft drinks advertising and negative news on HFCS on the demand for soft drinks. Negative news on HFCS is used a proxy for the relation between HFCS consumption and obesity in the United States. The results show that soft drinks is the main driver of the demand for HFCS. Furthermore, negative news on HFCS are found to have a negative and significant effect on the demand for soft drinks, but soft drinks advertising more than offsets the effect of negative news. A vector error correction model was also estimated and it identifies a long-term relationship between the per capita quantity consumed of soft drinks and HFCS. Lastly, consumption of soft drinks is found to Granger-cause consumption of HFCS.

The rest of the paper is organized as follows. The second section provides a review of the literature, followed by a description of the data and methodology employed. The next section presents a discussion of the empirical results. The last section presents conclusions and suggestions for further research.

Literature Review

In an early study, Carman (1982) developed a projection of the U.S. HFCS market for the period 1981-1990 based on a HFCS ceiling market share (25 percent), a logistic function, total caloric sweetener demand, and annual data from 1967 to 1980. He identified beverages and processed food products as the first and second highest potential users of HFCS, respectively. Specifically, he suggested that the potential use of HFCS would be 100 percent for beverage products and 75 percent for processed food products. Furthermore, he estimated a sweetener demand equation to develop a projection of the HFCS market for the period 1981-1990. HFCS was expected to increase from 21.93 pounds per capita in 1981 to 33.15 pounds per capita in 1990. The projection also showed that total demand for sweeteners and demand for HFCS depended mainly on population growth.

Barros (1992) estimated the effect of sugar prices on the consumption of HFCS in the United States. He developed a model of demand and supply of HFCS expressed in growth rates and estimated a reduced form of the demand for HFCS that covered the period 1971-1988. He found evidence that high sugar prices (such as those in 1970s and 1980) were not the only factors that promoted growth in HFCS consumption. Furthermore, his results show that a division of market shares for HFCS and sugar in the sweetener market was not strongly supported, and that protected sugar prices were not the only factor affecting the growth of HFCS consumption. In another study, Evans and Davis (2002) investigated the dynamics of the U.S. high fructose sweetener market and developed a derived demand model for HFCS. Their model’s assumptions are that HFCS price has been less than sugar price, HFCS behaves as sugar substitute only on a given range of the sugar demand curve, and HFCS price is relatively inelastic. They derive a reaction function in the spirit of the Stackelberg model in which HFCS suppliers are the sophisticated ones, while sugar suppliers are the naive ones. The model suggests that given that sugar prices are higher than HFCS price, and as long as HFCS price is above its associated average cost, HFCS suppliers are able to make economic rents. The results show that demand for HFCS is relatively less elastic and suggest that decreases in sugar price are not likely to change the pattern of sweetener use in the United States. The results also show that the price of soft drinks was, economically, the most important explanatory factor in the HFCS demand equation. In a more recent study Lakkakula, Schmitz, and Ripplinger (2016) estimate a sweetener demand system that includes major caloric sweeteners (sugar, HFCS and glucose) through a Quadratic AIDS model. Their empirical findings show that sugar and HFCS are positively expenditure elastic, whereas glucose is negatively expenditure elastic. That is, only sugar and HFCS will gain from an increase in sweetener expenditures. They also conclude that HFCS and glucose are highly elastic compared to sugar. Lastly, cross-price elasticity estimations reveals a stronger substitution between HFCS and glucose relative to HFCS-sugar, suggesting that claim that sugar and HFCS may be imperfect substitutes.

The above literature shows that HFCS demand is related to final products that use HFCS. Korves (2011) reports that the USDA estimated that, in 2010, 2.9 million tons of HFCS-42 were used in the production of food and beverages while 4.6 million tons of HFCS-55 were used in the production of soft drinks. This suggests that the derived demand for HFCS is mainly driven by the demand for processed foods and soft drinks. Therefore, it is important to conduct an economic analysis of the U.S. HFCS market while accounting for the dynamics in the soft drinks market. This study will focus exclusively on HFCS-55 because of the widespread use of it by the beverage industry as a sweetener.

Methodology and Data

The proposed model is a system of supply and demand equations for the HFCS and soft drinks markets, and it is estimated using two-stage least squares (2SLS). In the case of the HFCS market, the demand equation is expressed as

$$Q_{Dhfcs} = f\left(P_{hfcs}, P_s, Inc, Q_{sd}\right) \qquad (1)$$

where Q_{Dhfcs} is quantity demanded of HFCS, P_{hfcs} is the real list price of HFCS in cents per pound, P_s is real U.S. wholesale price of refined beet sugar in cents per pound, Inc is real personal disposable income, and Q_{sd} is per capita quantity of soft drinks. The supply equation is represented by

$$Q_{Shfcs} = f\left(P_{hfcs}, P_{cN}, STP, Trend\ \right) \qquad (2)$$

where Q_{Shfcs} is the quantity supplied of HFCS, P_{cn} is real price of corn, STP is sugar trade policy, and $Trend$ is a time variable used to control for changes in technology. Equation (1) includes per capita consumption soft drinks as a link between the HFCS and the soft drinks markets.

The demand and supply equations for the soft drink market are shown below

$$Q_{Dsd} = f(P_{sd}, Inc, Dnn, Adv_{sd}) \qquad (3)$$

where QD_{sd} is per capita quantity demanded of soft drinks, P_{sd} is real soft drinks producer price index, Inc is real personal disposable income, Dnn is a dummy variable for negative news about HFCS that takes the value of one from January, 2004 to December, 2013 and zero otherwise, and Adv_{sd} is per capita soft drinks advertising expenses.

$$Q_{Ssd} = f\left(P_{sd}, P_{hfcs}, Trend\right) \quad (4)$$

where QS_{sd} represents per capita quantity supplied of soft drinks where P_{sd} is real soft drinks producer price index, P_{hfcs} is the real list price of HFCS in cents per pound and $Trend$ is used to control for changes in technology.

This research uses quarterly data covering the period from 1982:1 to 2013:4. Prices of HFCS-55 are list prices in cents per pound of dry weight obtained from USDA/ERS. Per capita quantity of HFCS-55 in pounds was constructed by interpolation using annual data from the USDA/ERS and Proc Expand in SAS. Price of corn is in dollars per bushel and is also obtained from the USDA/ERS. The electricity producer price index is obtained from the Bureau of Labor Statistics. Real interest rate is computed by subtracting Moody's Seasoned AAA Corporate Bond Yield from inflation rate[1]. GDP deflator is from the Bureau of Economic Analysis (BEA). Wholesale price of refined beet sugar is in cents per pound is obtained from the USDA/ERS. Soft drinks producer price index (PPI) is obtained from the Bureau of Labor Statistics. Negative news on HFCS is a dummy variable that takes the value of 1 from January 2004 onwards and zero otherwise, and it is based on the publication date of the paper by Bray, Nielsen, and Popkin (2004) that suggests that overconsumption of HFCS in beverages is likely to be associated with obesity. Personal disposable income is obtained from the BEA. Per capita quantity of soft drinks is expressed in gallons and was constructed by interpolating yearly data from USDA/ERS, Beverage Digest, Advertising Age, Business News, and the American Beverage Association. Per capita advertising expense of soft drinks for Coca-Cola, Pepsico, and Dr. Pepper is constructed by using COMPUSTAT historical segments and data on total advertising expenses for these companies. We computed yearly advertising expenses for Coca-Cola, Pepsico, and Dr. Pepper by multiplying each company's share of U.S. sales in total sales by each company's total advertising expenses. Population is obtained from the BEA, and all monetary figures are in 2005 dollars. More detailed variable definitions, data sources, and descriptive statistics are available in Appendices 1 and 2, respectively.

Results

The first step in the empirical analysis is the examination of the time series and stationarity properties. This is important because when variables are nonstationary, standard ordinary least squares (OLS) models cannot be applied and there might be a spurious regression. Spurious regressions are normally characterized by having a high R^2 and statistically significant t-statistics; however, their results have no economic meaning (Granger and Newbold, 1974). The stationarity of the series is first investigated by applying the augmented Dickey-Fuller and the Phillips and Perron (1988) unit root tests. Results indicate that all series have a unit, but become

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[1] Moody's Seasoned AAA Corporate Bond Yield data is obtained from the Federal Reserve Bank of St. Louis, whereas inflation is represented by percentage change of 2009 GDP deflator.

stationary after being first differenced. That is, all variables are I(1). Thus, first differences of the logs of each series are used in the 2SLS estimations, and demand and supply are expressed as growth rates. Further, first differences have been found to contribute to reduce serial correlation and to improve the statistical properties of the estimates (George and King, 1971).

Table 1 shows results for the case of demand and supply estimations of HFCS-55 without concurrently estimating the supply and demand equations for soft drinks. The estimates for prices follow the laws of supply and demand in each equation. Note that increases in per capita consumption of soft drinks have a positive and very significant impact on the demand for HFCS. The results show that one percentage point increase in the growth rate of soft drinks increases the growth rate of demand for HFCS-55 by 1.32 percentage points.

Table 1. Demand and Supply of HFCS, 2SLS, 1982:1-2013:4

Demand and Supply of High Fructose Corn Syrup (HFCS)

Demand		***Supply***	
Variables	Dep. Var.: Per capita quantity of HFCS	Variables	Dep. Var.: Per capita quantity of HFCS
Constant	0.0023 (1.44)	Constant	0.0641*** (4.93)
Fd ln(real price of HFCS-55)	-0.1117** (-2.30)	Fd ln(real price of HFCS-55)	0.2962** (2.59)
Fd ln(real price of wholesale refined beet sugar)	-0.0211 (-1.10)	Fd ln (real price of corn)	-0.0530** (-2.17)
Fd ln(real per capita personal disposable income)	-0.0520 (-0.31)	Sugar trade policy	0.0170 (1.00)
Fd ln(per capita quantity of soft drinks)	1.3160*** (12.35)	Trend	0.0000*** (-4.70)
R-squared	0.5636	R-squared	0.1759
Adj. R-squared	0.5493	Adj. R-squared	0.1489
Obs.	127	Obs.	127

Asterisks indicate significance at the 10 percent (*), 5 percent (**), and 1 percent (***) level respectively. Values in parenthesis are t-values. Fd means first difference. Ln is the natural logarithm operator.

Table 2 shows the results of estimating the supply and demand equations for both the HFCS-55 and soft drink markets. The linkages between these two markets originate from HFCS-55 becoming a substitute for sugar in the production of soft drinks. As previously stated, each equation in the system is a double-log model, so the estimates represent growth rates. The most relevant result is the positive and significant effect of the quantity of soft drinks on the demand for HFCS-55. The results show that one percentage point increase in the growth rate of soft drinks increases the growth rate of demand for HFCS-55 by 1.55 percentage points. Again, the results also suggest that quantity of soft drinks is the main driver of the demand for HFCS-55. Once again results from the system of equations correspond with the laws of demand and supply in the HFCS market. It was unexpected to find that, given that HFCS and sugar are substitutes, increases in sugar prices have a negative and significant effect on the supply of HFCS-55.

Table 2. Demand and Supply of HFCS and Demand and Supply of Soft Drinks, 1982:1-2013:4

a. Demand and Supply of High Fructose Corn Syrup

Demand		***Supply***	
Variables	Dep. Var.: Per capita quantity of HFCS-55	Variables	Dep. Var.: Per capita quantity of HFCS-55
Constant	0.0019 (1.33)	Constant	0.0568*** (8.37)
Fd ln(real price of HFCS-55)	-0.0703 (-1.46)	Fd ln(real price of HFCS-55)	0.0478 (0.66)
Fd ln(real price of wholesale refined beet sugar)	-0.0294* (-1.67)	Fd ln (real price of corn)	-0.0278** (-2.11)
Fd ln(real per capita personal disposable income)	-0.0449 (-0.31)	Sugar trade policy	0.0060 (0.68)
Fd ln(per capita quantity of soft drinks)	1.5460*** (9.85)	Trend	0.0000*** (-7.95)
R-squared	0.47920	R-squared	0.3765
Adj. R-squared	0.46212	Adj. R-squared	0.3561
Obs.	127	Obs.	127

b. Demand and Supply of Carbonated Soft Drinks

Demand		***Supply***	
Variables	Dep. Var.: Per capita quantity of soft drinks	Variables	Dep. Var.: Per capita quantity of soft drinks
Constant	0.0066** (2.02)	Constant	0.0348*** (6.09)
Fd ln(soft drinks PPI)	-0.4248 (-0.72)	Fd ln(soft drinks PPI)	-1.8800*** (-4.61)
Fd ln(real personal disposable income)	0.0179 (0.16)	Fd ln(real price of HFCS-55)	-0.0401 (-0.88)
Dummy variable for negative news on HFCS	-0.0102*** (-4.88)	Trend	0.0000 (-4.40)
Fd ln(real per capita advertising for soft drinks)	0.1217** (2.46)		
R-squared	0.34849	R-squared	0.26613
Adj. R-squared	0.32713	Adj. R-squared	0.24824
Obs.	127	Obs.	127

Asterisks indicate significance at the 10 percent (*), 5 percent (**), and 1 percent (***) level respectively. Values in parenthesis are t-values. Fd means first difference. Ln is the natural logarithm operator.

Regarding the soft drinks market results, the estimate on negative news about HFCS-55 has negative and highly significant impact on the growth of demand for soft drinks. This suggests that people's concerns about consumption of HFCS and obesity is decreasing the growth of demand for soft drinks. However, the estimate on the growth of soft drinks per capita advertising has a positive and significant impact on the growth of demand for soft drinks. This coefficient is larger than the coefficient on negative news and more than offsets the effect of negative news.

However, the supply equation for soft drinks shows a negative and significant coefficient on price of soft drinks, which is against the law of supply. This contradictory result merits further investigation and justifies the additional cointegration analysis and testing for Granger causality between per capita quantities of HFCS and SD.

These empirical results show that the market for HFCS-55 depends on the soft drinks market and that advertising has an important direct impact on the growth of demand for soft drinks and an important indirect impact on the growth of demand for HFCS-55 through soft drinks quantity. This finding is in line with Evans and Davis' (2002) study that reports that soft drinks had the strongest effect in a HFCS derived demand estimation. In their study, the price of soft drinks was used as a proxy for final goods that contain HFCS. However, they did not estimate the demand and supply of HFCS and soft drinks together. Additionally, our results give support to Carman's (1982) study which reported estimates of HFCS ceilings regarding its use in different food products and suggested that beverages and processed foods were the food products that would allow for the largest use of HFCS.

Cointegration Analysis and Granger Causality

Given that all variables contain a unit root and become I(0) after being first differenced, the next step in our empirical analysis is to test for cointegration between the HFCS and soft drink quantities using the Johansen's method (Johansen, 1988). The estimation of vector error correction model (VECM) will allow for the identification of long-term relationships between the quantities per capita quantities of these two products. Table 3 shows the Johansen's trace test for cointegration which rejects the null hypothesis of no cointegration between HFCS and SD, but it fails to reject the null hypothesis that there is one cointegrating equation. Post estimation diagnostic tests reveal that the residuals are normally distributed and do not have ARCH effects.

Table 3. Johansen's trace test for cointegration of HFCS and SD per capita quantities

H0: Rank=r	H1: Rank>r	Trace Statistic	5% Critical Value	Drift in ECM	Drift in Process
0	0	31.6370**	15.34	Constant	Linear
1	1	0.7070	3.84		

The estimated parameter of the cointegrating vector $\hat{\beta} = (1, -1.68)'$ is shown in Table 4. The long-run relationship between HFCS quantity and SD quantity is given as HFCSQ=1.68SDQ. HFCS quantity is normalized to be 1.

Table 4. Long-Run Parameter Beta Estimates when RANK=1

Variable	
Ln HFCS-Q	1.00
Ln SD-Q	-1.68

To confirm the validity from the Johansen's cointegration test results, Granger causality between the two variables is now estimated. In the "Granger-sense," a variable x is said to cause y if it is useful in forecasting y. In other words, x will Granger-cause y if, given past values of y, past values of x are useful in predicting y (Granger, 1969). Table 5 shows the results from the Granger causality tests and show that the null hypothesis of no Granger-causality between soft drinks quantity and HFCS quantity is rejected at the 5%. That is, per capita quantity of soft drinks Granger-causes per capita quantity of HFCS. Or, HFCS consumption depends on SD consumption.

Table 5. Granger-Causality Wald Test

Chi-Square	Pr > ChiSq
66.95	<.0001

Conclusion

This study uses quarterly data that covers the period 1982:1-2013:4. It develops a system of demand and supply models to explain the relation between the HFCS market and the soft drinks market in the United States. This framework identifies important drivers of the demand for soft drinks and the effect of soft drinks on the demand for HFCS. The system of demand and supply equations is estimated by using first differences of all series and 2SLS methods.

The results show that soft drinks, as final goods that use HFCS as input, is the most important factor that drives the growth of demand for HFCS in the United States. This is in line with past research that finds soft drinks as the most important driver in a derived demand estimation of HFCS (Evans and Davis, 2002). In addition, regarding the demand for soft drinks, negative news about the relation between HFCS consumption and obesity decreases the growth of demand for soft drinks. However, the coefficient on soft drinks advertising more than offsets the effect of negative news on HFCS and increases the growth of demand for soft drinks. So, advertising has an important direct impact on the growth of demand for soft drinks and an important indirect impact on the growth of demand for HFCS through soft drinks quantity. Therefore, the results suggest that the market for HFCS depends on the market for soft drinks. The findings from the VECM and Granger causality test present more evidence of the linkages between the soft drinks and soda markets. Specifically, a long-term relationship was found between the quantities consumed of both products. Furthermore, results show that quantity per capita consumed/produced of soft drinks Granger-cause quantity per capita consumed/produced of HFCS. Further research is needed to identify and include other important variables in the supply and demand system of equations, so that the signs on these equations would be in line with the laws of demand and supply. This will likely mitigate the issue of some of inconsistent signs in our current estimations.

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Appendix 1 Variable definitions and data sources

Variable name	Variable definition	Source
Price of HFCS-55	Nominal list price in cents per pound of dry weight	USDA/ERS, Sugar and Sweeteners Yearbook Tables, Table 9. Accessed at http://www.ers.usda.gov/data-products/sugar-and-sweeteners-yearbook-tables.aspx
Quantity of HFCS-55	Total deliveries of HFCS-55 in tons	USDA/ERS, Sugar and Sweeteners Yearbook Tables, Table 30. Accessed at http://www.ers.usda.gov/data-products/sugar-and-sweeteners-yearbook-tables.aspx
Price of corn	Nominal price in dollars per bushel	USDA/ERS, Feed Grains Database, Custom Query for No. 2 Yellow Corn Market Prices, Central Illinois. Accessed at http://www.ers.usda.gov/data-products/feed-grains-database/feed-grains-custom-query.aspx
Electricity PPI	Electricity producer price index	Bureau of Labor Statistics
Real interest rate	Real interest rate. It is computed by subtracting Moody's Seasoned AAA Corporate Bond Yield from inflation rate.	Own calculations.
Moody's Seasoned AAA Corporate Bond Yield	Moody's Seasoned AAA Corporate Bond Yield	Federal Reserve Bank of St. Louis
Inflation	Quarterly percentage change of GDP deflator.	Own calculations.
GDP deflator	Seasonally adjusted quarterly GDP deflator.	Bureau of Economic Analysis
Price of refined beet sugar	Nominal wholesale price of refined beet sugar in cents per pound.	USDA/ERS, Sugar and Sweeteners Yearbook Tables, Table 5. Accessed at http://www.ers.usda.gov/data-products/sugar-and-sweeteners-yearbook-tables.aspx
Sugar trade policy	Real U.S. wholesale refined cane sugar price minus world refined sugar price	Own calculations.
Soft drinks price	Soft drinks producer price index	Bureau of Labor Statistics
Negative news on HFCS	Dummy variable that takes the value of 1 from January 2004 onwards and zero otherwise. Source: Bray, Nielsen, and Popkin (2004).	Own calculations.

Appendix 1 (*continued*)

Variable name	Variable definition	Source
Negative news on HFCS	Dummy variable that takes the value of 1 from January 2004 onwards and zero otherwise. It is based on the publication date of the paper by Bray, Nielsen, and Popkin (2004).	Own calculations.
Per capita personal disposable income	Seasonally adjusted per capita personal disposable income.	Bureau of Economic Analysis
Per capita quantity of soft drinks	Quarterly per capita quantity of soft drinks in gallons. It was constructed by interpolation using yearly data.	Own calculations
Annual per capita quantity of soft drinks	Annual per capita quantity of soft drinks in gallons.	USDA/ERS, Beverage Digest, Advertising Age, Business News, and American Beverage Association.
Per capita advertising of soft drinks	Per capita advertising expense of soft drinks in cents. It is constructed using U.S. sales, total sales, and total advertising expenses data for Coca-Cola, Pepsico, and Dr. Pepper.	Own calculations.
U.S. sales of soft drinks	U.S. sales for Coca-Cola, Pepsico, and Dr. Pepper.	COMPUSTAT's historical segments
Soft drinks advertising expense	Total advertising expenses for Coca-Cola, Pepsico, and Dr. Pepper.	COMPUSTAT Monthly Updates-Fundamental Annuals.
Population	Population	Bureau of Economic Analysis.

Appendix 2 Summary statistics, 1982:1-2013:4

Variable	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
HFCS per capita quantity (pounds)	128	12.99	2.25	6.15	16.15
Real HFCS-55 price	128	26.44	6.11	15.24	41.28
Real wholesale refined beet sugar price	128	34.29	7.68	21.89	51.95
Real personal disposable per capita income	128	27317.38	4866.20	18574.27	35130.13
Real corn price	128	3.45	1.23	1.72	6.89
Sugar trade policy	128	17.37	6.04	3.46	32.75
Per capita quantity of soft drink (gallons)	128	11.85	1.24	8.62	13.59
Soft drink price index 2005	128	88.53	18.00	61.58	123.75
Per capita soft drink advertising ($)	128	1.65	0.22	1.11	2.07