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The producer welfare effects of trade liberalization when goods are perishable and habit-forming: the case of asparagus

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Abstract

Asparagus is a perishable, highly seasonal crop. We find that out-of-season imports of asparagus caused habit formation that increased demand in the U.S. growing seasons. We find that habit effects offset about 64% of the welfare losses to U.S. asparagus producers from increased Mexican imports under NAFTA and all of the U.S. producer welfare losses from increased Peruvian imports under the Andean Trade Preference Act. We estimate that the U.S. producer welfare losses from NAFTA are less than the annualized value of market loss assistance provided them in the 2008 Farm Bill.

JEL classifications: D12, F130, Q17, Q18

Keywords: Free trade agreements; NAFTA; Andean Trade Preference Act; Mexico; Peru; Vegetable; Habits; Equilibrium displacement model

1. Introduction

Prior to the 1990s, asparagus was a seasonal, spring vegetable, largely unavailable in the U.S. outside of the months of February to June (see Fig. 1). Asparagus grows from a deep established rootstock, requiring two to three years of growth following its planting before producing an annual crop for approximately the next 10 years. After several months of harvesting in the early spring, the asparagus shoots are allowed to fully develop ("fern out") to regenerate the root stock. In Mexico, the harvest season can be extended, as plants can be harvested earlier in warmer areas and later in cooler mountainous areas. In Peru, the harvest season runs largely counter to the U.S. because of the reversed growing seasons of the southern hemisphere. Since 2005, over 95 of the U.S. domestic asparagus market has been supplied by Peru, Mexico, and the U.S, with each country showing a strong seasonality in its supply cycle. The U.S. produces mainly between February and June; Peru, between June and January; and, Mexico, between January and March and, at a lesser level, between June and August (see Fig. 2).

In roughly this same period, the U.S. significantly liberalized agricultural trade with Mexico and Peru. The North American Free Trade Agreement (NAFTA) of 1994 gradually eliminated most tariffs on agricultural imports from Mexico and Canada over a 13-year period. The Andean Trade Preference Act (ATPA) of 1991 (and its successors, including the Peruvian Trade Promotion Act of 2007) similarly eliminated tariffs on Peruvian imports. A key policy concern surrounding the passage and renewal of these agreements are the effects of imports on the welfare of U.S. agricultural producers. In terms of political economy, classical trade theory implies that trade liberalization that increases imports will benefit domestic consumers and harm domestic producers. However, in the case of agricultural goods, two factors may mitigate this harm. First, if imported goods are perishable and counter-seasonal, domestic producers face little if any direct competition with foreign producers. Second, if the increased availability of the good causes consumers to form habits that extend into the domestic marketing season, domestic producers may enjoy a demand increase that offsets the supply increase associated with import competition when it overlaps the domestic market season.

Asparagus is strongly seasonal in supply and difficult to preserve, traits it shares with grapes, peaches, and cherries. While other agricultural commodities such as apples, citrus, and melons may be stored for longer periods, the USDA's Agricultural Marketing Service (2004) notes that asparagus has a maximum marketing period of three weeks. Moreover, because asparagus requires a well-established rootstock, it is less amenable

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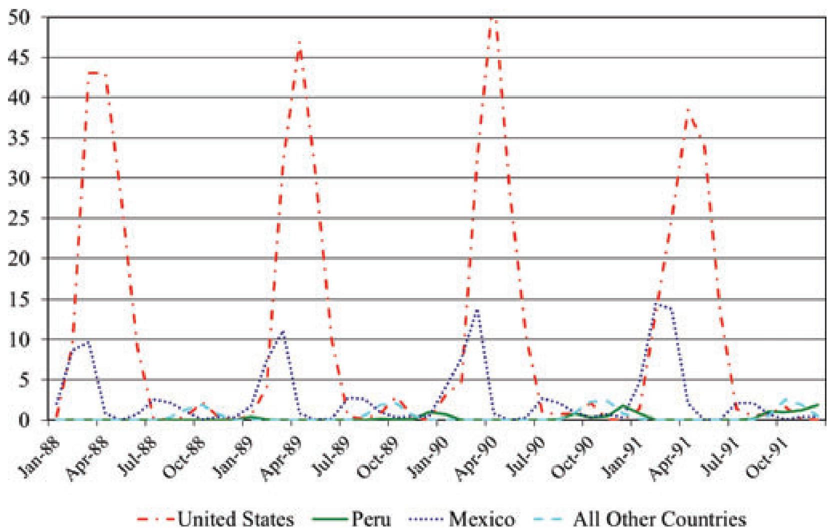

Fig. 1. U.S. Fresh asparagus supply by source: 1988–1991 (millions of pounds).

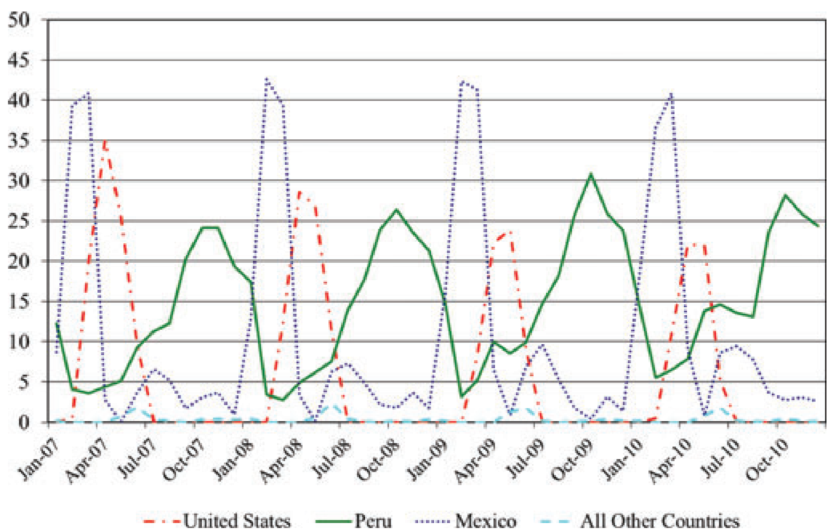

Fig. 2. U.S. fresh asparagus supply by source: 2007–2010 (millions of pounds).

to horticultural practices including greenhouse production and delayed planting that can extend the growing cycle of annual crops such as tomatoes and broccoli. In seeming acknowledgement of this seasonality, the Most Favored Nation (MFN) tariff rate is reduced from its usual rate of 21.3% to 5% between September 15 and November 15.

This article estimates the producer welfare impact of trade liberalization for asparagus in light of its seasonality of supply and habit effects in consumption. This work is most closely related to that of Stanton (2007) who showed Chilean table grape imports, which arrive counter-seasonally to U.S. production, cause consumers to form habits for table grapes that extend into the U.S. growing season and do not depress U.S. grape prices. While other work has also found evidence of habit formation in food consumption (Blanciforti and Green, 1983; Holt and Goodwin, 1997; Zhen et al., 2011), our work extends existing analysis into a specific application where habit effects might mitigate the effect of tariff reduction on producer welfare. Our method is as follows. First, we estimate a Trans Log (TL) demand system for four fresh vegetables (asparagus, broccoli, carrots, and cauliflower) and a numeraire good while allowing demand to be influenced by habits as captured by the effect of lagged consumption on current demand. Second, we recover demand elasticities with respect to price and lagged consumption. Third, we use an equilibrium displacement model to simulate the consumer and producer welfare effects resulting from a change in the asparagus tariff rates, where three sources (the U.S., Mexico, and Peru) are assumed to supply U.S. asparagus market.

The equilibrium displacement model allows us to isolate the trade and habit effects resulting from a change in tariff rates for asparagus. To isolate the trade effect, we simulate the quantity changes resulting from a tariff change based on our estimated demand and conjectured supply elasticities while ignoring the role of habits. To isolate the habit effect, we construct a simulated change in lagged consumption variable and assume that it has a contemporaneous effect on demand. We then use our elasticities to estimate how the change in lagged consumption (i.e., the loss of habits) reduces demand. For both the trade and habit effects, we calculate our simulated change in producer welfare as a percentage of total industry revenue. The total effect of a tariff change on producer welfare is the sum of the trade and habit effects.

We then consider how NAFTA and the ATPA affected the welfare of U.S. asparagus producers. Policy makers are concerned that, despite its benefits for consumers, these agreements have harmed domestic producers. As compensation for their losses, the 2008 Farm Bill provided domestic asparagus producers \$15 million in market loss assistance[1] for price reductions caused by increased imports between 2004 and 2007. The assistance was split evenly between fresh and frozen producers, compensating frozen producers at 53.3¢ per pound and fresh producers at 44.1¢ per pound on an average fresh price of 89.1¢ per pound (Benemelis, 2011). NAFTA and the ATPA eliminated tariff on Mexican and Peruvian imports from their MFN level of 21.3% in most months and 5% in September, October, and November. Using Monte Carlo simulations, we find while the trade effect of NAFTA reduced U.S. asparagus producer welfare by 0.28%, the habit effect increased U.S. asparagus producer welfare by 0.17% or approximately 63% of the welfare loss. For the ATPA, the trade effect reduced U.S. asparagus producer welfare by 0.09%, while the habit effect increased it by 0.23%, resulting in a net benefit to U.S. producers. And, for NAFTA and the ATPA together, the trade effect reduced U.S. asparagus producer welfare by 0.36%, while the habit effect increased it by 0.40%, again resulting in a net benefit to U.S. producers. In general, the magnitude of our estimates of the change in U.S. producer welfare are small, especially compared to the welfare gains of trade partners and the lost revenue of the tariff. We also find that NAFTA alone reduced fresh asparagus producer welfare by only \$180 thousand for the 2004–2007 growing seasons which is less than the annualized amount of \$1.875 million (half of \$15 million over four years) provided to fresh asparagus producers as market loss assistance as part of the 2008 Farm Bill.

2. Demand model

Let $\tilde{p}_{i,t}$ be the price of the *i*th good in the *t*th period, $p_{i,t}$, normalized by contemporaneous expenditure, y_t (i.e., $\tilde{p}_{i,t} = p_{i,t}/y_t$). Utility, ψ_t, depends on N prices and the model parameters as specified in the following (indirect) TL utility function:

$$\ln \psi_t(\tilde{p}_{i,t}, \alpha_{i,t}, \beta_{ij}, \varepsilon_{i,t}) = \alpha_0 + \sum_{i=1}^{N} \alpha_{i,t} \ln \tilde{p}_{i,t} + \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \beta_{ij} \ln \tilde{p}_{i,t} ln \tilde{p}_{j,t} + \sum_{i=1}^{M} \varepsilon_{i,t} \ln \tilde{p}_{i,t}. \tag{1}$$

The $\beta_{i,j}$ term captures the effect of price on utility and $\varepsilon_{i,t}$ is the error term. The $\alpha_{i,t}$ term captures demand shifters other than price. In estimation, $\alpha_{i,t}$ is specified to be a linear function of an intercept ($\alpha_{i,0}$), 11 monthly dummies ($D_{Mon,t}$), a time trend ($trend_t$), and a term containing cumulative lagged consumption ($lagQ_{j,t}$).

A substantial literature documents the desirable properties of the TL demand system with regard to flexibility, aggregation, and performance, especially as compared to the Almost Ideal Demand (Christensen et al., 1975; Holt and Goodwin, 2009; Lewbel, 1989; Piggott, 2003; Wang et al., 1996). Previous studies have shown that habit effects are significant in a variety of applications (Becker et al., 1994; Carroll et al., 2000; Dynan, 2000; Fuhrer, 2000), including food demand (Blanciforti and Green, 1983; Holt and Goodwin, 1997; Zhen et al., 2011). Some research, however, has failed to find evidence of habits (Bryant and Davis, 2008). The habit effect, therefore, might be idiosyncratic to the commodity considered. Moreover, the habit effect might be conflated with the effect of consumers forming inventories across periods if data measure disappearance rather than consumption. This inventory effect will work in opposite direction to the habit effect, tending to make demand fall in response to an increase in lagged consumption (Zhen et al., 2011).

To capture the habit effect, we include lagged consumption in the demand system. Specifically, the $lagQ_{j,t}$ term equals the sum of the consumption of good *j* in periods $t-1$ through $t-l$ discounted by *d*, a term that captures the declining "memory" of consumers with regard to a previous period's consumption. These relationships are specified as:

$$\alpha_{i,t} = \alpha_{i,0} + \sum_{Mon=1}^{11} \alpha_{i,Mon} D_{Mon,t} + \alpha_{i,t} trend_t + \sum_{j=1}^{N} \alpha_{i,lagQ_j} lagQ_{j,t}, \tag{2}$$

$$lagQ_{j,t} = \sum_{l=1}^{L} d^l \log q_{j,t-l}. \tag{3}$$

L is the length of consumption memory, which we set at 12 months because previous empirical studies of habit formation have found that using the most recent lags captures most of the dynamics in consumption (Chen and Ludvigson, 2009; Fuhrer,

[1] Asparagus Revenue Market Loss Assistance Payment Program: U.S. Farm Bill of 2008 §10404, 75 FR, pages (41397–41404).

2000).[2] Additionally, we apply the symmetry, equality, and adding-up restrictions (Christensen et al., 1975):

$$\beta_{ij} = \beta_{ji}, \tag{4}$$

$$\sum_{i=1}^{N} \beta_{ij} = \sum_{i=1}^{N} \beta_{ji} = 0, \tag{5}$$

$$\sum_{i=1}^{N} \alpha_{i,0} = 1, \text{ where, } \sum_{i=1}^{N} \alpha_{i,Mon} = 0, \sum_{i=1}^{N} \alpha_{i,t} = 0,$$
$$\sum_{i=1}^{N} \alpha_{i,lagQ_j} = 0. \tag{6}$$

Pollak and Wales (1992) and Holt and Goodwin (2009) note that by adding the restriction in (5) our model is synonymous with the log TL Demand System. After suppressing the t subscript, the expenditure shares, s_i, are solved in (7) via Roy's Identity:

$$s_i = \tilde{p}_i q_i = -\left(\alpha_i + \sum_{j=1}^{N} \beta_{ij} ln(p_j)\right). \tag{7}$$

From Eq. (7), elasticities with respect to price, income, and lagged consumption are recovered as:

$$\varepsilon_{q_i,p_j} = \frac{\partial q_i}{\partial p_j}\frac{p_i}{q_i} = \frac{\partial q_i}{\partial \ln p_j}\frac{1}{q_i} = -\beta_{ij}/s_i - 1_{ij},$$
$$\text{where } 1_{ij} \text{ equals 1 if } i = j, 0 \text{ otherwise}, \tag{8}$$

$$\varepsilon_{q_i,y} = \frac{\partial q_i}{\partial y}\frac{y}{q_i} = 1 + \sum_{j=1}^{J} \beta_{ij}/s_i, \tag{9}$$

$$\varepsilon_{q_i,lagQ_j} = \frac{\partial q_i}{\partial lagQ_j}\frac{lagQ_j}{q_i} = \frac{\alpha_{i,lagQ_j}}{\tilde{p}_i}\frac{lagQ_j}{q_i}$$
$$= \frac{\alpha_{i,lagQ_j \times lagQ_j}}{s_i}. \tag{10}$$

Later in the article, we use Monte Carlo simulations to estimate these both averages and standard deviations of these elasticities, which we then use to simulate the producer welfare effects of NAFTA and the ATPA.

[2] In the empirical literature, habit variables have been alternately captured through the inclusion of single-period lagged consumption terms (Bryant and Davis, 2008, Piggott, 2003) or the discounted sum of multiple periods of lagged consumption (Zhen et al., 2011). We use the latter specification.

3. Data

Our data consist of monthly price and quantity data on fresh vegetable shipments from the vegetable and melon yearbook of the USDA's Economic Research Service (ERS) (2009). We include asparagus, broccoli, carrots, and cauliflower within the demand system because prices for these goods are collected over a longer time period than for other goods. In addition, these goods are more tightly defined than other goods, such as beans and lettuce, which include many varieties. Finally, each of these goods is typically sold with minimal processing and branding. In our raw data, quantities representing national level availability[3] and are reported as the sum of net monthly imports and domestic vegetable shipments in 100,000 pound units. Prices are the domestic shipping prices per hundredweight and originate from Agricultural Marketing Service (AMS) data.[4] For instruments, we obtain annual yields on Mexican and U.S. production of asparagus, broccoli, carrots, and cauliflower from the United Nations Food and Agricultural Organization's FAOSTAT website.

As it is only comprised of only four vegetables, our demand system is incomplete and these goods are unlikely to represent an income separable segment of the demand system. To account for the possible biases that emerge with an incomplete demand system, we follow LaFrance and Hahnemann (1989) by augmenting our demand system with a numeraire good. This specification allows us to proceed with our estimation as if the demand system were complete. We use the Consumer Price Index from the Bureau of Labor Statistics (in 2011) as the price of the numeraire good and Total Personal Consumer Expenditure as a measure of total expenditure. The expenditure on the numeraire good is total expenditure minus expenditure on our four vegetables. Quantities of the numeraire goods can then be inferred from its price and inferred expenditure.

Table 1 provides means and standard deviations of prices, quantities, and market shares between 1992 and 2010. Because expenditure on our four fresh vegetables comprised of a relatively small portion of total expenditure, shares of expenditure are broken out with and without the numeraire. Notably, fresh asparagus sells at a considerably higher price relative to other fresh goods and represents approximately 35 of the consumer's budget within our subset of four vegetables.

[3] Although AMS quantity data can omit home-grown and locally sold items, the concentrated geography of production of these goods minimizes that problem.

[4] AMS, however, only reports prices when domestically produced goods are shipped. In 77 months, AMS did not record domestic price for asparagus, although prices for all other goods are recorded. AMS did, however, record a Caribbean import price for asparagus which includes imports from Peru, which is the main supplier. Moreover, in 84 months, the two prices overlap and the Caribbean import price is approximately 9.12 higher than the domestic shipping price. So, for the 77 months where the domestic shipping price is missing for asparagus, we use the Caribbean import price corrected downward by 9.12%.

Table 1
Summary statistics on prices, quantities, and budget shares of vegetable data

		Asparagus	Broccoli	Carrots	Cauliflower	Numeraire
Prices ($/hundredweight)	Mean	167.1	39.21	21.81	42.90	127.97
	St. Dev.	61.1	11.50	4.66	13.60	16.49
Quantities: pounds per capita	Mean	0.80	2.75	3.98	1.37	25,240,659
	St. Dev.	0.49	0.45	1.08	0.30	5,511,489
Shares	Mean	0.00053	0.00043	0.00034	0.00023	99.9985
	St. Dev.	0.00029	0.00018	0.00018	0.00012	0.0006
Shares (excluding numeraire)	Mean	34.57	28.10	22.43	14.90	
	St. Dev.	10.99	5.99	5.62	3.89	

Sources: Agricultural Marketing Service (2008).

4. Estimation and results

To reduce the possibility of price endogeneity bias, we use a two-stage least-squares method to estimate our TL demand system. We use of trends, monthly dummies, and lagged prices as instruments for current prices. Additionally, we follow Roberts and Schlenker (2010) and use crop yields as instruments for identifying demand shifts based on the assumption that more closely related to supply shocks such as exogenous weather shifts and are more readily available from existing data. Lagged prices are also included because their close correlation with current prices helps to avoid potential weak instrument bias.

Tables 2 and 3 provide the estimated parameters of the demand systems in Eq. (7) where the subscript *i*, equal to *a*, *b*, *c*, *f*, and *n,* indexes that goods parameters referring to asparagus, broccoli, carrots, cauliflower, and the numeraire good, respectively. As Eq. (7) indicates, the negative value of α on a seasonal dummy variable implies a strengthening of demand. Also, prices in the demand system ($\tilde{p}$) are log income-normalized prices that are negative. The own price-effects are significant for each of our goods. In Table 2, the $\alpha_{i,0}$ term can be loosely interpreted as the intercept term in a demand equation. The combined effect of habits, the time trend, and seasonality makes the "total α" term negative in most months. The time trend, beginning at one in January 1984, grows by one per month and is captured by $\alpha_{i,t}$. Trends are not significant for any of the goods.

Table 2 also indicates that some seasonality is present within each good, as indicated by those months in which $\alpha_{i,Mon}$ is negative (indicating increased demand, as per Eq. (7)) or positive (indicating decreased demand). Seasonality is particularly strong with asparagus demand in the early domestic harvest months of January through April. We speculate that this seasonality might result from consumer habituation to eat certain foods at specific times of the year, a phenomenon bolstered by cultural events that encourage the consumption of seasonal crops, such as Spargelfest (literally, asparagus festival in German). Alternatively, the domestic growing season might be associated with a higher quality crop. Our data, however, cannot separate unmeasured quality changes associated with ripeness or the psychic benefit of domestic production.[5] While some literature has indicated that even seemingly homogenous products are differentiated by country of origin (Grant et al., 2010), that issue is outside the scope of this research.

In Table 2, habits effects, as opposed to inventory effects, are indicated by the parameter capturing the effect of lagged consumption ($\alpha_{i,lagq_j}$) having a negative sign. The significance of habit effects is determined through the interaction of the memory term (*d*) and the own- and cross-commodity effects of lagged consumption on current consumption ($\alpha_{i,lagq_j}$). The memory term, *d*, is estimated to be 0.56 and significantly different from zero. However, the memory of a previous period's consumption on current consumption is relatively short. For example, the effect of consumption after four months is about 10% of its effect after one month. Although the own-lag effects are of the expected sign (i.e., lagged consumption having a positive effect on demand), they are not statistically significant within our estimation. Two factors explain this. First, the interaction of the memory and lag terms affects their joint significance. When the memory term (*d*) is restricted to its estimated value and the model is re-estimated, each of the own-lag terms becomes significant. Second, in addition to the habit effect, the lag terms themselves may be capturing an inventory effect where previous periods purchases are stored and depress consumption in later months (Zhen et al., 2011). Isolating the inventory effect is difficult without posing additional structure on the consumer choice problem (as in Hendel and Nevo, 2006). Empirically, it is very difficult to separate these two effects in estimation. Cross-commodity lagged effects are mixed, with lagged broccoli consumption increasing asparagus demand and lagged cauliflower demand decreasing it.

The TL demand system specifies demand elasticities as a function of budget shares given in Eqs. (8) through (10). One can obtain point estimates of these elasticities by evaluating the formulas at the means or by evaluating them at each point in the data set and then taking the average. We use the latter method. While the variance in elasticities may be obtained analytically

[5] For asparagus, production is also relatively geographically concentrated and requires several years planning in its cultivation making local and home production limited.

Table 2
Parameter estimates from the translog demand system: Intercept, price trend, and lagged consumption effects

Parm.	Est.	St. dev.	*t*-Value	*P*-value	Parm.	Est.	St. dev.	*t*-Value	*P*-value
Intercept terms					Lagged consumption terms				
$\alpha_{0,a}$	−0.00015	0.00019	−0.81	0.419	$\alpha_{lag,a,a}$	−2.04E-06	1.53E-06	−1.34	0.183
$\alpha_{0,b}$	−0.00006	0.00009	−0.62	0.533	$\alpha_{lag,a,b}$	−1.04E-06	1.68E-06	−0.62	0.538
$\alpha_{0,c}$	−0.0001	6.3E-05	−1.64	0.104	$\alpha_{lag,a,c}$	1.34E-06	1.69E-06	0.79	0.429
$\alpha_{0,f}$	0.000067	9.9E-05	0.68	0.499	$\alpha_{lag,a,f}$	−1.23E-06	1.22E-06	−1.01	0.315
Price effect terms					$\alpha_{lag,a,n}$	4.805E-06	4.1E-06	1.17	0.244
$\beta_{a,a}$	−6.21E-06	3.16E-06	−1.96	0.051	$\alpha_{lag,b,a}$	−2.67E-07	5.85E-07	−0.46	0.649
$\beta_{a,b}$	−1.29E-06	1.39E-06	−0.93	0.352	$\alpha_{lag,b,b}$	−1.61 E-07	1.2E-06	−1.38	0.169
$\beta_{a,c}$	−1.29E-06	8.59E-07	−1.5	0.134	$\alpha_{lag,b,c}$	3.80E-08	9.179E-07	0.04	0.967
$\beta_{a,f}$	−1.25E-06	1.37E-06	−0.91	0.364	$\alpha_{lag,b,f}$	−3.52E-07	6.32E-07	−0.56	0.578
$\beta_{b,b}$	−5.36E-06	1E-06	−5.3	<.0001	$\alpha_{lag,b,n}$	2.039E-06	2.1E-06	0.96	0.339
$\beta_{b,c}$	−7.79E-07	4.75E-07	−1.64	0.102	$\alpha_{lag,c,a}$	−5.90E-08	3.90E-07	−0.15	0.880
$\beta_{b,f}$	−1.93E-07	1.06E-06	−0.18	0.856	$\alpha_{lag,c,b}$	−6.22E-07	6.43E-07	−0.97	0.334
$\beta_{c,c}$	−3.30E-06	3.51E-07	−9.39	<.0001	$\alpha_{lag,c,c}$	−3.96E-07	7.36E-07	−0.54	0.591
$\beta_{c,f}$	−4.16E-07	5.08E-07	−0.82	0.414	$\alpha_{lag,c,f}$	−6.67E-07	4.02E-07	−1.66	0.098
$\beta_{f,,f}$	−3.56E-06	1.91E-06	−1.87	0.064	$\alpha_{lag,c,n}$	3.17E-06	1.6E-06	2.03	0.044
Trend effects					$\alpha_{lag,f,a}$	7.58E-08	5.37E-07	0.14	0.888
$\alpha_{t,a}$	−3.53E-09	3.21E-08	−0.11	0.912	$\alpha_{lag,f,b}$	−5.73E-07	9.30E-07	−0.62	0.539
$\alpha_{t,b}$	−2.83E-09	1.52E-08	−0.19	0.852	$\alpha_{lag,f,c}$	−2.85E-07	9.92E-07	−0.29	0.774
$\alpha_{t,c}$	−1.21E-08	1.18E-08	−1.03	0.303	$\alpha_{lag,f,f}$	−9.57E-07	7.48E-07	−1.28	0.202
$\alpha_{t,f}$	1.23E-08	1.72E-08	0.72	0.475	$\alpha_{lag,f,n}$	−1.25E-06	2.7E-06	−0.46	0.643
					Memory (discounting) term				
					d	0.55989	0.2053	2.73	0.007

Parameter estimates for the translog demand system: monthly effects

	Est.	St. dev.	*t*-Value		Est.	St. dev.	*t*-Value
$\alpha_{Jan,a}$	−2.97E-06	1.12E-06	−2.65	$\alpha_{Jan,c}$	−6.38E-07	3.40E-07	−1.88
$\alpha_{Feb,a}$	−5.32E-06	1.44E-06	−3.69	$\alpha_{Feb,c}$	−3.72E-07	4.42E-07	−0.84
$\alpha_{Mar,a}$	−6.48E-06	1.49E-06	−4.35	$\alpha_{Mar,c}$	−8.36E-07	4.38E-07	−1.91
$\alpha_{Apr,a}$	−3.23E-06	1.97E-06	−1.64	$\alpha_{Apr,c}$	−5.08E-07	5.99E-07	−0.85
$\alpha_{May,a}$	−1.67E-06	2.24E-06	−0.75	$\alpha_{May,c}$	−8.86E-07	6.93E-07	−1.28
$\alpha_{Jun,a}$	7.93E-08	2.03E-06	0.04	$\alpha_{Jun,c}$	−5.79E-07	6.18E-07	−0.94
$\alpha_{Jul,a}$	−2.05E-07	2.01E-06	−0.10	$\alpha_{Jul,c}$	−3.58E-07	5.52E-07	−0.65
$\alpha_{Aug,a}$	−4.30E-07	1.73E-06	−0.25	$\alpha_{Aug,c}$	−1.62E-07	4.65E-07	−0.35
$\alpha_{Sep,a}$	−1.33E-06	1.90E-06	−0.70	$\alpha_{Sep,c}$	−4.07E-07	5.62E-07	−0.72
$\alpha_{Oct,a}$	−2.67E-06	2.20E-06	−1.21	$\alpha_{Oct,c}$	−8.13E-07	6.83E-07	−1.19
$\alpha_{Nov,a}$	−1.43E-06	1.19E-06	−1.2	$\alpha_{Nov,c}$	−4.77E-07	3.77E-07	−1.27
$\alpha_{Jan,b}$	−7.69E-07	5.53E-07	−1.39	$\alpha_{Jan,f}$	−5.91E-07	6.19E-07	−0.95
$\alpha_{Feb,b}$	−7.30E-07	7.61E-07	−0.96	$\alpha_{Feb,f}$	−5.90E-07	8.34E-07	−0.71
$\alpha_{Mar,b}$	−3.45E-07	7.11E-07	−0.49	$\alpha_{Mar,f}$	−7.63E-07	7.84E-07	−0.97
$\alpha_{Apr,b}$	9.40E-08	8.92E-07	0.11	$\alpha_{Apr,f}$	−3.87E-07	9.53E-07	−0.41
$\alpha_{May,b}$	−2.67E-07	1.12E-06	−0.24	$\alpha_{May,f}$	−1.24E-06	1.27E-06	−0.98
$\alpha_{Jun,b}$	1.12E-07	9.96E-07	0.11	$\alpha_{Jun,f}$	−7.94E-07	1.11E-06	−0.72
$\alpha_{Jul,b}$	−2.03E-07	1.00E-06	−0.20	$\alpha_{Jul,f}$	−9.78E-07	1.10E-06	−0.89
$\alpha_{Aug,b}$	2.36E-07	8.26E-07	0.29	$\alpha_{Aug,f}$	−7.02E-07	8.65E-07	−0.81
$\alpha_{Sep,b}$	3.95E-09	9.21E-07	0.00	$\alpha_{Sep,f}$	−9.30E-07	9.44E-07	−0.98
$\alpha_{Oct,b}$	−7.39E-07	1.10E-06	−0.67	$\alpha_{Oct,f}$	−1.25E-06	1.17E-06	−1.06
$\alpha_{Nov,b}$	−2.58E-07	6.11E-07	−0.42	$\alpha_{Nov,f}$	−4.87E-07	6.60E-07	−0.74

through the variance of the estimated parameters, we use a Monte Carlo Simulation method recommended by Bryant and Davis (2008). In our application, 5,000 thousand draws of the parameters are generated in MATLAB using the multivariate random normal number generator using the estimated mean and covariance matrix of the parameter. For each of the 5,000 sets of parameter, a unique set of elasticities are created. The average and standard deviations of these demand elasticities with respect to price and income are given in Table 3. Similar elasticities with respect to lagged consumption are given in Table 4.

In general, all the goods in our demand system are found to be complements, with the noticeable exception of the numeraire good. The own-price demands are found to be elastic for all our vegetables goods. Unsurprisingly, the demand for the numeraire good is very inelastic, indicating a general unresponsiveness of

Table 3
Elasticities of demand with respect to price and income (averages and standard deviations)

	Asparagus	Broccoli	Carrot	Cauliflower	Numeraire
Asparagus Price	−2.96	−0.41	−0.50	−0.76	0.00
	(0.99)	(0.44)	(0.34)	(0.84)	(0.00)
Broccoli Price	−0.41	−2.69	−0.30	−0.12	0.00
	(0.44)	(0.32)	(0.19)	(0.66)	(0.00)
Carrot Price	−0.41	−0.24	−2.29	−0.25	0.00
	(0.27)	(0.15)	(0.14)	(0.31)	(0.00)
Cauliflower Price	−0.39	−0.06	−0.16	−3.17	0.00
	(0.43)	(0.34)	(0.20)	(1.16)	(0.00)
Numeraire Prices	3.16	2.40	2.25	3.29	−1.00
	(1.95)	(1.05)	(0.79)	(2.18)	(0.00)
Income	4.66	3.55	3.21	3.81	−10.22
	(2.36)	(1.33)	(0.8)	(1.61)	(5.46)

Standard deviations of Monte Carlo estimates are in parentheses.

Table 4
Elasticities of demand with respect to lagged consumption (average and st. dev.)

Q Demand / Lag *Q*	Asparagus	Broccoli	Carrot	Cauliflower	Numeraire
Asparagus	−0.65	−0.08	−0.02	0.05	0.00
	(0.47)	(0.18)	(0.15)	(0.33)	(0.00)
Broccoli	−0.34	−0.51	−0.24	−0.36	0.00
	(0.54)	(0.37)	(0.25)	(0.57)	(0.00)
Carrot	0.41	0.01	−0.16	−0.17	0.00
	(0.54)	(0.29)	(0.29)	(0.61)	(0.00)
Cauliflower	−0.38	−0.11	−0.26	−0.58	0.00
	(0.39)	(0.2)	(0.16)	(0.46)	(0.00)
Numeraire	0.95	0.69	0.68	1.06	0.00
	(0.95)	(0.57)	(0.52)	(1.01)	(0.00)

Standard deviations of Monte Carlo estimates are in parentheses.

total expenditure to changes in the price of vegetables. Each of the four vegetables is estimated to be a luxury good. Table 4 shows that the lag elasticities for asparagus and broccoli are relatively small, suggesting that changes in cumulative discounted lagged consumption cause small changes in future consumption. The cross-commodity effect of lagged consumption is less uniform, either increasing or decreasing demand in different cases. Lagged consumption of asparagus reduces the demand for broccoli and carrots, but not cauliflower; lagged consumption of cauliflower reduces the demand for each of the other goods.

5. The trade and habit effects on producer welfare

In modeling the effect of eliminating tariff preferences on producer welfare, we separate out the trade effect and the habit effect. The trade effect occurs when a fall in tariff rates increases available supply and reduces the price received by domestic producers in the current period. The habit effect occurs when increased current consumption causes consumers to form habits, increasing demand and the prices received by domestic producers in future periods. While the effect of a positive habits on producer welfare are clear, estimating its effect on consumer welfare is problematic because preferences are determined by the endogenous variable of habits (Pollak, 1978).

Both trade and habit effects can be evaluated through a simplified equilibrium displacement model (Gardner, 1975; Muth, 1964). This model allows for the direct simulation of exogenous changes to variables shifting demand or cost—in our case, tariff changes—as a function of demand and supply elasticities and current prices and quantities. It has been used to consider policy effects of tobacco legislation (Sumner and Wohlgenant, 1985), research and promotion (Wohlgenant, 1993), advertising (Alston et al., 2001a,b; Kinnucan, 1996; Piggott et al., 1995), labeling (Brester et al., 2004), traceability (Pendell et al., 2010), and export subsidies (Duffy and Wohlegenant, 1991).

To generate our welfare estimates, we supplement the demand elasticities from our Monte Carlo simulations with simulated supply elasticities. The available literature suggests that the own-price supply for asparagus is approximately 0.4 (Málaga et al., 2001; Onyango and Bhuyan, 2000; Ornelas and Shumway, 1993; Torok and Huffman, 1986). Therefore, in our 5000 Monte Carlo simulations, we assume this elasticity is drawn from a normal distribution with mean 0.4 and standard deviation of 0.1 and is constant across all suppliers in all months. While this might suggest that a positive supply response is possible when the good is out of season, the weighting of the country-level supply elasticities by their consumption shares eliminates this possibility. We assume that cross-price supply elasticities between asparagus and our other crops is zero.[6]

In the equilibrium displacement model, we isolate the trade effect by first simulating the effect on prices and quantities traded resulting from a tariff on Mexican and Peruvian imports. In the absence of NAFTA and the ATPA, these tariffs would be 5% in September through November and 21.3% during the rest of the year. We then isolate the habit effect by assuming that reduced lagged consumption creates a contemporaneous habit effects that lowers demand (having estimated that our habit effects are positive). Next, we provide estimates of how NAFTA and the ATPA affected the U.S. asparagus market by providing estimates of the mean and standard deviation of the change in producer welfare, consumer welfare, and tariff revenue. We also provide on disaggregated estimates of the change in producer welfare for our three supply sources—Mexico, Peru, and the U.S.

[6] Asparagus requires approximately two to three years of root stock cultivation before yielding significant output and then continues to produce for approximately 10 years thereafter. While this prevents substitution across farmland in production, producers may increase their own product supply response to increasing prices. For example, domestic producers may harvest more frequently or produce later through the growing season. Foreign producers may exports more to the U.S. and send less to the domestic market.

5.1. The equilibrium displacement model

Let k index the country of origin for a supply quantity, where K is the total number of import sources. Define Q^D as an $N \times 1$ vector of the U.S. domestic demands, depending on an $N \times 1$ vectors of prices, P, and lagged consumption quantities of each good, *lag Q*. Define $Q^{S,k}$ as an $N \times 1$ vector of the supply functions for the kth country supplying goods the U.S., depending on the $N \times 1$ vector of prices net of tariffs, $(1 - t_k)P$. In equilibrium, the difference of domestic demand and supplies from all sources is zero, or:

$$Q^D(P, lagQ) - \sum_k Q^{S,k}((1 - t_k)P) = 0. \tag{11}$$

Totally differentiate Eq. (11) with respect to the log variables yields Eq. (12).

$$\frac{\partial Q^D}{\partial \ln P}\partial \ln P + \frac{\partial Q^D}{\partial \ln LagQ}\partial \ln LagQ - \sum_K \frac{\partial Q^{S,k}}{\partial \ln P}\partial \ln P + \sum_K \frac{\partial Q^{S,k}}{\partial \ln P} t_k = 0. \tag{12}$$

Divide Eq. (12) by Q_i on a row by row basis to convert it to an elasticity format following Brester et al. (2004). Let $\boldsymbol{E_P^D}$ and $\boldsymbol{E_{Lag\,Q}^D}$ be $N \times N$ matrices of the demand elasticities with respect to price and lagged quantities (*Lag Q)*. Let $\boldsymbol{\varphi}$ denote the kth countries share of the ith good's supply and let $\boldsymbol{\varphi E_P^S}$ be the $N \times NK$ matrix of supply elasticities weighted by kth country's share of supply, where the first $N \times N$ is the matrix of partial derivatives of country's 1 supply ($Q^{S,k=1}$) with respect to ln P, the second $N \times N$ is the matrix of partial derivations of country's 2 supply ($Q^{S,k=2}$) with respect to ln P, and so on. Let $\boldsymbol{I}$ equal a vertical stack of K identity matrices, each $N \times N$ in size, so that $\boldsymbol{I}$ has $NK \times N$ dimensions. Let $\boldsymbol{t}$ equal a vertical stack of K diagonal matrices with $N \times N$ dimensions, where the diagonal terms are the tariff rates of ith good for the kth country. In this case, $\boldsymbol{t}$ has $NK \times N$ dimensions. Let i_k be a $N \times 1$ matrix of ones. In elasticity format, the new equilibrium equation is:

$$\boldsymbol{E_P^D}\partial \ln P + \boldsymbol{E_{Lag\,Q}^D}\partial \ln LagQ - \left(\boldsymbol{\varphi}_k \boldsymbol{E_P^{S,k}}\right)\boldsymbol{I}\partial \ln P + \left(\boldsymbol{\varphi}_k \boldsymbol{E_P^{S,k}}\right)\boldsymbol{t} i_k = 0. \tag{13}$$

Collecting terms yields:

$$\left(\boldsymbol{E_P^D} - \left(\boldsymbol{\varphi}_k \boldsymbol{E_P^{S,k}}\right)I\right)\partial \ln P + \boldsymbol{E_{Lag\,Q}^D}\partial \ln LagQ - \left(\boldsymbol{\varphi}_k \boldsymbol{E_P^{S,k}}\right)\boldsymbol{t} i_k = 0. \tag{14}$$

Equation (14) can now be rewritten as Eq. (13) as:

$$\boldsymbol{A}\partial \ln P + \boldsymbol{B}\partial \ln LagQ + \boldsymbol{C}t i_k = 0. \tag{15}$$

In Eq. (15), let $\boldsymbol{A}$ equal $(\boldsymbol{E_P^D} - (\boldsymbol{\varphi}_k \boldsymbol{E_P^{S,k}})\boldsymbol{I})$, $\boldsymbol{B}$ equal $\boldsymbol{E_{Lag\,Q}^D}$, and $\boldsymbol{C}$ equal $(\boldsymbol{\varphi}_k \boldsymbol{E_P^{S,k}})$. This equation can now be used to recover the trade and habit effects of a tariff change sequentially. First, the trade effect is isolated by assuming that $\partial lagQ$ is zero and determining, in the absence of habits, the effect of a tariff increase on prices and quantities. Second, the habit effect estimated are assumed to have a contemporaneous effect on demand, ignoring the tariff's effect which was accounted for in the first step. While it is possible, we do not iterate the process of updating habit effects in response to the subsequent second step quantity changes because doing so would unrealistically compresses a long run process to an immediate one.

The trade effects on prices and quantities are:

$$\partial \ln P = -\boldsymbol{A}^{-1}(\boldsymbol{C}t i_k) \text{ and } \partial \ln Q = \boldsymbol{E_P^D}\partial \ln P. \tag{16}$$

In our simulations, we assume that the trade effects impact on quantity consumed has a contemporaneous impact on habits. The $\partial \ln Q$ can then be used to calculate $\partial \ln lagQ$ and reapplied to Eq. (15).[7] The habit effect shifts prices and quantity by:

$$\partial \ln P = -\boldsymbol{A}^{-1}\boldsymbol{B}\partial \ln lagQ \text{ and } \partial \ln Q = \left(\boldsymbol{\varphi}_k \boldsymbol{E_P^{S,k}}\right)\boldsymbol{I}\partial \ln P. \tag{17}$$

Several simplifying assumptions make the estimation of Eqs. (16) and (17) relatively straightforward. First, because we are primarily concerned with the welfare effect to producers of asparagus, we can ignore cross price effects by assuming that cross-price supply elasticities are zero. The long time horizon associated with growing asparagus makes it unlikely that acreage or supply could respond to the prices of other commodities in the short run. This specification allows us to focus narrowly on solely the own-price and own-lag demand elasticities and the own-price supply elasticity to consider the effects on asparagus producer welfare.

Using a method similar to Brester et al. (2004), the producer welfare effects are then recovered from the point estimates of the changes in quantity and price. Define Q^* and Q^{**} as the price matrix before and after the tariff change. Similarly, define P^* and P^{**} as prices and $((1 - t)P)^*$ and $((1 - t)P)^{**}$ as prices net of tariffs before and after the tariff change. The welfare change from a generic shift in quantities and prices are:

$$\Delta CS_i = \int_{P_i^{**}}^{P_i^*} Q_i^D(P_i)\partial P_i \approx -\partial P_i \left(\frac{1}{2}(2Q_i + \partial Q_i)\right), \tag{18}$$

[7] If $q_{i,t}$ is approximately equal to $q_{i,t-l}$ then the change in habits is $\partial lagq_{i,t}/lagq_{i,t} \approx \sum_{l=1}^{12} d^l(\partial q_{i,t-l}/q_{t-l})$. However, when $q_{i,t}$ differs significantly from $q_{i,t-l}$, this specification over-weights the effect on habits in months were consumption is small as the percentage change for the same change in consumption will be appear much larger. We correct for this problem by multiplying the percentage change in lagged consumption for a given month by the monthly average share g_t of average annual consumption. In this case,

$$\partial lagQ_{i,t}/lagQ_{i,t} = \sum_{l=1}^{12} d^l(\partial q_{i,t-l}/q_{i,t-l})g_{i,t-l}.$$

$$\Delta PS_i = \sum_K \int_{((1-t)P)_i^{**}}^{((1-t)P)_i^*} Q_{i,k}^S(t_{i,k}P_i)\partial(t_{i,k}P_i)$$

$$\approx \sum_k (\partial P_i t_{i,k} - \partial t_{i,k} P_i)\frac{1}{2}(2Q_{i,k} + \partial Q_{i,k}). \quad (19)$$

On a good by good basis, these consumer and producer surpluses can be represented as a percentage of total expenditure for good i (prior to the tariff change being enacted) as:

$$\frac{\Delta CS_i}{(P \times Q)_i} = \partial \ln \mathrm{P}_i(1 + 0.5\partial \ln Q_i), \quad (20)$$

$$\frac{\Delta PS_i}{(P \times Q)_i} = \sum_{k=1}^{K}(\partial \ln \mathrm{P}_i - \partial t_{i,k})'(1 + 0.5\partial \ln Q_{i,k}). \quad (21)$$

Both Eqs. (20) and (21) can be directly calculated from the price and quantity shifts calculated through Eqs. (16) and (17). Tax revenue can also be calculated as a percentage of total expenditure of good i as:

$$\frac{\Delta TR_i}{(PQ)_i} = \sum_{k=1}^{K} t_{i,k}\left(1 + 0.5\partial \ln Q_{i,k}\right). \quad (22)$$

5.2. Estimation results

Table 5 provides estimates of the mean changes to tariffs, prices, and quantities resulting from NAFTA and the ATPA when the habit effect is excluded.[8] For the cumulative annual changes, standard deviations are provided in parenthesis. Prices fall by: 0.34% under NAFTA, 0.17% under the ATPA, and 0.51% under both agreements. Conversely, quantities rise by 1.44% under NAFTA, 0.71% under the ATPA, and 2.14% under both agreements.

Table 6 provides means and standard deviations for the change in welfare measures from the NAFTA and ATPA tariff reductions on asparagus. With an estimated average elasticity of –2.97, demand for asparagus is elastic. Conversely, with a conjectured elasticity of 0.4, supply is inelastic. Together, these specifications imply that the benefits of a tariff reduction accrue more toward producers than consumers and our simulations bear this out. NAFTA increases total producer benefits (across all sources) by approximately 6.1% but only increases consumer benefits by 0.3%. The ATPA increases total producer benefits by 5.7% but only increases consumer benefits by 0.2%. Both agreements together raise total producer benefits by 11.8% and consumer benefits by 0.5%. However, these consumer and producer benefit increases are associated with lost tariff revenue, rather than increased total welfare. The total annual change in welfare (the sum of the changes in producer welfare, consumer welfare, and tariff revenue) is nearly zero on a percentage basis.[9]

Table 7 provides estimates of the disaggregated effects on the producer surplus when habit effects are excluded. NAFTA, for instances, raises the surplus to Mexican producers by 18.7% while lowering it for the U.S. and Peruvian producers by 0.3% and 0.1%, respectively. The ATPA raises the surplus to Peruvian producers by 13.0% but lowers it to Mexican and U.S. producers by 0.13% and 0.1%, respectively. In this case, Mexican asparagus producers are harmed more by the ATPA than U.S. producers. Finally, both NAFTA and the ATPA together reduce U.S. producer welfare by 0.4% while raising it by 18.6% and 12.85% for Mexican and Peruvian producers, respectively.

Table 8 reports the changes to price and quantity from NAFTA and the ATPA once habit effects are included. Here, the price of asparagus falls by only 0.08% under NAFTA, rises 0.03% under the ATPA, and falls by 0.04% under both agreements. Thus, in the case of the ATPA, the upward price pressure from the habit effect that increases demand exceeds the downward price pressure of the trade effect that increases supply. Moreover, quantities of asparagus sold increase by 4.3% under NAFTA, 2.7% under the ATPA, and 7.0% under both agreements together.

Similarly, Table 9 shows the changes in consumer surplus, producer surplus, and tariff revenue once habit effects are included in the model.[10] Now, the total producer surplus increases: 6.4% under NAFTA (an additional 0.24% beyond the estimates excluding habits shown in Table 6), 5.9% under the ATPA (an additional 0.20%), and 12.21 under both agreements (an additional 0.44%).[11] The percentage reduction in tariff revenue in assumed to be unchanged from their values when habit effects are excluded. Based on annual revenue of to the asparagus trade of $451.3 million, total welfare, therefore, increase by 0.47% under NAFTA ($2.1 million), 0.39% under the ATPA ($1.76 million), and 0.84% under both agreements ($4.0 million).

Table 10 provides the change in the surplus to producers disaggregated across suppliers when habit effects are included. As the habit effect causes an increase in demand, the producer surplus increases for each region. Several increases are interesting when Table 10 is contrasted with Table 7. First, while NAFTA causes the surplus to Peruvian producers to fall by 0.16% when habit effects are excluded, the surplus rises by 0.21% when it is included. Moreover, the U.S. producer surplus falls 0.32% under NAFTA when habits are excluded but only 0.18% when habits are included. In this instance, habit effect offsets about 64% of the loss to asparagus producers from NAFTA. Second, the ATPA causes the surplus to U.S. producers to actually rise by 0.1%. Finally, the estimated combined reduction in producer

[8] Note that the difference in a logged variable ($\partial \ln P$ or $\partial \ln Q$) is simply that variable's (P or Q) percentage change.

[9] Because the sum of the consumer and producer surplus have a strong negatively covariance with tariff revenue, the standard deviation of the total welfare is close to zero as well.

[10] Consumer welfare is not calculated in this table because habits shift the demand curve, thereby preventing ordinary welfare analysis.

[11] These figures are obtained by subtraction the producer welfare changes in Table 9 by those in Table 6 for each case.

Table 5
Effects of NAFTA and the ATPA on tariff rates, prices, and quantities for asparagus (all figures given as percentages changes)

	τ (tariffs)		$\partial \ln P$			$\partial \ln Q$		
	NAFTA	ATPA	NAFTA	ATPA	Both NAFTA and the ATPA	NAFTA	ATPA	Both NAFTA and the ATPA
Jan	21.3	21.3	−0.50	−0.25	−0.75	2.12	1.08	3.20
Feb	21.3	21.3	−1.00	−0.08	−1.08	4.14	0.32	4.46
Mar	21.3	21.3	−0.83	−0.06	−0.88	3.51	0.25	3.75
Apr	21.3	21.3	−0.09	−0.09	−0.18	0.37	0.37	0.74
May	21.3	21.3	0.00	−0.08	−0.09	0.01	0.37	0.39
Jun	21.3	21.3	−0.17	−0.20	−0.38	0.57	0.67	1.24
Jul	21.3	21.3	−0.25	−0.24	−0.49	1.12	1.07	2.18
Aug	21.3	21.3	−0.19	−0.30	−0.49	0.84	1.32	2.16
Sep	5.0	5.0	−0.01	−0.10	−0.12	0.07	0.51	0.58
Oct	5.0	5.0	−0.02	−0.17	−0.19	0.08	0.55	0.63
Nov	5.0	5.0	−0.03	−0.16	−0.19	0.10	0.52	0.63
Dec	21.3	21.3	−0.05	−0.47	−0.51	0.23	2.19	2.42
Annual	–	–	−0.34	−0.17	−0.51	1.44	0.71	2.14
			(0.39)	(0.36)	(0.71)	(0.37)	(0.26)	(0.63)

Standard deviations of Monte Carlo estimates for annual figures are in parentheses.

Table 6
Effect of NAFTA and the ATPA on the consumer surplus (ΔCS), producer surplus (ΔPS), tariff revenue (ΔTR), and total welfare (ΔTW) while ignoring habit effects (all figures are given as percentage changes of total asparagus expenditure)

	Effect of NAFTA				Effect of ATPA				Effect of NAFTA and ATPA			
	ΔCS	ΔPS	ΔTR	ΔTW	ΔCS	ΔPS	ΔTR	ΔTW	ΔCS	ΔPS	ΔTR	ΔTW
Jan	0.47	12.11	−12.57	0.01	0.24	7.02	−7.26	0.00	0.71	19.15	−19.84	0.02
Feb	0.90	16.89	−17.77	0.02	0.07	1.61	−1.68	0.00	0.97	18.50	−19.45	0.02
Mar	0.80	9.97	−10.77	0.01	0.06	1.08	−1.13	0.00	0.86	11.06	−11.91	0.01
Apr	0.08	1.21	−1.29	0.00	0.08	1.96	−2.05	0.00	0.16	3.17	−3.33	0.00
May	0.00	0.09	−0.09	0.00	0.08	2.28	−2.37	0.00	0.09	2.37	−2.46	0.00
Jun	0.13	3.67	−3.80	0.00	0.15	6.64	−6.79	0.00	0.28	10.31	−10.58	0.00
July	0.25	8.16	−8.41	0.00	0.24	11.56	−11.80	0.00	0.49	19.74	−20.22	0.02
Aug	0.19	6.30	−6.49	0.00	0.30	13.63	−13.92	0.01	0.49	19.93	−20.40	0.02
Sep	0.02	0.38	−0.39	0.00	0.12	4.44	−4.56	0.00	0.13	4.82	−4.95	0.00
Oct	0.02	0.50	−0.52	0.00	0.12	4.31	−4.44	0.00	0.14	4.81	−4.95	0.00
Nov	0.02	0.64	−0.66	0.00	0.12	4.17	−4.29	0.00	0.14	4.81	−4.95	0.00
Dec	0.05	1.02	−1.07	0.00	0.49	18.87	−19.35	0.02	0.54	19.87	−20.40	0.02
Annual	0.32	6.12	−6.44	0.00	0.16	5.65	−5.8	0.00	0.48	11.77	−12.24	0.01
	(0.27)	(0.26)	(0.00)	(0.00)	(0.22)	(0.22)	(0.00)	(0.00)	(0.46)	(0.45)	(0.00)	(0.00)

Standard deviations of Monte Carlo estimates for annual figures are in parentheses.

welfare under NAFTA and the ATPA together falls from 0.43% of asparagus revenue when habit effects are excluded to 0.08% when they are included. While the estimated standard deviation suggests that a confidence interval for these welfare estimates includes both positive and negative values, it is important to note that there is no *a priori* reason to presume that a habit effect inclusive welfare estimate is necessarily of certain sign.

To compensate producers for losses over the four-year period of 2004–2007, the 2008 Farm Bill provided $1.875 million annually to fresh asparagus producers and an identical amount for frozen producers. In that period, total U.S. expenditure on asparagus averaged $451.3 million annually (in 2008 dollars).[12] In 2007, 2,605 farms are reported to produced asparagus (Economic Research Service, 2012). While these data does not distinguish fresh and frozen asparagus production, it is commonly understood that farms are likely to produce for both markets. On an annualized basis, the combined subsidy for asparagus farm is $1,343 per farm ($3.5 million/2,605 farms).

When we incorporate the habit effect, we find that NAFTA reduced the annual surplus to U.S. producers by 0.10% of total revenue (approximately $472 thousand or $181 per farm). At the same time, we find that the ATPA increased the producer surplus by approximately 0.15% (approximately $659 thousand or $253 per farm). Both agreements together increased the

[12] This figure is based on AMS movement data and price. In this period, the U.S. share of expenditure was 28.6, implying that U.S. producer's earned $166.9 million annually. In independently gathered data, NASS reports revenues to U.S. asparagus farmers from all sources as $118.7 million.

Table 7
Effect of NAFTA and the ATPA on the asparagus producer surplus (ΔPS) for individual supply sources *while ignoring habit effects* (all figures given as percentage changes of total asparagus expenditure)

	ΔPS from NAFTA			ΔPS from the ATPA			ΔPS from NAFTA and the ATPA		
	Mexico	U.S.	Peru	Mexico	U.S.	Peru	Mexico	U.S.	Peru
Jan	19.96	−0.48	−0.48	−0.24	−0.24	20.17	19.73	−0.72	19.73
Feb	19.57	−0.92	−0.92	−0.07	−0.07	20.33	19.50	−0.99	19.50
Mar	19.65	−0.82	−0.82	−0.06	−0.06	20.34	19.60	−0.87	19.60
Apr	20.32	−0.08	−0.08	−0.08	−0.08	20.32	20.24	−0.16	20.24
May	20.39	0.00	0.00	−0.08	−0.08	20.32	20.31	−0.09	20.31
Jun	20.28	−0.13	−0.13	−0.15	−0.15	20.26	20.13	−0.28	20.13
July	20.16	−0.25	−0.25	−0.24	−0.24	20.17	19.93	−0.50	19.93
Aug	20.22	−0.19	−0.19	−0.30	−0.30	20.12	19.93	−0.49	19.93
Sep	4.93	−0.02	−0.02	−0.12	−0.12	4.84	4.82	−0.13	4.82
Oct	4.93	−0.02	−0.02	−0.12	−0.12	4.83	4.81	−0.14	4.81
Nov	4.93	−0.02	−0.02	−0.12	−0.12	4.83	4.81	−0.14	4.81
Dec	20.35	−0.05	−0.05	−0.50	−0.50	19.94	19.87	−0.55	19.87
Annual	18.73	−0.28	−0.13	−0.13	−0.09	12.98	18.60	−0.36	12.85
	(0.26)	(0.27)	(0.27)	(0.22)	(0.22)	(0.21)	(0.44)	(0.46)	(0.44)

Standard deviations of Monte Carlo estimates for annual figures are in parentheses.

Table 8
The habit effects of NAFTA and ATPA tariffs on lagged quantities($\partial \ln LagQ$), Price ($\partial \ln P$), and Quantities ($\partial \ln P$) of Asparagus (all figures given as percentage changes of total asparagus expenditure)

	$\partial \ln LagQ$			$\partial \ln P$			$\partial \ln Q$		
	NAFTA	ATPA	Both	NAFTA	ATPA	Both	NAFTA	ATPA	Both
Jan	0.13	0.65	0.78	0.45	0.10	0.55	2.11	2.39	4.50
Feb	0.16	0.71	0.87	0.88	−0.08	0.80	3.79	1.30	5.09
Mar	0.35	0.84	1.19	0.74	−0.12	0.62	3.38	1.07	4.46
Apr	1.03	1.43	2.47	−0.14	−0.22	−0.36	1.69	2.22	3.91
May	1.12	1.11	2.23	−0.24	−0.15	−0.39	2.04	2.31	4.35
June	0.61	0.69	1.31	0.00	0.00	0.00	2.28	2.60	4.88
July	0.43	0.44	0.88	0.16	0.15	0.31	2.51	2.50	5.00
Aug	1.50	0.43	1.93	−0.13	0.21	0.07	6.21	2.71	8.92
Sept	4.17	0.41	4.58	−0.89	0.03	−0.86	13.34	1.74	15.08
Oct	4.08	0.69	4.78	−0.87	−0.03	−0.89	12.03	2.51	14.54
Nov	1.88	1.50	3.38	−0.38	−0.21	−0.59	5.57	4.83	10.41
Dec	0.23	2.05	2.28	0.00	0.05	0.05	0.95	8.52	9.48
Annual	1.13	0.93	2.07	0.08	−0.04	0.04	4.31	2.69	7.01
	(0.00)	(0.00)	(0.00)	(0.38)	(0.29)	(0.64)	(2.9)	(1.77)	(4.67)

Standard deviations of Monte Carlo estimates for annual figures are in parentheses.

surplus by approximately 0.04% (approximately $178 thousand or $68 per farm). The disparate effect of NAFTA (increasing Mexican imports) and the ATPA (increasing Peruvian imports) on producer welfare has two causes. First, the ATPA represented a smaller tariff reduction because the MFN tariff rates in mid-September through mid-November are 5% rather than 21.3%. All the estimated welfare effects of the ATPA are smaller than those of NAFTA, despite the fact that Peru and Mexico have comparable shares of the U.S. market. Second, Mexican imports compete more directly with U.S. production within their growing season. For much of the period under consideration, asparagus was a notably seasonal good. With a growing season counter-cyclical to the U.S., Peruvian imports did not compete directly with U.S. production but does sustain habits that increase demand for U.S. product.

When habit effects are excluded from the analysis, the estimated losses to U.S. producer surplus would have been much greater. NAFTA would have reduced U.S. producer welfare by (approximately $1.24 million or $478 per farm), 0.09% under the ATPA (approximately $0.39 million or $147 per farm), and 0.36% under both agreements ($1.00 million or $382 per farm). Our analysis shows that even when the habits are excluded from welfare estimates, the losses to U.S. producers from imports result from tariff reductions are less than the annualized benefit of market loss assistance.

6. Conclusions

We find that lagged consumption has a positive effect on demand, which has important welfare implications for trade in counter-seasonal goods. In the case of asparagus trade between the U.S., Mexico, and Peru, we find that the habit effect offsets a substantial portion of the harm of increased imports

Table 9
Effect of NAFTA and the ATPA on the consumer surplus (ΔCS), producer surplus (ΔPS), tariff revenue (ΔTR), and total welfare (ΔTW) including habit effects (all figures are given as percentage changes of total asparagus expenditure)

	Effect of NAFTA				Effect of ATPA				Effect of NAFTA and ATPA			
	ΔCS	ΔPS	ΔTR	ΔTW	ΔCS	ΔPS	ΔTR	ΔTW	ΔCS	ΔPS	ΔTR	ΔTW
Jan	0.50	12.14	−12.57	0.06	0.38	7.16	−7.27	0.27	0.87	19.32	−19.86	0.33
Feb	0.94	16.92	−17.77	0.08	0.22	1.75	−1.68	0.30	1.15	18.69	−19.46	0.37
Mar	0.88	10.05	−10.77	0.15	0.23	1.25	−1.14	0.35	1.11	11.31	−11.92	0.49
Apr	0.30	1.43	−1.29	0.43	0.38	2.27	−2.05	0.60	0.67	3.69	−3.34	1.02
May	0.24	0.33	−0.09	0.48	0.32	2.52	−2.37	0.47	0.55	2.85	−2.46	0.93
Jun	0.26	3.80	−3.80	0.26	0.30	6.79	−6.79	0.29	0.55	10.59	−10.61	0.54
July	0.35	8.26	−8.42	0.18	0.34	11.66	−11.81	0.19	0.68	19.93	−20.25	0.36
Aug	0.50	6.63	−6.51	0.62	0.39	13.72	−13.93	0.18	0.88	20.35	−20.49	0.75
Sep	0.83	1.27	−0.40	1.71	0.20	4.53	−4.56	0.17	1.02	5.80	−4.99	1.83
Oct	0.82	1.37	−0.52	1.67	0.27	4.46	−4.44	0.29	1.07	5.83	−4.99	1.91
Nov	0.41	1.04	−0.67	0.79	0.43	4.49	−4.30	0.63	0.82	5.53	−4.98	1.37
Dec	0.10	1.07	−1.07	0.10	0.91	19.31	−19.42	0.80	1.01	20.36	−20.48	0.89
Annual	0.55	6.36	−6.44	0.47	0.35	5.85	−5.81	0.39	0.9	12.21	−12.27	0.84
	(0.36)	(0.37)	(0.00)	(0.00)	(0.28)	(0.28)	(0.00)	(0.00)	(0.62)	(0.62)	(0.00)	(0.00)

Standard deviations of Monte Carlo estimates for annual figures are in parentheses.

Table 10
Total effect of NAFTA and the ATPA on the asparagus producer surplus (ΔPS) across sources (all figures are given as percentages changes of total asparagus expenditure)

	NAFTA			ATPA			Both NAFTA and the ATPA		
	Mexico	U.S.	Peru	Mexico	U.S.	Peru	Mexico	U.S.	Peru
Jan	19.99	−0.45	−0.45	−0.10	−0.10	20.31	19.90	−0.55	19.90
Feb	19.60	−0.88	−0.88	0.08	0.08	20.48	19.68	−0.80	19.68
Mar	19.73	−0.74	−0.74	0.12	0.12	20.52	19.85	−0.63	19.85
Apr	20.54	0.14	0.14	0.22	0.22	20.62	20.76	0.35	20.76
May	20.63	0.24	0.24	0.15	0.15	20.55	20.79	0.39	20.79
Jun	20.41	0.00	0.00	0.00	0.00	20.41	20.41	0.00	20.41
July	20.26	−0.16	−0.16	−0.15	−0.15	20.27	20.12	−0.31	20.12
Aug	20.55	0.13	0.13	−0.21	−0.21	20.22	20.35	−0.07	20.35
Sep	5.84	0.89	0.88	−0.03	−0.03	4.93	5.81	0.86	5.80
Oct	5.82	0.87	0.85	0.03	0.03	4.98	5.84	0.89	5.83
Nov	5.33	0.38	0.38	0.21	0.21	5.16	5.54	0.59	5.53
Dec	20.40	0.00	0.00	−0.05	−0.05	20.39	20.37	−0.05	20.36
Annual	18.85	−0.10	0.27	0.03	0.15	13.18	18.88	0.04	13.46
	(0.37)	(0.38)	(0.38)	(0.29)	(0.29)	(0.28)	(0.62)	(0.64)	(0.62)

Standard deviations of Monte Carlo estimates for annual figures are in parentheses.

associated with tariff reductions. Consumption of asparagus in the off-season sustains habits that continue into the domestic production seasons. Once habit effects are incorporated, the loss to U.S. producers from NAFTA falls by about 64%. In the same situation, the loss to U.S. producers from the ATPA is entirely eliminated. In our simulations, U.S. producers actually benefit from the ATPA in its role of reinforcing habits. Moreover, Peruvian producers benefit from NAFTA as it sustains asparagus consumption habits into their growing season as well.

The perishability and seasonality of asparagus underpins our findings that the harm to domestic producer welfare from trade is mitigated by consumer habits that reinforce in-season demand. While we do not expect that these traits are necessarily common across goods, or even across agricultural commodities, they may be present with situations where trade agreements are under consideration. Fresh table grapes, stone fruits, and cut flowers are increasingly being imported as seasonal crops from the southern hemisphere where their growing cycle is countercyclical to the U.S. In addition to the benefits to consumers of increased out of seasonal availability, the harm to U.S. producers from their importation may be smaller than once thought.

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References

Agricultural Marketing Service, 2004. Agricultural Export Transportation Handbook. United States Department of Agriculture, Washington, DC.

Agricultural Marketing Service. 2008. Fresh Fruit and Vegetable Shipments By Commodities, States, and Months, ed. USDA, vol. FVAS-4. Market News Branch, Washington, DC.

Alston, J.M., Chalfant, J.A., Piggott, N.E., 2001a. Incorporating demand shifters in the Almost Ideal demand system. Econ. Lett. 70(1), 73–78.

Alston, J.M., Freebairn, J.W., James, J.S., 2001b. Beggar-thy-neighbor advertising: Theory and Application to generic commodity promotion programs. Am. J. Agric. Econ. 83(4), 888–902.

Becker, G.S., Grossman, M., Murphy, K.M., 1994. An empirical analysis of cigarette addiction. Am. Econ. Rev. 84(3), 396–418.

Benemelis, I., 2011. USDA Issues Asparagus Revenue Market Loss Assistance Payments. United States Department of Agriculture, Washington, DC.

Blanciforti, L., Green, R., 1983. An almost ideal demand system incorporating habits: An analysis of expenditures on food and aggregate commodity groups. Rev. Econ. Stat. 65(3), 511–515.

Brester, G.W., Marsh, J.M., Atwood, J.A., 2004. Distributional impacts of country-of-origin labeling in the U.S. meat industry. J. Agric. Resour. Econ. 29(2), 206–227.

Bryant, H.L., Davis, G.C., 2008. Revisiting aggregate U.S. meat demand with a Bayesian averaging of classical estimates approach: Do we need a more general theory? Am. J. Agric. Econ. 90(1), 103–116.

Carroll, C.D., Overland, J., Weil, D.N., 2000. Saving and growth with habit formation. Am. Econ. Rev. 90(3), 341–355.

Chen, X., Ludvigson, S.C., 2009. Land of addicts? An empirical investigation of habit-based asset pricing models. J. Appl. Economet. 24(7), 1057–1093.

Christensen, L.R., Jorgenson, D.W., Lau, L.J., 1975. Transcendental logarithmic utility functions. Am. Econ. Rev. 65(3), 367–383.

Duffy, P.A., Wohlegenant, M.K., 1991. Effects of an export subsidy on the U.S. cotton industry. South. J. Agric. Econ. 3, 1–7.

Dynan, K.E., 2000. Habit Formation in consumer preferences: Evidence from panel data. Am. Econ. Rev. 90(3), 391–406.

Economic Research Service, 2012. U.S. Asparagus Statistics. United States Department of Agriculture, Washington, DC.

Economic Research Service, 2009. Vegtables and Melons Yearbook Data. USDA, Washington, DC.

Fuhrer, J.C., 2000. Habit formation in consumption and its implications for monetary-policy models. Am. Econ. Rev. 90(3), 367–390.

Gardner, B.L., 1975. The farm-retail price spread in a competitive food industry. Am. J. Agric. Econ. 57(3), 399–409.

Grant, J.H., Lambert, D.M., Foster, K.A., 2010. A seasonal inverse almost ideal demand system for north American fresh tomatoes. Can. J. Agric. Econ./Revue canadienne d'agroeconomie 58(2), 215–234.

Hendel, I., Nevo, A., 2006. Measuring the implications of sales and consumer inventory behavior. Econometrica 74(6), 1637–1673.

Holt, M.T., Goodwin, B.K., 2009. The Almost Ideal and Translog Demand Systems. In: Baltagi, B.H., Sadka, E. (Eds.), Quantifying Consumer Preferences (Contributions to Economic Analysis). Emerald Books, Bingley, UK, 37 pp.

Holt, M.T., Goodwin, B.K., 1997. Generalized habit formation in an Inverse Almost Ideal Demand System: An application to meat expenditures in the U.S. Emp. Econ. 22(2), 293–320.

Kinnucan, H.W., 1996. A note on measuring returns to generic advertising in interrelated markets. J. Agric. Econ. 47(1–4), 261–267.

LaFrance, J.T., Hanemann, W.M., 1989. The dual structure of incomplete demand systems. Am. J. Agric. Econ. 71(2), 262–274.

Lewbel, A., 1989. Exact aggregation and a representative consumer. Quart. J. Econ. 104(3), 621–633.

Málaga, J.E., Williams, G.W., Fuller, S.W., 2001. US-Mexico fresh vegetable trade: The effects of trade liberalization and economic growth. Agric. Econ. 26(1), 45–55.

Muth, R.F., 1964. The derived demand curve for a productive factor and the industry supply curve. Oxford Econ. Papers 16(2), 221–234.

Onyango, B., Bhuyan, S., 2000. A Supply Response Analysis of the Fruits and Vegetables Sector in New Jersey. The State University of New Jersey, Rutgers.

Ornelas, F., Shumway, C.R., 1993. Supply response and impact of government-supported crops on the Texas vegetable industry. Agric. Res. Econ. Rev. 22(1), 27–29.

Pendell, D.L., Brester, G.W., Schroeder, T.C., Dhuyvetter, K.C., Tonsor, G.T., 2010. Animal identification and tracing in the United States. Am. J. Agric. Econ. 92(4), 927–940.

Piggott, N.E., 2003. The nested PIGLOG model: An application to U.S. food demand. Am. J. Agric. Econ. 85(1), 1–15.

Piggott, R.R., Piggott, N.E., Wright, V.E., 1995. Approximating farm-level returns to incremental advertising expenditure: Methods and an application to the Australian meat industry. Am. J. Agric. Econ. 77(3), 497–511.

Pollak, R.A., 1978. Endogenous tastes in demand and welfare analysis. Am. Econ. Rev. 68(2), 374–379.

Pollak, R.A., Wales, T.J., 1992. Demand System Specification and Estimation. Oxford University Press, Oxford.

Roberts, M.J., Schlenker, W., 2010. Identifying supply and demand elasticities of agricultural commodities: Implications for the US ethanol mandate. SSRN eLibrary.

Stanton, J., 2007. Habits in fresh produce consumption. J. Food Prod. Market. 13(1), 1–18.

Sumner, D.A., Wohlgenant, M.K., 1985. Effects of an increase in the federal excise tax on cigarettes. Am. J. Agric. Econ. 67(2), 235–242.

Torok, S.J., Huffman, W.E., 1986. U.S.-Mexican trade in winter vegetables and illegal immigration. Am. J. Agric. Econ. 68(2), 246–260.

Wang, Q., Halbrendt, C., Johnson, S.R., 1996. A non-nested test of the AIDS vs. the translog demand system. Econ. Lett. 51(2), 139–143.

Wohlgenant, M.K., 1993. Distribution of gains from research and promotion in multi-stage production systems: The case of the U.S. beef and pork industries. Am. J. Agric. Econ. 75(3), 642–651.

Zhen, C., Wohlgenant, M.K., Karns, S., Kaufman, P., 2011. Habit formation and demand for sugar-sweetened beverages. Am. J. Agric. Econ. 93(1), 175–193.