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A Demand Analysis for Fresh Tomatoes in the Dallas-Fort Worth Grocery Market.

Jose A. Lopez*
School of Agriculture, Texas A&M University-Commerce, Commerce, TX 75429

ABSTRACT

Tomatoes are the fourth most consumed vegetable in the nation. With most U.S. tomatoes produced for processing, tomato imports for the fresh market are much greater than tomato imports for the processed market. Consequently, it is critical and increasingly valuable for fresh-market producers who sell directly to grocery chains, food service providers, and farmers' markets to analyze emerging consumption trends and the substitution patterns among different types of tomatoes and vegetables. This study used the Almost Ideal Demand System (AIDS) to estimate the demand parameters for fresh tomatoes in the Dallas-Fort Worth, TX grocery market using home-scanned data for the year 2012. Unlike previous fresh fruit and vegetable studies, the study reports current disaggregated tomato elasticities, including Hicksian and Marshallian price elasticities and expenditure elasticities. The analysis identifies tomato types that are highly marketable in the Dallas-Fort Worth metropolitan area and provides useful information regarding recent market trends.

KEY WORDS*:* Demand, elasticities, scanner data, tomato

INTRODUCTION

Tomatoes are either produced for processing or for fresh-market consumption. Unlike processed tomatoes, fresh tomatoes are handpicked to preserve fruit quality. The use of mechanical equipment generally increases the amount harvested and results in more tomatoes being sent to processing than to the fresh market. For example, in 2008, approximately 89% of total tomatoes produced in the U.S. were processed (USDA-ERS 2012). Most processed-tomato producers contract with firms who process vegetables into food items such as soups, condiments, juices, etc., while most fresh-market producers sell in the open market (USDA-ERS 2012) or directly to local grocery chains, food service providers, and/or farmers' markets (Strange et al. 2000).

Tomatoes are the fourth most consumed vegetable in the nation (USDA-ERS 2012). U.S. consumption of fresh tomatoes has increased steadily over the past 10 years (Table 1) despite declining trends in U.S. area planted, area harvested, and production for fresh-market tomatoes. From 2005 to 2014, U.S. area planted, area harvested, production, and yield of fresh-market tomatoes decreased by about 25%, 25%, 30%, and 8%, respectively (Table 2). Despite these recent declines, U.S. fresh-market tomato production remains above 1.1 million metric tons per year with peak production of 1.8 million metric tons in 2005 (Table 1). Although per-capita consumption per year declined slightly in volume terms over the period 2005-2014, the amount spent in dollars per person per year

* Corresponding author: Jose.Lopez@tamuc.edu

increased. In 2005, the average person in the U.S. spent $8.54 per year on fresh-market tomatoes, while in 2014 the average person spent an additional $0.54 annually (Table 1).

Table 1. Fresh-market tomatoes: U.S. production, exports, imports, apparent consumption, apparent per-capita consumption, and ratio of imports to consumption, 2005-2014.

Year	Production[a]	Exports[b]	Imports[b]	Apparent Consumption	Apparent Per-Capita Consumption	Ratio of imports to consumption
	Quantity (t)				Quantity (kg/person)	(%)
2005	1,789,968	147,951	951,786	2,593,803	8.70	37
2006	1,645,363	144,184	992,339	2,493,519	8.29	40
2007	1,525,297	160,777	1,070,808	2,435,327	8.02	44
2008	1,412,352	170,132	1,116,335	2,358,556	7.69	47
2009	1,507,516	170,380	1,189,601	2,526,738	8.16	47
2010	1,268,291	120,752	1,532,489	2,680,028	8.58	57
2011	1,379,195	114,564	1,491,014	2,755,645	8.75	54
2012	1,299,997	117,329	1,532,162	2,714,831	8.55	56
2013	1,197,077	109,468	1,537,472	2,625,081	8.20	59
2014	1,237,401	112,830	1,550,475	2,675,047	8.29	58
	Value (1,000 $)				Value ($/person)	(%)
2005	1,637,394	166,131	1,075,119	2,546,381	8.54	42
2006	1,584,708	172,625	1,233,408	2,645,491	8.79	47
2007	1,168,693	191,866	1,220,498	2,197,325	7.23	56
2008	1,414,131	210,032	1,431,589	2,635,689	8.59	54
2009	1,344,217	212,122	1,403,583	2,535,677	8.19	55
2010	1,352,315	196,873	1,798,238	2,953,680	9.46	61
2011	1,291,875	184,930	2,137,870	3,244,815	10.30	66
2012	874,195	152,349	1,867,605	2,589,450	8.16	72
2013	1,177,592	156,275	1,979,770	3,001,087	9.38	66
2014	1,134,616	166,114	1,960,938	2,929,440	9.08	67

[a] From 2005 to 2010, cherry, grape, tomatillo, and greenhouse tomatoes are excluded.
[b] Data are for fresh or chilled tomatoes (Harmonized Tariff Schedule (HTS) subheadings 07020020, 07020040, and 07020060) on a fresh-weight basis.
Sources: Production data from USDA-NASS (2015), USDA-NASS (2012), USDA-NASS (2009), USDA-NASS (2006), USDA-NASS (2003), and USDA-NASS (2000). Exports and imports data retrieved by author from the USITC Interactive Tariff and Trade DataWeb, Version 3.1.0, of the United States International Trade Commission (USITC). Population retrieved by author from International Monetary Fund, International Financial Statistics.
Notes: Production data are raw product intended for fresh-market sales only. Apparent consumption equals production minus exports plus imports.

Table 2. Fresh-market tomatoes: U.S. area planted, harvested, production and yield, 2005-2014.

Year	Area planted (acres) [a]	Area harvested (acres) [a]	Production (t) [a]	Yield (t/acre) [a]
2005	136,000	129,800	1,789,968	13.79
2006	125,300	120,200	1,645,363	13.69
2007	116,400	108,100	1,525,297	14.11
2008	109,200	105,250	1,412,352	13.42
2009	113,200	108,700	1,507,516	13.87
2010	107,700	103,000	1,268,291	12.31
2011	105,400	99,710	1,379,195	13.83
2012	104,500	101,000	1,299,997	12.87
2013	103,400	99,600	1,197,077	12.02
2014	101,800	97,600	1,237,401	12.68

[a] From 2003 to 2010, cherry, grape, tomatillo, and greenhouse tomatoes are excluded.
Source: Area planted, area harvested, and production data from USDA-NASS (2015), USDA-NASS (2012), USDA-NASS (2009), USDA-NASS (2006), USDA-NASS (2003), and USDA-NASS (2000).
Note: Production data are raw product intended for fresh-market sales only. Yield data equals production divided by area harvested.

California and Florida together account for about 71% of U.S. fresh-market tomato production (Table 3). Although these two states produce most fresh-market tomatoes in volume terms, the state with the highest yield is Alabama (Table 4). With a yield of 13.88 t/acre, California ranks fifth in production per acre, behind Alabama (14.99 t/acre), Florida (14.82 t/acre), North Carolina (14.38 t/acre), and Virginia (14.12 t/acre). Generally, Texas ranks as the sixteenth largest fresh-market tomato producer in the U.S. with an average production of 5.3 thousand metric tons (Table 3) and an average yield of 5.35 t/acre (Table 4).

With downward trends in the area planted, area harvested, and production of fresh tomatoes in the U.S. market (Table 2), the international market plays a key role in satisfying rising U.S. consumption of fresh tomatoes. As recently as 2014, 58% of fresh-market tomatoes consumed in the U.S. were imported capturing 67% of total per-capita expenditures on fresh-market tomatoes by U.S. consumers (Table 1). Imports allow U.S. consumers to eat more vegetables and enjoy year-round access to fresh produce (Huang and Huang 2007).

Over the past 20 years, the main destination for U.S. exports of fresh-market tomatoes has been Canada and Mexico. Although the volume of U.S. exports to Canada are approximately 3.86 times greater than U.S. exports to Mexico, the volume of U.S. exports to Canada decreased from 2005 to 2010 while the volume of U.S. exports to Mexico increased from 2005 to 2009 (Table 5). Since 2010, the volume of U.S. exports to Canada has remained relatively steady, while the volume of U.S. exports to Mexico has declined (Table 5). As expected, U.S. export patterns in dollar terms are similar to the export patterns in volume terms (Table 5). More importantly, Canada and Mexico combined account for 97% of the export market in volume and dollar terms (Table 5).

Table 3. Fresh-market tomatoes: U.S. production (metric tons) by state, 2005-2014[a].

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average 2005-14
California	541,046	520,725	503,488	528,663	513,014	506,210	563,589	514,374	462,665	461,531	511,530
Florida	704,883	611,216	604,231	474,367	557,829	388,049	464,026	435,449	408,687	419,120	506,786
Georgia	97,160	91,444	81,647	38,102	57,153	(D)	(D)	(D)	19,958	26,082	58,792
Virginia	93,984	85,593	69,218	59,693	65,317	42,865	45,904	59,058	33,747	29,211	58,459
Tennessee	56,608	53,978	52,571	50,802	61,689	64,682	47,400	43,091	50,893	60,146	54,186
Ohio	97,296	89,811	28,576	50,303	69,672	57,561	34,110	19,278	26,989	43,273	51,687
North Carolina	36,287	49,351	43,409	49,351	50,893	31,933	63,866	48,671	47,174	38,555	45,949
New Jersey	27,216	23,678	26,989	28,304	28,939	28,304	27,624	25,719	26,671	28,304	27,175
South Carolina	17,690	21,772	10,796	22,135	15,105	18,507	22,135	37,421	28,576	40,642	23,478
Michigan	27,941	20,865	22,952	24,766	27,216	18,144	19,958	23,587	26,127	21,137	23,269
New York	16,329	18,144	19,595	23,269	15,876	17,781	19,595	24,766	20,230	14,152	18,974
Alabama	14,470	18,234	22,725	21,546	18,280	18,597	19,867	18,869	13,472	19,051	18,511
Pennsylvania	23,269	16,692	19,051	15,966	13,109	11,476	7,847	8,709	14,061	18,824	14,901
Arkansas	18,779	13,880	6,759	12,655	2,903	8,482	10,433	12,927	6,804	6,940	10,056
Indiana	10,206	4,990	6,804	6,532	5,443	4,899	3,810	5,080	6,940	6,895	6,160
Texas	6,804	4,990	6,486	5,897	5,080	(D)	(D)	(D)	4,082	3,538	5,268
Other States [b]					(X)	50,802	29,030	22,997	(X)	(X)	34,277
United States	1,789,968	1,645,363	1,525,297	1,412,352	1,507,516	1,268,291	1,379,195	1,299,997	1,197,077	1,237,401	1,426,246

(D) Withheld to avoid disclosing data for individual operations.

(X) Not applicable.

[a] From 2005 to 2010, cherry, grape, tomatillo, and greenhouse tomatoes are excluded.

[b] From 2009-2014, other states includes Georgia and Texas.

Source: Production data from USDA-NASS (2015), USDA-NASS (2012), USDA-NASS (2009), USDA-NASS (2006), USDA-NASS (2003), and USDA-NASS (2000).

Note: Production data are raw product intended for fresh-market sales only.

Table 4. Fresh-market tomatoes: U.S. yield (metric tons per acre) by state, 2005-2014.[a]

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average 2005-14
Alabama	13.15	15.20	17.46	17.24	14.06	14.29	15.88	14.51	12.25	15.88	14.99
Florida	16.78	15.88	17.46	15.06	16.60	13.15	14.97	13.61	12.02	12.70	14.82
North Carolina	14.51	15.42	13.15	14.51	15.42	9.98	19.96	14.74	14.74	11.34	14.38
Virginia	16.78	17.46	15.38	12.70	13.61	9.53	9.98	19.05	14.06	12.70	14.12
California	12.70	12.70	13.61	14.29	13.15	14.06	16.10	14.29	13.61	14.29	13.88
Tennessee	10.89	13.83	13.83	12.70	15.42	14.06	12.47	11.34	14.97	15.42	13.49
Georgia	15.42	16.33	16.33	9.07	12.70	(D)	(D)	(D)	9.07	11.34	12.89
Ohio	14.74	13.61	9.53	10.93	15.15	12.25	10.66	7.71	7.94	12.02	11.45
Michigan	12.70	10.43	10.43	11.79	13.61	9.07	9.98	9.07	10.89	11.11	10.91
New Jersey	9.07	8.16	9.30	9.75	9.98	9.75	9.53	9.53	9.53	9.75	9.43
Arkansas	15.65	11.57	6.12	14.06	2.90	7.71	8.71	12.93	6.80	7.71	9.42
South Carolina	5.90	7.26	3.72	8.85	7.94	7.71	8.85	11.34	9.53	12.70	8.38
New York	8.16	9.07	8.16	8.62	6.35	6.35	7.26	8.85	7.48	5.44	7.58
Pennsylvania	6.12	7.94	9.53	9.98	7.71	4.99	4.13	5.13	6.40	7.53	6.94
Indiana	6.80	4.99	6.80	7.26	6.80	5.44	4.99	7.26	7.71	8.39	6.65
Texas	5.67	4.54	5.90	5.90	6.35	(D)	(D)	(D)	4.54	4.54	5.35
Other States [b]					(X)	10.57	7.85	5.49	(X)	(X)	7.97
United States	13.79	13.70	14.11	13.43	13.88	12.29	13.83	12.88	12.02	12.70	13.26

(D) Withheld to avoid disclosing data for individual operations.

(X) Not applicable.

[a] From 2005 to 2010, cherry, grape, tomatillo, and greenhouse tomatoes are excluded.

[b] From 2009 to 2014, other states includes Georgia and Texas.

Source: Production data from USDA-NASS (2015), USDA-NASS (2012), USDA-NASS (2009), USDA-NASS (2006), USDA-NASS (2003), and USDA-NASS (2000).

Note: Production data are raw product intended for fresh-market sales only.

Table 5. All fresh-market tomatoes: U.S. exports of domestic merchandise, by principal markets, 1996-2014[a].

Market	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2005-14
	Quantity (metric tons)										
Canada	130,501	119,177	121,562	124,184	110,358	87,610	89,197	89,822	89,326	94,830	105,657
Mexico	13,591	19,691	34,827	43,746	57,722	29,007	23,272	22,363	15,368	14,200	27,379
Japan	1,713	3,769	2,911	392	491	1,229	45	987	1,582	693	1,381
Bahamas	887	958	760	755	703	873	688	839	787	1,103	835
Trin Tobago	209	100	153	204	210	586	454	950	1,358	914	514
China	0	0	0	4	5	0	0	1,187	185	514	190
Korea	113	132	53	101	114	90	0	65	356	56	108
Bermuda	86	106	85	112	119	116	107	57	68	13	87
Barbados	87	39	57	129	46	96	58	60	36	97	71
Hong Kong	0	17	20	0	1	94	165	183	142	30	65
All other	765	195	350	504	611	1,051	580	815	260	381	551
Total	147,951	144,184	160,777	170,132	170,380	120,752	114,564	117,329	109,468	112,830	136,837
	Value (1,000 $)										
Canada	149,806	144,496	150,840	157,239	139,371	117,453	132,728	113,044	121,731	125,563	135,227
Mexico	7,758	20,928	34,614	49,353	68,669	72,046	48,924	31,986	26,615	33,333	39,423
Japan	5,177	4,860	3,945	469	897	2,704	94	1,227	2,549	1,608	2,353
Bahamas	1,171	1,300	1,230	1,275	1,145	1,401	1,148	1,369	1,561	2,275	1,388
Trin Tobago	232	79	141	210	266	733	617	1,193	1,909	1,324	670
China	0	0	0	5	14	0	0	1,684	314	713	273
Bermuda	172	246	213	271	248	274	276	110	106	18	193
Korea	83	172	88	96	166	156	0	99	800	55	172
Cayman Is	0	21	0	79	462	325	105	94	131	149	137
Turks Caic Is	95	71	56	187	124	301	157	70	85	191	134
All other	1,638	452	739	847	759	1,479	881	1,474	473	885	963
Total	166,131	172,625	191,866	210,032	212,122	196,873	184,930	152,349	156,275	166,114	180,932

[a] Data are for fresh or chilled tomatoes (Harmonized Tariff Schedule (HTS) subheadings 07020020, 07020040, and 07020060) on a fresh-weight basis. Source: USITC.

Table 6. All fresh-market tomatoes: U.S. imports for consumption, by principal sources, 2005-2014.

Source	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
	Quantity (metric tons)										
Mexico	801,408	844,343	949,486	987,914	1,046,869	1,380,111	1,327,309	1,379,519	1,381,306	1,389,334	1,148,760
Canada	141,642	135,141	111,723	119,385	130,310	142,590	141,349	139,311	140,240	146,534	134,823
Guatemala	0	4	252	1,155	2,762	5,408	17,351	8,937	12,088	10,308	5,827
EU-28											
Netherlands	6,249	6,148	5,171	3,445	5,308	863	308	351	339	254	2,844
Spain	275	2,141	480	1,035	93	0	0	0	0	8	403
Belgium	871	1,240	554	198	367	69	0	0	0	0	330
All other	23	294	19	6	0	34	1	0	0	5	38
Subtotal	7,419	9,823	6,224	4,684	5,768	965	309	351	339	268	3,615
Dominican R	857	2,422	2,650	2,853	2,862	2,172	4,162	3,224	3,202	3,924	2,833
Israel	348	570	241	221	195	360	104	369	0	37	244
All other	112	36	232	125	836	883	431	451	295	70	347
Total	951,786	992,339	1,070,808	1,116,335	1,189,601	1,532,489	1,491,014	1,532,162	1,537,472	1,550,475	1,296,448
	Value (1,000 $)										
Mexico	781,234	918,755	960,047	1,142,868	1,125,527	1,487,411	1,807,703	1,578,591	1,637,535	1,656,406	1,309,608
Canada	271,977	284,206	238,148	269,236	255,521	293,775	299,936	268,634	320,075	283,052	278,456
Guatemala	0	5	283	1,502	3,981	7,385	21,962	12,135	15,840	14,221	7,731
EU-28											
Netherlands	16,229	17,796	15,028	10,991	12,500	3,400	2,044	2,336	2,416	1,762	8,450
Spain	820	4,810	1,474	2,423	196	0	0	0	0	21	974
Belgium	2,167	2,652	1,110	534	672	312	0	0	0	0	745
All other	30	188	25	8	0	43	4	0	0	8	31
Subtotal	19,245	25,446	17,637	13,957	13,367	3,755	2,048	2,336	2,416	1,791	10,200
Dominican R	1,216	3,284	3,217	2,942	2,879	2,942	5,550	4,597	3,518	5,124	3,527
Israel	1,251	1,653	873	836	570	957	275	776	0	148	734
All other	195	60	294	248	1,737	2,013	396	536	386	195	606
Total	1,075,119	1,233,408	1,220,498	1,431,589	1,403,583	1,798,238	2,137,870	1,867,605	1,979,770	1,960,938	1,610,862

[a] Data are for fresh or chilled tomatoes (Harmonized Tariff Schedule (HTS) subheadings 07020020, 07020040, and 07020060) on a fresh-weight basis.
Source: USITC.

Similarly, over the past 20 years, the main sources of U.S. imports of fresh tomatoes were Canada and Mexico. Contrary to the principal markets for U.S. exports, the U.S. volume of imports from Mexico is approximately 8.52 times greater than U.S. imports from Canada. However, imports from Mexico and Canada have both increased since 2005 (Table 6). Mexico and Canada account for 99% of the U.S. imports of fresh tomatoes (Table 6). While U.S. exports of fresh tomatoes to Canada declined 27.33% from 2005 to 2014 (Table 5), U.S. imports of fresh tomatoes from Canada increased slightly by 3.45% during the same period (Table 6). Conversely, U.S. exports of fresh-market tomatoes to Mexico increased by 4.48% from 2005 to 2014 (Table 5), while U.S. imports of fresh-market tomatoes from Mexico increased by 73.36% (Table 6). Over the past ten years, U.S. exports to Mexico and Canada averaged 133,035 t or $174.65 million (Table 5) while U.S. imports from Mexico and Canada averaged 1,283,583 t or $1,588.06 million (Table 6).

Greenhouse and Roma tomatoes accounted for about 79.1% of fresh-market imports from 2005 to 2014 (Figure 1). Imports of greenhouse tomatoes rapidly increased from 2005-2014, while imports of Roma tomatoes increased from 2005 to 2010, then declined from 2010 to 2014 (Figure 1). Fresh-market cherry and grape tomatoes together account for 6% of imports. All other fresh-market tomato imports make up the remaining 14.9% of volume, but have a declining market share (Figure 1).

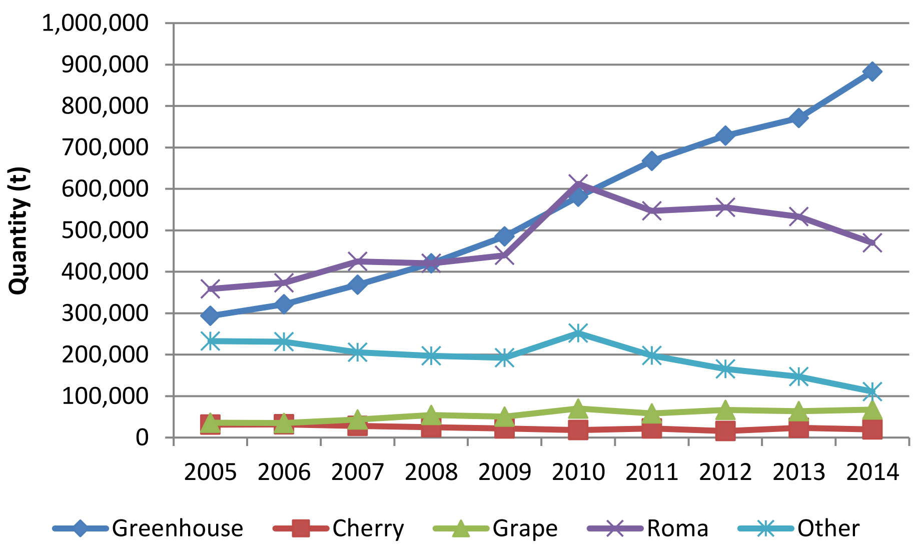

Figure 1. Fresh-market tomatoes: U.S. imports for consumption by type, 2005-2014.
Source: USITC.
Note: All data are on a fresh-weight basis. Data for fresh or chilled greenhouse tomatoes include Harmonized Tariff Schedule (HTS) commodities 0702002010, 0702004010, and 0702006010. Data for fresh or chilled Roma or other Roma tomatoes include HTS commodities 0702002060, 0702002065, 0702004060, 0702004065, 0702006060, and 0702006065. Data for fresh or chilled grape tomatoes include HTS commodities 0702002045, 0702004045, 0702004046, and 0702006045. Data for fresh or chilled cherry or other cherry tomatoes include HTS commodities 0702002030, 0702002035, 0702004030, 0702004035, 0702006030, and 0702006035. Data for fresh or chilled tomatoes or other tomatoes include HTS commodities 0702002090, 0702002095, 0702002099, 0702004090, 0702004098, 0702004099, 0702006090, 0702006095, 0702006099.

Although per-capita consumption of fresh tomatoes has fluctuated between 7.69 and 8.75 kg over the past 10 years (Table 1), this number has increased dramatically over the past three decades. In 1981, average annual per-capita consumption of fresh tomatoes was 5.58 kg (Boriss and Brunke 2011). This large increase in per-capita consumption has been attributed to several factors, including cultural diversity (Nzaku and Houston 2009; Lucier et al. 2000), trade liberalization, and the increasing awareness of the benefits to a healthy lifestyles (Grant and Foster 2005; Huang and Huang 2007). Studies have also emphasized the positive benefits of eating fresh produce (Deghan et al. 2011). An average medium-sized tomato can provide up to 40% of the recommended dietary intake of Vitamin C. Tomatoes also contain folate, potassium, flavonoids, and phytosterol (Beecher 1998). Lycopene, a compound found in tomatoes, has also been found to help with immune responses and to reduce the risk of various diseases such as cancer, cardiovascular diseases, and to be inversely related to breast and prostate cancer (Agarwal and Rao 2000). Income and age have also been found to be positively correlated with fresh tomatoes consumption (Lucier et al. 2000).

Increasing fresh-market tomato consumption makes an understanding of the substitution patterns among different types of tomatoes valuable for producers and distributors. The main objective of this study was to appropriately estimate Hicksian and Marshallian price elasticities and expenditure elasticities for fresh tomatoes at the retail level using home-scanned consumption data and a demand system approach. Unlike previous fresh fruit and vegetable studies (Brandow 1961; George and King 1971; Brumfield et al. 1993; You et al. 1996; Henneberry et al. 1999; Agarwal and Rao 2000; Thompson 2003; Grant and Foster 2005; Jung et al. 2005; Nzaku and Houston 2009; Padilla and Acharya 2009; Deghan et al. 2011; Naanwaab and Yeboah 2012; Niu and Wohlegenaut 2012; Seale et al. 2013), this study reports current disaggregated tomato elasticity estimates for the Dallas-Fort Worth (DFW) metropolitan area.

Agriculture is a primary contributor to the DFW metropolitan area which consists of eight counties: Denton, Tarrant, Johnson, Collin, Dallas, Ellis, Rockwall, and Koffman (Bennett and Hanselka 2013). The metropolitan area comprises over 910,000 acres of agricultural land with about 91% of the acres in crops and 9% in pasture (Bennett and Hanselka 2013). Between 2007 and 2012, the region enjoyed an increase in the number of farms and land in farms by 10%, while the number of farms and land in farms in the state of Texas only changed by about 0.55% and -0.19%, respectively (Bennett and Hanselka 2013). With a healthy and increasing production agriculture base in the DFW metropolitan area, the increasing interest of local growers in greenhouse vegetables deserves appropriate attention. A demand analysis of fresh-market tomatoes at the retail level provides useful information to DFW vegetable growers in terms of market consumption patterns and a better understanding of retail varieties that sell the most, including information about their retail market prices.

METHODS AND PROCEDURES

Various demand systems have been used to analyze demand for fresh fruits and vegetables, including the Rotterdam model (e.g., Seale et al. 2013), the Almost Ideal Demand System (AIDS) (e.g., Thompson 2003), the linear approximation (LA) of the AIDS (e.g., Naanwaab and Yeboah 2012; Padilla and Acharya 2009; Nzaku and Houston 2009; Heneberry et al. 1999), the quadratic AIDS (e.g., Thompson 2003), first difference (FD) version of the AIDS (e.g., Jung et al. 2005), and the inverse AIDS (e.g., Grant and

Foster 2005). Henneberry et al. (1999) used misspecification tests to show that the Rotterdam functional form was inappropriate in their fruit and vegetable demand system. This study uses Deaton and Mullbauer's (1980) AIDS to estimate how fresh-market tomatoes perform at the retail level.

Deaton and Muelbauer's (1980) AIDS model is considered an arbitrary first order approximation of any demand system. It satisfies the axioms of choice and aggregates perfectly over consumers up to a market demand function without invoking parallel linear Engel curves. The functional form is consistent with household-budget data, can be used to test the properties of homogeneity and symmetry through linear restrictions on fixed parameters, and is not difficult to estimate. In the AIDS model, the Marshallian demand function for commodity *i* in share form is specified as:

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} \log(p_{jt}) + \beta_i \log[X_t/P_t] + \varepsilon_{it}, \quad (1)$$

where w_{it} is the budget share for commodity *i* at time *t*; p_{jt} is the price of commodity *j* at time *t*; X_t is total household expenditure on the commodities being analyzed; α_i, β_i, and γ_{ij} are parameters, ε_i is a random term of disturbances, and P_t is a price index.

In a nonlinear approximation, the price index P_t is defined as:

$$\log(P_t) = \alpha_0 + \sum_k \alpha_k \log(p_{kh}) + \frac{1}{2} \sum_k \sum_j \gamma_{kj} \log(p_{kh}) \log(p_{jh}). \quad (2)$$

The demand theory properties of adding-up, homogeneity and symmetry are imposed on the system of equations by restricting parameters in the model as follows:

Adding-up: $\sum_i \alpha_i = 1, \sum_j \gamma_{ij} = 0, \text{ and } \sum_i \beta_i = 0;$ (3)

Homogeneity: $\sum_i \gamma_{ij} = 0;$ (4)

Symmetry: $\gamma_{ij} = \gamma_{ji}.$ (5)

The parameter estimates and the mean expenditure shares are used to estimate the Marshallian (uncompensated) and the Hicksian (compensated) price elasticities as well as the expenditure elasticities. Following Green and Alston (1990), the elasticities are estimated as:

Marshallian Price Elasticity: $e_{ij} = \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i}\left(\alpha_i + \sum_k \gamma_{kj} \log(p_k)\right) - \delta_{ij}$ (6)

Hicksian Price Elasticity: $e_{ij}^c = e_{ij} + w_j e_i$ (7)

Expenditure Elasticity: $e_i = 1 + \frac{\beta_i}{w_i}$ (8)

where δ_{ij} is the Kronecker delta, which is equal to 1 if *i* = *j* and equal to 0 otherwise.

One equation is omitted in the estimation of this system, but the parameters of that equation are recovered by making use of the theoretical classical properties. Usually the equation excluded is the one holding the smallest budget share.

DATA AND PROCEDURES

Scanner data allow researchers quick access to data for many products at both the consumer and retail level. Data on sales in dollars and units, average unit prices, and unit sizes from January 1 to December 28, 2012 for various types of tomatoes were obtained from The Nielsen Company. These data represent random purchases at the retail level, is reported in four-week cycles, and covers the DFW grocery market.

A total of 1,031 tomato purchases collected in 2012[1] resulted in 28 types of tomatoes (Table 7) and were subsequently grouped in four categories (Table 8): cherry tomatoes (cherry and cherry mixed tomatoes), grape tomatoes (grape, grape cherry, grape hydroponic, grape sweet, scarlet pearl grape, and sugar plum grape), regular tomatoes, and other types of tomatoes (baby, baby Roma sweet, beefsteak, campari, campari sweet hydroponic, cocktail, HVSM-GRH, mandarin sweet, medley, mixed, Roma, salad, sweet, sweet greenhouse tricolor, sweetheart, tear drop, tesoro, vine ripe, and yellow sweet). In 2012, regular tomatoes at $1.22/lb sold the most followed by grape tomatoes at $2.09/lb, other tomatoes at $3.00/lb, and cherry tomatoes at $2.86/lb (Table 8). However, other tomatoes generated the highest revenues ($1.74 million), followed by grape tomatoes ($1.47 million), regular tomatoes ($1.44 million), and cherry tomatoes ($0.98 million).

Table 7. Random sample of fresh-market tomato purchases from the DFW grocery market in 2012.

Tomato Type	Quantity (lbs)	Price ($/lb)	Volume Share	Revenue ($)
Baby	33,841	3.23	1.2072%	109,306
Baby Roma Sweet	1,618	3.24	0.0577%	5,242
Beefsteak	4,128	0.21	0.1473%	867
Campari	26,385	2.13	0.9412%	56,200
Campari Sweet Hydroponic	95,215	3.50	3.3964%	333,253
Cherry	342,867	2.86	12.2305%	980,600
Cherry Mixed	22	1.69	0.0008%	37
Cocktail	19,894	1.53	0.7096%	30,438
Grape	658,628	2.05	23.4940%	1,350,187
Grape Cherry	15	0.61	0.0005%	9
Grape Hydroponic	42,476	2.65	1.5152%	112,561
Grape Sweet	496	2.19	0.0177%	1,086
HVSM-GRH	7,107	2.45	0.2535%	17,412
Mandarin Sweet	17	0.61	0.0006%	10
Medley	947	5.56	0.0338%	5,265
Mixed	14	1.43	0.0005%	20

[1] One random purchase of Medley tomatoes was eliminated from the analysis given that the unit size was considerably different from the other tomato unit sizes. It was considered an outlier likely resulting from reporting an incorrect unit size.

Table 7 cont.

Tomato Type	Quantity (lbs)	Price ($/lb)	Volume Share	Revenue ($)
Regular	1,180,285	1.22	42.1021%	1,439,948
Roma	49,890	1.76	1.7796%	87,806
Salad	10,419	6.18	0.3717%	64,389
Scarlet Pearl Grape	305	0.26	0.0109%	79
Sugar Plum Grape	1	0.27	0.0000%	0
Sweet	72,450	1.06	2.5844%	76,797
Sweet Greenhouse Tricolor	56	2.46	0.0020%	138
Sweetheart	33,698	4.89	1.2020%	164,783
Tear Drop	378	10.21	0.0135%	3,859
Tesoro	22,703	1.14	0.8098%	25,881
Vine Ripe	29,189	3.37	1.0412%	98,367
Yellow Sweet	170,345	2.44	6.0764%	415,642
Total	2,803,388	1.92	100.0000%	5,380,185

Table 8. Random sample of fresh-market tomato purchases by category from the DFW grocery market in 2012.

Tomato Type	Quantity (lbs.)	Price ($/lb.)	Volume Share	Budget Share	Revenue ($)
Cherry	342,889	2.86	12.23%	17.80%	979,308
Grape	701,615	2.10	25.03%	25.91%	1,467,565
Regular	1,180,285	1.22	42.10%	25.38%	1,435,569
Other	578,598	3.00	20.64%	30.91%	1,736,393
Total	2,803,388	2.00	100.00%	100.00%	5,618,834

RESULTS

The AIDS model was estimated using an iterated seemingly unrelated regression (ITSUR) procedure in SAS version 9.3. The parameters were estimated imposing the theoretical neoclassical restrictions and excluding the other tomato category. Figure 2 depicts the budget shares used in the estimation of the demand system. Overall, budget shares are volatile with regular tomatoes exhibiting the largest budget share (an average of 42.10%), followed by other tomatoes (30.91%), grape tomatoes (25.03%) and cherry tomatoes (17.80%) (Figure 2).

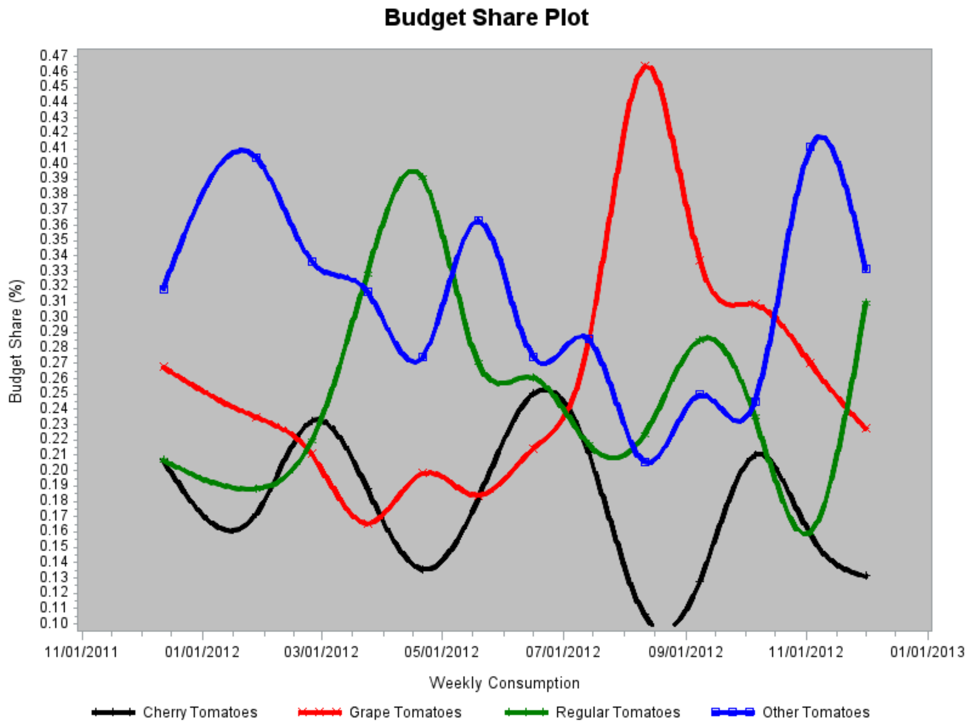

Figure 2. Fresh-market tomato budget shares by type, random sample from the DFW grocery market in 2012.

The AIDS model parameter estimates are reported in Table 9. Of the 17 parameters estimated by the model (α_i, i = 1, …, 4; γ_{1j}, j = 1, …, 4; γ_{2j}, j = 2, …, 4; γ_{3j}, j = 3, 4; γ_{4j}, j = 4; and β_i, i = 1, …, 3), five were significant at the 5% probability level, three at the 10% probability level, and 10 were not significant. In terms of goodness of fit, 66.65% of the total variation in the cherry tomato budget share is explained by the AIDS model. Similarly, 49.15% and 77.39% of the total variation in the budget share for grape tomatoes and regular tomatoes is explained by the AIDS model, respectively.

A demand function can be described in terms of its elasticity values. In this AIDS model, the elasticities measure the percentage response of the quantity demanded to a one percent change in the price of a tomato type (i.e., the own- or cross-price elasticities) or to a one percent change in total tomato expenditures (i.e., the expenditure elasticity). The own-price elasticity of demand measures the percent change in the quantity demanded of a tomato type from a one percent change in the price of the same tomato type. The cross-price elasticity of demand measures the percent change in the quantity demanded of a tomato type from a one percent change in the price of another tomato type. If the cross-price elasticity of demand is positive, the commodities are said to be substitutes; while if it is negative, the commodities are said to be complements. The compensated (net) price elasticities take into account both the price and real income effect while uncompensated (gross) price elasticities take into account only the price effect. The Marshallian (uncompensated) and Hicksian (compensated) price elasticities are reported in Tables 10 and 11.

All own-price elasticities have the expected negative sign and were greater than -1; suggesting fresh-market tomatoes are inelastic, which is consistent with Naanwaab and Yeboah (2012). This suggests tomato consumers are not very responsive to changes in prices of grape tomatoes. In addition, among own-price elasticities, the grape tomato own-price elasticity was the greatest. A 1% increase in the price of grape tomatoes is expected to decrease the consumption of grape tomatoes by 0.7908%, ceteris paribus. Since grape tomatoes are inelastic, even though quantity consumed declines, it is expected that a 1% increase in the price of grape tomatoes will result in an increase in total revenue because the change in price exceeds the change in quantity demanded.

Excluding own-price elasticities, there are as many negative cross-price elasticities as there are positive cross-price elasticities. All cross-price elasticity estimates are inelastic, which is also consistent with Naanwaab and Yeboah (2012). Negative cross-price elasticities suggest that the considered tomato categories are complementary, while positive cross-price elasticities suggest that they are substitutes. Since this study analyzes scanner data from the DFW grocery market and only considered fresh-market tomatoes in the estimation of the demand system, two types of tomatoes are considered complements in the sense that they are bought together, but not in the sense that they are necessarily consumed together. Negative cross-price elasticities are not uncommon when considering the same commodity in the estimation of the demand system (e.g., Thompson, 2003). Similarly, two tomato types are considered substitutes when buyers purchase one or the other, but not both. For instance, grape and cherry tomatoes, and grape and regular tomatoes are (gross and net) complements, suggesting that they were found to be bought together most of the time. Conversely, cherry and regular tomatoes are (gross and net) substitutes, suggesting that grocery buyers purchased most of the time either one or the other, but not together. The results are generally consistent when looking at either Marshallian (Table 10) or Hicksian (Table 11) price elasticities since most of the time the Marshallian price elasticity estimates have the same sign as the corresponding Hicksian price elasticity estimates.

Recent disaggregated tomato price and expenditure elasticity estimates for the DFW grocery market are not available. The last disaggregated price elasticity estimates for the DFW grocery market were reported by Thompson (2003) for the period 1997-1999 and only included Marshallian own-price elasticities. Hicksian own-price and expenditure elasticity estimates were not reported by Thompson (2003). When comparing elasticities, it is important to remember that differences in model functional forms, sample sizes, and time period under consideration, among other things, tend to make elasticity estimates different from one study to another. Marshallian own-price elasticity estimates in previous studies range from -1.1967 to -0.0100, excluding the own-price elasticity for cherry tomatoes reported by Thompson (2003) since he obtained an unexpected positive sign (Table 13). Our Marshallian own-price elasticity estimates range from -0.7908 (own-price elasticity of grape tomatoes) to -0.1094 (own-price elasticity of other tomatoes) (Table 10). Similarly, our Hicksian own-price elasticity estimates, which range from -0.5132 (own-price elasticity of cherry tomatoes) to -0.0423 (own-price elasticity of regular tomatoes), fall within the range reported in previous studies, which is -0.5317 to -0.0300.

Table 9. AIDS Model Parameter Estimates.

	Cherry Tomatoes		**Grape Tomatoes**		**Regular Tomatoes**		**Other Tomatoes**	
Parameter	Parameter Estimate	Approx. Prob. > |t|	Parameter Estimate	Approx. Prob. > |t|	Parameter Estimate	Approx. Prob. > |t|	Parameter Estimate	Approx. Prob. > |t|
α_i	2.7013*	0.0295	-5.3546*	0.0032	1.8484**	0.0502	1.8049	0.4272
γ_{1i}	-0.1735	0.6127	0.8314*	0.0032	-0.2392	0.1615	-0.4188	0.1212
γ_{2i}	0.8314*	0.0322	-1.8488**	0.0730	0.4531	0.2134	0.5643	0.5394
γ_{3i}	-0.2392	0.1615	0.4531	0.2134	0.0705	0.6486	-0.2845	0.1563
γ_{4i}	-0.4188	0.1212	0.5643	0.5394	-0.2845	0.1563	0.1390	0.7956
β_i	-0.1688*	0.0359	0.3721*	0.0023	-0.0948**	0.1099	-0.1086	0.4652
Goodness of Fit								
	R-Square	Adj. R-Sq	R-Square	Adj. R-Sq	R-Square	Adj. R-Sq	R-Square	Adj. R-Sq
	0.6665	0.5553	0.6186	0.4915	0.8304	0.7739	0.1598	0.0284

Note: Significant at the 0.05 and 0.10 probability levels are indicated by an asterisk (*) and double asterisks (**), respectively.

Table 10. Marshallian price elasticities by types of fresh-market tomatoes.

i\j	Cherry	Grape	Regular	Other
Cherry	-0.5039	-0.1774	0.1940	-0.5726
Grape	-0.5464*	-0.7908*	-0.5805*	-0.5187
Regular	0.0338	-0.1238	-0.1168	-0.4199*
Other	-0.4360	0.0284	-0.3504	-0.1094

Note: Significant at the 0.05 and 0.10 probability levels are indicated by asterisks (*) and double asterisks (**), respectively.

Table 11. Hicksian price elasticities by types of fresh-market tomatoes.

i\j	Cherry	Grape	Regular	Other
Cherry	-0.5132	-0.1639	0.2072	-0.5565
Grape	-0.1126*	-0.1596*	0.0378*	0.2344
Regular	0.1454	0.0386	-0.0423	-0.2262*
Other	-0.3205	0.1964	-0.1858	-0.3098

Note: Significant at the 0.05 and 0.10 probability levels are indicated by asterisks (*) and double asterisks (**), respectively.

The expenditure elasticities are reported in Table 12. The expected positive sign was obtained in all expenditure elasticities, which suggests all types of tomatoes considered in the study are “normal” goods. A 1% increase in the consumers’ budget for tomatoes is expected to increase the consumption of each tomato by the percentages reported in Table 12. In addition, all but one of the expenditure elasticities were less than one. When the expenditure elasticity of a good is greater than one, the commodity is considered a “luxury” good implying that consumers are very responsive to changes in their budget for tomatoes, i.e., consumption of grape tomatoes. For example, a 1% increase in the consumers’ budget for tomatoes is expected to increase grape tomato consumption by 2.44%. Similarly, the closer the expenditure elasticity of a good is to zero, the more the good is considered a “necessity.” That is, regardless of the consumers’ tomato budget increasing or decreasing, they will adjust personal tomato consumption very little. Our expenditure elasticity estimates have a wider range than previous studies (Table 13). This is likely because our study is the only one that reports disaggregated expenditure elasticities, while all previous studies have only reported one aggregated expenditure elasticity for fresh-market tomatoes.

Table 12. Expenditure elasticities by types of fresh-market tomatoes.

i	Expenditure Elasticities
Cherry	0.0521
Grape	2.4363*
Regular	0.6267*
Other	0.6486

Note: Significant at the 0.05 and 0.10 probability levels are indicated by asterisks (*) and double asterisks (**), respectively.

Table 13. Marshallian and Hicksian own-price and expenditure elasticity estimates for U.S. fresh-market tomatoes in previous studies.

					Marshallian Own-Price		Hicksian Own-Price		Expenditure	
Study	Model	Period	Commodity	Market	Estimate	Sig.	Estimate	Sig.	Estimate	Sig.
Naanwaab and Yeboah (2012)	LA/AIDS	1970-2010	Tomatoes	U.S.	-0.4430	***	n.a.	n.a.	0.6870	***
Naanwaab and Yeboah (2012)	LA/AIDS	2010	Tomatoes	U.S.	-0.5970	***	n.a.	n.a.	0.7330	***
Nzaku and Houston (2009)	LA/AIDS	1989-2008	Tomatoes	Imported	-0.5438	n.a.	-0.5317	n.a.	0.1111	n.a.
Nzaku and Houston (2009)	LA/AIDS	1989-2008	Tomatoes	U.S.	-1.1948	n.a.	-0.4505	n.a.	1.5056	n.a.
Seale et al. (2013)	Rotterdam	1989-2009	Tomatoes	Imp. Mexico	n.a.	n.a.	-0.0300	n.a.	1.1800	n.a.
Seale et al. (2013)	Rotterdam	1989-2009	Tomatoes	Imp. Canada	n.a.	n.a.	-0.3700	n.a.	0.7800	n.a.
Jung et al. (2005)	double-log	1990-2001	Tomatoes	U.S. & Imp.	-0.6140	**	-0.1136	n.a.	0.7702	**
Jung et al. (2005)	Rotterdam	1990-2001	Tomatoes	U.S. & Imp.	-0.8468	**	-0.1530	**	1.0640	**
Jung et al. (2005)	FD/AIDS	1990-2001	Tomatoes	U.S. & Imp.	-1.1967	**	-0.2192	**	1.5047	**
Thompson (2003)	QAIDS	1997-1999	Regular	Dallas, TX	-0.7890	n.a.	n.a.	n.a.	n.a.	n.a.
Thompson (2003)	QAIDS	1997-1999	Greenhouse	Dallas, TX	-0.4800	n.a.	n.a.	n.a.	n.a.	n.a.
Thompson (2003)	QAIDS	1997-1999	On the Vine	Dallas, TX	-0.0100	n.a.	n.a.	n.a.	n.a.	n.a.
Thompson (2003)	QAIDS	1997-1999	Roma	Dallas, TX	-1.5400	n.a.	n.a.	n.a.	n.a.	n.a.
Thompson (2003)	QAIDS	1997-1999	Cherry	Dallas, TX	0.0500	n.a.	n.a.	n.a.	n.a.	n.a.
Henneberry et al. (1999)	LA/AIDS	1970-1992	Tomatoes	U.S.	-0.2300	**	-0.1100	n.s.	n.a.	n.a.
You et al. (1996)	Composite	1960-1993	Tomatoes	U.S.	-0.4050	***	n.a.	n.a.	0.7978	***

Note: Significance at the 0.01, 0.05, and 0.10 probability levels are indicated by triple asterisks, double asterisks, and single asterisks, respectively. The abbreviations n.a. and n.s. stand for not available and not significant, respectively.

CONCLUSION

The consumption of tomatoes has rapidly increased over the last four decades in the U.S. In 2000, tomato consumption increased approximately 30% over the previous decade (Lucier et al. 2000). In 1981, average annual per-capita consumption of fresh-market tomatoes was 5.58 kg (Boriss and Brunke 2011), rising to 8.29 kg in 2014 (Table 1). This increasing trend in consumption is partly due to increasing Hispanic and Asian population in the U.S. (Nzaku and Houston 2009), the NAFTA's opening of free trade agreements (Grant and Foster 2005; Huang and Huang 2007), and the growth of the U.S. economy. Additionally, tomato consumption has increased due to trends in healthy lifestyles (Beecher 1998), and the increasing popularity of the positive benefits of eating fresh tomatoes (Deghan et al. 2011), including helping with immune responses, and decreasing risk of breast and prostate cancer and cardiovascular diseases (Agarwal and Rao 2000).

Texas ranks as the sixteenth largest U.S. fresh-market tomato producing state. Although California and Florida dominate the fresh tomato market (a 71% market share combined), the Texas fresh-market tomato industry produces about $23.3 million per year.[2] An understanding of the trends reported in this study can provide valuable information for DFW area producers considering investing or diversifying into fresh-market tomato enterprises.

Many characteristics of the DFW metropolitan area make growing vegetables attractive. From 2007 to 2012, the number of farms and farmland increased in the DFW metropolitan area by about 10% (Bennett and Hanselka 2013). In fact, farms of all sizes increased, but the most rapid increase was exhibited by smaller acreage farms (Bennett and Hanselka 2013). Some of these small acreage farms are in urban locations and allow for "agrientertainment" such as wineries offering festivals, pumpkin farms providing Halloween shopping, pasture farms allowing hayrides, corn farms growing corn mazes, and cut-your-own Christmas trees offering sleigh rides and ornament making (Bennett and Hanselka 2013). Clearly, vegetable farmers could engage in pick-your-own operations. The DFW metropolitan area also has more than 30 farmers' markets (Bennett and Hanselka 2013), which make growing vegetables locally attractive. This is informative since Brumfield et al. (1993) concluded that states may be successful in promoting local fresh-market tomatoes on the basis of origin alone.

This study, unlike previous fresh fruit and vegetable studies referenced in the introduction, reports current disaggregated tomato elasticity estimates of interest to existing or potential vegetable farmers in the DFW metropolitan area. The study also identified tomato types that are highly marketable in the DFW metropolitan area such as regular tomatoes (42.10% market share), grape tomatoes (23.49% market share), and cherry tomatoes (12.23% market share), and may consequently provide insight on tomato varieties that could be grown locally to meet the DFW market demand. Emerging tomato types such as yellow sweet tomatoes (6.08% market share), Campari tomatoes (3.40% market share), and sweet tomatoes (2.58% market share) appear appealing to fresh-market consumers of tomatoes.

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[2] Weighted overall fresh-market tomato retail price = $2.0043/lb (Table 8) times 5,268 t production in Texas in 2014 (Table 3) times 2,204.62 lb/t equal approximate value of Texas fresh-market tomato production at retail prices.

The own-price elasticity estimates indicated that fresh-market tomato consumers are not very responsive to changes in own prices. It is also expected that increases in the price of fresh-market tomatoes will result in increased total revenue because the price increase more than offsets the quantity decrease. Additionally, the expenditure elasticity estimates suggested that as the economy grows and consumers' expenditure budgets on fresh-market tomatoes increase, consumption of fresh-market tomatoes in DFW is expected to increase. This result, combined with the characteristics of the DFW metropolitan market, reinforces growing vegetables in the DFW metropolitan area as being attractive.

Finally, using an AIDS model to estimate elasticities has several advantages over the ad-hoc conventional approach of estimating single-equation demand curves. One of the main advantages is that the resulting elasticity estimates are more rigorous and reflective of consumer choices. The elasticity estimates are important because they are used to summarize and describe the underlying demand functions. For example, the elasticities estimate how much fresh-market tomato consumption is expected to change given changes in fresh-market tomato prices or a change in the consumers' expenditure budget.

Due to financial constraints, only one year of data was purchased from The Nielsen Company. The study could be easily expanded to include more years, provided additional funds were available. The study could also be expanded to include more vegetables such as carrots, cauliflower, celery, etc. and even fresh-salad mixes. Given that promotion of local produce is becoming increasingly important, the study could alternatively include source of origin in the analysis. A separate study could also evaluate the processed-tomato market. Finally, the study could use the estimated elasticities to generate a sensitivity analysis of likely tomato prices for fresh tomato producers in the DFW area and combine it with data from local production practices to conduct a profitability analysis.

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REFERENCES

Agarwal S, Rao AV. 2000. Tomato Lycopene role in human health and chronic diseases. Canadian Medical Association Journal 163:739-744. [accessed November 22, 2016]. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC80172/pdf/20000919s00019p739.pdf.

Bennett B, Hanselka D. 2013. The impact of agribusiness in the Dallas-Fort Worth Metroplex. Texas A&M AgriLife Extension, Texas A&M University System. [accessed May 18, 2015]. http://agecoext.tamu.edu/files/2013/08/DFWMetroplex.pdf.

Boriss H, Brunke H. 2011. Fresh tomatoes profile. Agricultural Marketing Resource Center, Agricultural Issues Center, University of California. University of California. [accessed January 14, 2015].

http://www.agmrc.org/commodities__products/vegetables/fresh_tomatoes_profile.cfm#.

Brandow GE. 1961. Interrelationships among demands for farm products and implications for control of market supply. Pennsylvania Agricultural Experiment Station Bulletin 680.

Beecher GR. 1998. Nutrient content of tomatoes and tomato products. Proceedings of the Society of Experimental Biology and Medicine 218:98-100. [accessed November 22, 2016]. https://www.researchgate.net/publication/13679423_Nutrient_Content_of_Tomatoes_and_Tomato_Products.

Brumfield RG, Adelaja AO, Lininger K. 1993. Consumers tastes, preferences, and behavior in purchasing fresh tomatoes. Journal of American Society of Horticulture Science 118:433-438. [accessed November 22, 2016]. http://journal.ashspublications.org/content/118/3/433.full.pdf.

Deaton A., Muellbauer. An almost ideal demand system. 1980. The American Economic Review 70:312-326. [accessed November 22, 2016]. https://assets.aeaweb.org/assets/production/journals/aer/top20/70.3.312-326.pdf.

Deghan M, Askhtar-Danesh N, Merchant AT. 2011. Factors associated with fruit and vegetable consumption among adults. Journal of Human Nutrition and Dietics 24:128-134. [accessed November 22, 2016]. https://www.researchgate.net/publication/49847129_Factors_associated_with_fruit_and_vegetable_consumption_among_adults.

George PS, King GA. 1971, March. Consumer demand for food commodities in the United States with projections for 1980. Giannini Foundation Monograph No. 26, Oakland (CA): University of California. [accessed November 22, 2016]. http://ageconsearch.umn.edu/bitstream/11936/1/ms710026.pdf.

Grant J, Foster KA. 2005. An inverse almost ideal demand system of Fresh Tomatoes in the U.S. Paper presented at: American Agricultural Economics Association Annual Meeting; Providence, RI. [accessed November 22, 2016]. http://ageconsearch.umn.edu/bitstream/19193/1/sp05he03.pdf.

Green R. Alston, JM. 1990, May. Elasticities in AIDS Models. American Journal of Agricultural Economics 7:442-445. [accessed November 22, 2016]. http://agecon2.tamu.edu/people/faculty/capps-oral/agec%20635/Readings/Elasticities%20in%20AIDS%20Models.pdf.

Henneberry SR, Piewthongngam K, Qiang H. 1999. Consumer food safety concerns and fresh produce consumption. Journal of Agricultural and Resource Economics 24:98-113. [accessed November 22, 2016]. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.545.7233&rep=rep1&type=pdf.

Huang S, Huang K. 2007, September. Increased U.S. imports of fresh fruit and vegetables. Washington (DC): U.S. Department of Agriculture, Economic Research Service, Pub. No. FTS-328-01. [accessed November 22, 2016]. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.483.6411&rep=rep1&type=pdf.

Jung J, VanSickle J, Seale J. 2005. Demand analysis of the U.S. fresh tomato market. Paper presented at: Southern Association of Agricultural Economics Association Annual Meeting; Little Rock, AR. [accessed November 22, 2016].

https://www.researchgate.net/publication/23515367_Demand_Analysis_of_the_US_Fresh_Tomato_Market.

Lucier G, Lin BH, Allshouse J, Kantor L. 2000. Factors affecting tomato consumption in the United States. Vegetables and Specialties Situation and Outlook Report. Washington (DC): U.S. Department of Agriculture, Economic Research Service, Pub. No. VGS-282. [accessed January 14, 2015]. http://usda.mannlib.cornell.edu/usda/ers/VGS/2000s/2000/VGS-11-16-2000.pdf.

Naanwaab C, Yeboah O. 2012. Demand for fresh vegetables in the United States: 1970-2010. Economics Research International 2012:1-11. [accessed on November 22, 2016]. https://www.hindawi.com/journals/ecri/2012/942748/.

Niu L, Wohlgenant M. 2012. A censored demand system analysis of fruits and vegetables by different income groups using micro data. Paper presented at: Agricultural and Applied Economics Association Annual Meeting; Seattle, WA. [accessed November 22, 2016]. http://ageconsearch.umn.edu/bitstream/123946/2/Niu%20and%20Wohlgenant%20%282012%29.pdf.

Nzaku K, Houston JE. 2009. Dynamic estimation of US demand for fresh vegetable imports. Paper presented at: Agricultural and Applied Economics Association Annual Meeting; Milwaukee, WI. [accessed November 22, 2016]. http://ageconsearch.umn.edu/bitstream/52209/2/AAEApaperdraft072409.pdf.

Padilla L., Acharya R. 2009. Effects of health information on fruit and vegetable consumption. Paper presented at: Agricultural and Applied Economics Association Annual Meeting; Tampa, FL. [accessed November 22, 2016]. http://ageconsearch.umn.edu/bitstream/21742/1/sp00pa04.pdf.

Seale JL, Zhang L, Traboulsi MR. 2013. U.S. import demand and supply response for fresh tomatoes, cantaloupes, onions, oranges, and spinach. Journal of Agricultural and Applied Economics 45:435-452. [accessed November 22, 2016]. http://ageconsearch.umn.edu/bitstream/155419/2/jaae453ip6.pdf.

Statistical Analysis System (SAS) Software, SAS Institute Inc. http://www.sas.com/en_us/home.html

Strange M, Schrader W, Hartz T. 2000. Fresh-market tomato production in California. Oakland (CA): University of California, Vegetable Research and Information Center, Pub. No. 8017. [accessed November 22, 2016]. http://anrcatalog.ucdavis.edu/pdf/8017.pdf.

Thompson GD. 2003. Retail demand for greenhouse tomatoes: differentiated fresh produce. Paper presented at: American Agricultural Economics Association Annual Meeting; Montreal, CN. [accessed November 22, 2016]. http://ageconsearch.umn.edu/bitstream/21946/1/sp03th01.pdf.

U.S. Department of Agriculture (USDA) - Economic Research Service (ERS). 2012. Tomatoes. USDA ERS. [accessed January 14, 2015]. http://www.ers.usda.gov/topics/crops/vegetables-pulses/tomatoes.aspx.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2014. Vegetables 2014 Summary: January 2015. Washington (DC): U.S. Department of Agriculture, National Agricultural Statistic Service, ISSN: 0884-6413. [accessed August 3, 2015]. http://usda.mannlib.cornell.edu/usda/nass/VegeSumm//2010s/2015/VegeSumm-01-29-2015.pdf.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2012. Vegetables 2011 Summary: January 2012. Washington (DC): U.S. Department of Agriculture, National Agricultural Statistic Service, ISSN: 0884-6413. [accessed August 3, 2015]. http://usda.mannlib.cornell.edu/usda/nass/VegeSumm//2010s/2012/VegeSumm-01-26-2012.pdf.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2009. Vegetables 2008 Summary: January 2009. Washington (DC): U.S. Department of Agriculture, National Agricultural Statistic Service, Pub. No. Vg 1-2 (09). [accessed August 3, 2015]. http://usda.mannlib.cornell.edu/usda/nass/VegeSumm//2000s/2009/VegeSumm-01-28-2009.pdf.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2006. Vegetables 2005 Summary: January 2006. Washington (DC): U.S. Department of Agriculture, National Agricultural Statistic Service, Pub. No. Vg 1-2 (06). [accessed August 3, 2015]. http://usda.mannlib.cornell.edu/usda/nass/VegeSumm//2000s/2006/VegeSumm-01-27-2006.pdf.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2003. Vegetables 2002 Summary: January 2003. Washington (DC): U.S. Department of Agriculture, Pub. No. Vg 1-2 (03). [accessed August 3, 2015]. http://usda.mannlib.cornell.edu/usda/nass/VegeSumm//2000s/2003/VegeSumm-01-29-2003.pdf.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2000. Vegetables 1999 Summary: January 2000. Washington (DC): U.S. Department of Agriculture, Pub. No. Vg 1-2 (00) a. [accessed August 3, 2015]. http://usda.mannlib.cornell.edu/usda/nass/VegeSumm//2000s/2000/VegeSumm-01-28-2000.pdf.

U.S. International Trade Commission (USITC). USITC Interactive Tariff and Trade DataWeb Version 3.1.0. [accessed August 3, 2015]. https://dataweb.usitc.gov/scripts/user_set.asp.

You Z, Epperson JE, Huang CL. 1996. A composite demand system for fresh fruits and vegetables in the United States. Journal of Food Distribution Research 27:11-22. [accessed November 22, 2016] http://ageconsearch.umn.edu/bitstream/27894/1/27030011.pdf.