Survival of the Fittest: Export Duration and Failure into U.S. Fresh Fruit and Vegetable Markets

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1. Introduction

Over the past twenty-five years, US imports of fresh fruits and vegetables have increased sharply from $2.4 billion in 1989 to $15.9 billion in 2013 (US International Trade Commission). Many factors have likely contributed to this growth in imports, including increasing consumer incomes, changes in consumer preferences for year round supply of fresh produce, and greater variety of fresh fruits and vegetables available to consumers, and reductions in tariffs and non-tariff barriers as well as increase market access through bi- and multi-lateral trade agreements (Aksoy and Beghin, 2005; Clemens, 2004; Lucier et al., 2006; Johnson, 2010).

The growth in US imports has mainly been along the intensive margin, which is defined as the change in the value of trade for existing relationships over a period of time and commodity. In this case, we define an existing relationship as whether a country exported a given fresh fruit or vegetable to the US in 1989. Then, the intensive margin for an existing relationship is computed by subtracting the value of trade in 1989 from the value of trade in 2013. For example, in 1989, the cif value of apple imports from Argentina was $9.77 million. In 2013, the cif value of apple imports from Argentina was $11.02 million. Thus, the intensive margin increased by $1.25 million. Of the $13.5 billion growth in the value of US fresh fruit and vegetable imports between 1989 and 2013, 76 percent (or $10.3 billion) occurred along the intensive margin.

There are several drawbacks with focusing just on changes in the intensive or extensive margins of trade. First, the changes are sensitive to the choice of the beginning and ending data of the analysis. Not only will this choice influence what country-commodity pairs are considered an "existing good," but the choice of longer time periods tends to yield larger growths in the intensive margins than for shorter time periods. Second, and more importantly, because a change in the intensive or extensive margin compares just two points in time, these measures do not provide on insights on the stability of trade relationships between the US and the countries supplying fresh fruits and vegetables. It could be the case that a country just happened to export a given product to the US at the chosen beginning and end dates, but infrequently or never in the periods in between these two dates.

Recent work by Besedeš and Prusa (2006a, 2006b), Nitsch (2009), Obashi (2010), and Cadot *et al*. (2011) have shown that the duration of trade relationships tends to be short with numerous entries and exists in a market, which leads to multiple spells of service. Besedeš and Prusa compared US imports for two periods, 1972 to 1988 and 1989 to 2001, with commodities being defined at the 7-digit Tariff Schedule (TS) system or 10-digit Harmonized System (HS) level. During both periods, more than half of trade relationships fail after one year of service and about 70% fail within two years of service. The mean spell length, which is defined as the consecutive number of years an exporter ships a given product to the US, was about 3 years but the median spell length was only 1 year. Nitsch (2009) conducted a similar analysis for German imports in 1995-2005 and also found that on average, trade relationships between countries for a given product tend to be short-lived with numerous entries and exits.

Between 1989 and 2013, the duration of trade relationships between the US and exporters of fresh fruits and vegetables also exhibit a pattern of multiple spells, but with a longer average duration than found by Besedeš and Prusa. Defining duration as the number of consecutive years that a country exports a specific fresh fruit or vegetable commodity, the average duration was 4.8 years between 1989 and 2013. The average duration for fresh fruits was slightly longer at 5.0 years when compared the average 4.5 year duration for fresh vegetables. However, as shown in Table 1, there is significant variation in the average duration across different fresh fruit and vegetable categories. Pears/quinces, asparagus, and bananas have the longest average duration of at least 7 years, while currants, potatoes, and globe artichokes have the shortest average duration of three years or less. On average, there were two spells of exporting for each country-commodity pair over this 25 year time period with fruits having slightly fewer number of spells at 1.9 compared with vegetables in 2.1. There is also less variation in the average number of spells across commodities, with pears/quinces and cauliflower/broccoli averaging 1.5 spells or less and fresh beans, lemons and peppers averaging 2.4 or more spells.

In addition to variation in duration and number of spells by commodity, there is also variation in average duration and number of spells by country. Table 2 lists the average duration and number of spells for 27 countries that exported at least 20 fresh fruit or vegetable categories to the US between 1989 and 2013. For these countries, the average duration across all categories is 7.2 years, which is higher than overall average duration of 4.8 years. So on average, countries that tend to supply a broader range of products to the US tend to have longer duration than other countries. However, the variation in average duration between countries is larger than between commodities. Mexico, Canada, Chile, and Guatemala have the longest average duration of at least ten years, and up to 19.3 years for Mexico. Conversely, Turkey, Thailand, France, Brazil, and Colombia have average durations of 3.5 years or less. The average number of spells for these countries is slightly higher, at 2.2, then the average of 2.0 across all countries, with a range of 1.5 spells for Mexico and South Africa to 3.1 spells for Turkey.

Given the dynamic nature observed in US fresh fruit and vegetable imports, the objective of this paper is to identify the factors that affect the duration of trade in this market. In addition to factors typically included in trade duration studies, such as distance, tariff rates, exchange rates, and GDP, we also consider whether US phytosanitary regulations, which have been shown to affect the level of US imports (Peterson, *et al*. 2013), affect duration as well. To our knowledge, this is the first study to assess the effect of phytosanitary regulations on trade duration. In addition, using data on fresh fruit and vegetable production for the US and its export partners, we can assess the extent that size and reliability affects duration.

2. Empirical Model

Several different methodologies have been utilized to analyze trade duration, with survival analysis being the most common (Besedeš and Prusa 2006a, 2006b). However, there are several drawbacks with survival analysis. Non-parametric estimators, such as the Kaplan Meier survivor function are limited to making pairwise comparisons. Thus, it is not possible to hold additional factors that affect duration constant. A major issue in the use of proportional hazard models is data censoring, which occurs when a spell of service begins before the sample period (left-censored) or when a spell of service has not ended by the end of the sample period (right-censored). Finally, Hess and Persson (2010) note that survival analysis may not be appropriate when using annual bilateral trade data because many spells of service will have the same length because the annual trade data masks the dynamics of trade shipments that occur on a more frequent basis (monthly, or even daily).

To address these concerns, we specify a logit model to determine how different factors affect the probability that a country exports a given fresh fruit or vegetable product category to the US in a given year. This approach will allow our model to control for multiple independent variables and avoid the data censoring problem by defining the dependent variable as a (0,1) binary variable instead of the years of service. In general, the probability that country o exports commodity k to the US in time t will depend on the underlying supply and demand conditions in both o and the US, trade costs, and other macroeconomic conditions:

(1) $$y_{okt} = f\left(S_{okt}, D_{okt}, S_{USkt}, D_{USkt}, TC_{okt}, MC_{kt}\right)$$

where y_{okt} equals 1 if country *o* exports commodity *k* to the US in time *t* and 0 otherwise; S_{okt} and S_{USkt} are supply conditions for commodity *k* in the US and the exporting country in time *t*; D_{okt} and D_{USkt} are demand conditions for commodity *k* in the US and the exporting country in time *t*; TC_{okt} is the trade costs associated with exporting commodity *k* from region *o* to the US in time *t*; and MC_{kt} are global macroeconomic conditions affecting commodity *k* in time *t*. Within each of these broad categories of independent variables, we will identify one or more independent variables that will be included in our econometric model to control for these effects. We next discuss these specific independent variables.

The supply conditions for the US and the exporting country in our model are comprised of two components: supply availability and reliability. All else constant, we expect that a larger available supply of commodity *k* in the exporting country would increase the probability that it exports that commodity to the United States. Conversely, a larger available supply of commodity *k* in the US would reduce the probability. We measure the supply availability as the quantity of commodity *k* produced in a given region. Similarly, more reliable exporting regions would have a higher probability of exporting commodity *k* to the US, all else constant, while a greater reliability of US supply, the lower the probability that a country will export to the United States. In this paper, we define reliability in terms of the variability of production and if an exporting country consistently ships commodity *k* to the United States. Specifically, we measure production variability as the ratio of the standard deviation of the production of commodity *k* in the three previous years divided by the average level of production in the previous three years. By using a ratio, this provides a measure of the variability in production as a percent of average production. Thus, a larger value implies less reliability. The consistency of exports is measured by the inclusion of lagged dependent variables in the model. Thus, we expect that regions that exported commodity *k* last year would, all else constant, have a higher probability of exporting this year. To allow for a more general dynamic relationship, we include the lagged dependent variables for the previous three years in the econometric model.

Representing the demand conditions for commodity *k* in the US and exporting regions is more challenging because data on per-capita consumption by commodity is not generally available in all regions. However, if fresh fruits and vegetables are normal goods, then an increase in real per-capita GDP would be associated with an increase in per-capita consumption. Thus, we included real per-capita GDP of the exporting country as an independent variable in our econometric model. Because US per-capita GDP will only vary across time but not commodity, its effect will be captured by a set of year dummy variables in the model. An alternative US demand condition would be to consider the relative prices of commodity *k* produced domestically and the *cif* price of the imported product from region *o*. Assuming that the consumers view domestic and import varieties of commodity as heterogeneous and holding quality differences and all else constant, an increase in the US producer price of commodity *k* should cause US consumers to substitute toward imports, thereby increasing the probability that region *o* would export commodity *k* to the United States. Conversely, an increase in the *cif* price of commodity *k* from region *o* would cause US consumers to substitute away from that variety, thereby reducing the probability that region *o* would export commodity *k* to the United States.

Trade costs in our econometric model are represented by three different components: international transport costs, tariffs, and required phytosanitary treatments. To capture variations in transport costs across commodities, exporters, and time, we utilize the ratio of the *cif* to the *fob* (Customs) value reported in the US trade data (US International Trade Commission, 2014) rather than using distance, which is commonly used in gravity models, to control for transport costs. A drawback to this approach is the missing values in the data when region *o* does not export commodity *k* to the US in a given year. To mitigate this problem, we fill in the missing values by using the average ad valorem transport costs for commodity-region pairs with multiple periods of exports to the US or by using the observed ad valorem transport costs for commodity *k* from a neighboring region. For example, the observed ad valorem transport costs for commodity *k* from Chile could be used as a proxy for the ad valorem transport costs of commodity *k* from Argentina. All else constant, we expect that a larger value of this ratio, which can also be interpreted as a transport cost ad valorem equivalent, should reduce the probability of exporting.

Two common features of US bilateral tariff rates for fresh fruits and vegetables is the common use of specific tariffs and the use of seasonal tariff rates. For example, for fresh or chilled tomatoes, the US MFN tariff rate is 2.8 cents/kilogram for imports entering during the periods July 15 – August 31 and November 15 – February 28/29. In the remainder of the year the MFN tariff rate is 3.9 cents/kilogram.[1] For other product categories, such as Brussels sprouts, the US imposes a 12.5 percent ad valorem MFN tariff. To account for the use of specific rate and seasonal tariffs, we compute an ad valorem tariff equivalent by dividing the "calculated duties" by the *fob* or customs values reported in the US International Trade Commission (USITC) trade database. As with the transport costs, the drawback of this approach is the missing values in the data when region *o* does not export commodity *k* to the US in a given year. We adopt a similar approach to fill in the missing tariff values by using the average ad valorem tariff rates for a commodity-region pairs with multiple periods of exports to the US or apply the observed tariff rates for countries with identical trade preferences, such as EU Member

[1] The tariff rate for countries with free trade agreements or other preferential arrangements for tomatoes is zero.

States. For most country-commodity pairs, we have at least one observation during the period 1993-2009 where it is possible to compute an ad valorem equivalent.[2]

Sanitary and Phytosanitary (SPS) regulations are important for many food and agricultural products due to concerns regarding food safety and the protection of plant and animal health. The use of phytosanitary measures, such as methyl bromide fumigation or cold treatment, are important for fresh fruits and vegetables to control for pests that could be transmitted through international trade. Their use, which is not uniform across exporters for a given product (Peterson, *et al.*, 2013), imposes additional cost to exporters that face treatment requirements. Because the cost of complying with phytosanitary regulations is not available on a country-commodity basis, we use a set of binary variables to indicate whether the US requires a phytosanitary treatment for a particular country-commodity pair.

The last category of independent variables in our general empirical model, what we call global macroeconomic conditions, are represented in our econometric model by the bilateral exchange rate between region *o* and the US, the volatility of that bilateral exchange rate, and global price of commodity *k*. All else constant, we expect that if a country's currency depreciates relative the US dollar, that the probability of exporting would increase. The currency depreciation would make the price of all commodities exported by that country to the US relatively less expensive than exports by other suppliers or to the domestically produced commodity, leading to users in the US to substitute toward those products. Greater exchange rate volatility, which would increase the risk of selling in the US market, would be expected to lower the probability of exporting. We measure exchange rate volatility as the standard

[2] Another possible source of bilateral tariff rates is the TRAINS database. However, this database depends on countries reporting their tariff values, which leads to sparse data for most countries and products.

deviation in the bilateral exchange rate over the past three years divided by the average value of that exchange rate over the past three years.

Because the US typically sources its imports of a given commodity from several different regions and most exporters service more than a single export market, price changes in other regions could affect the mix of regions supplying the US market. To control for this possibility, we include the average global price of commodity *k*, defined as the average *fob* unit-price of commodity *k* across all exporting regions, as an independent variable.[3] The impact of an increase in the global price of commodity *k*, all else equal, will depend on whether the import demand or the export supply effect dominates. If the import demand effect, which would arise if region *o*'s exports of commodity *k* becomes less expensive than exports of commodity *k* from other regions, dominates then the probability of exporting would increase. Conversely, if the supply effect dominates, which would arise from region *o* exporting more to other destinations with higher prices than the US market, then the probability of exporting would decrease.

Formally, our base econometric model can now be specified as:

$$\begin{aligned} y_{okt} &= \beta_0 + \alpha_{ok} + \lambda_t + \beta_1 y_{okt-1} + \beta_2 y_{okt-2} + \beta_3 y_{okt-3} + \beta_4 prod_{okt} + \beta_5 varp_{okt} + \beta_6 prod_{USkt} + \\ &\quad \beta_7 varp_{USkt} + \beta_8 GDP_{ot} + \beta_9 usprice_{kt} + \beta_{10} exprice_{okt} + \beta_{11} tcost_{okt} + \beta_{12} tariff_{okt} + \\ &\quad \sum_p \delta_p treat_{pokt} + \beta_{13} er_{ot} + \beta_{14} vare_{ot} + \beta_{15} gprice_{okt} + \varepsilon_{okt} \end{aligned} \tag{2}$$

where α_{ok} and λ_t are are exporter-by-commodity (group) and year fixed effects; y_{okt-1}, y_{okt-2}, and y_{okt-3} are lagged dependent variables; $prod_{okt}$ is the quantity of commodity *k* produced in region *o* in time *t* (1,000 mt); $varp_{okt}$ is the variability of production of commodity *k* produced in region *o* in time *t*; GDP_{ot} is the real per-capita GDP in region *o* in time *t* measured in 2010 US dollars; $usprice_{kt}$ is US producer price of commodity *k* in time *t* (\$/mt); $exprice_{okt}$ is the export price of

[3] We also considered specifications that used exporter/US and exporter/global relative prices, but the relative prices were highly correlated. Thus, we chose to use the absolute price specification instead.

commodity k from region o in time t; $tcost_{okt}$ is the ad valorem international transport cost of shipping commodity k from region o to the US in time t; $tariff_{okt}$ is the ad valorem equivalent of US tariffs on commodity k from region o in time t; $treat_{pokt}$ is a binary variable equal to 1 if phytosanitary treatment p is required on commodity k from region o in time t; er_{ot} is the bilateral real exchange rate between region o and the US in time t; $vare_{ot}$ is the variability of the bilateral exchange rate in time t; $gprice_{kt}$ is the average global *fob* unit-value of commodity k in time t; and ε_{okt} is an error term.

While equation (2) controls for many of the natural factors that affect whether a country exports to the United States or not, there is likely to be considerable amount of unobserved heterogeneity not accounted for in the model. One approach to deal with the unobserved heterogeneity would be to use a logit fixed effects estimator. One drawback with this estimator is that any country-commodity pair that exports to the US in all time periods or never exports to the US is dropped from the sample. In our sample, almost 2,700 observations would be dropped, raising concerns about a sample selection problem. Alternatively, one could define a set of country-commodity dummy variables to include in the model, which would be equivalent to using a fixed effects estimator. However, it is not possible to include 3,220 unique country-commodity pairs (70 countries x 46 commodities) in the model. To address this problem, we create five aggregate fruit, four aggregate vegetable, and eight aggregate regions, along with 34 individual countries to create a manageable set of 220 unique region-aggregate commodity pairs. Table 3 provides a concordance between the 46 commodities in our sample and the 9 aggregate fruit or vegetable category. Table 4 provides a list of the 70 countries included in the sample and identifies if they are included in one of the eight regional aggregates.

3. Data

US trade data on *fob* and *cif* values plus calculated duty was collected for 46 fresh fruits and vegetables for the period 1993 through 2008 from the US International Trade Commission (USITC) Interactive Tariff and Trade Dataweb. The 46 product categories were chosen to correspond with the fresh fruit and vegetable identifiers used in the Animal and Plant Health Inspection Service (APHIS) *Fresh Fruits and Vegetables Import Manual* (USDA, APHIS, 2009a), which contains information (organized by exporting country) on the regulatory regime and the conditions under which an exporter can ship to the United States. As shown in Table 3, most fresh fruit and vegetable products are associated with a single HS 6-digit category. However, further disaggregation is required to disaggregate lemons, limes, mangoes, squash, pumpkins, cabbages, and okra in the trade data.

Because the US imports fresh fruits and vegetables from over 150 countries, we employed a filter to get the number of countries to a more manageable size. To be included in the sample, a country must have shipped at least $100,000 of at least one product for at least three years (out of the 13 years in our sample). Note that this does not mean that *every* product a country exports must total $100,000 or more, but just a single product. If that condition is met, the exporter and all of the products it ships, some of which may total considerably less than $100,000, are included in the sample. Using this filter results in 70 countries in our sample. These countries account for approximately 95 percent of total US imports of fresh fruits and vegetables.

Production data is obtained from the Statistics Division of the Food and Agricultural Organization (FAO) of the United Nations (United Nations, 2014). Some FAO commodity definitions do not match the HS product definitions contained in the trade data. For example, the

FAO product category green onion (including shallots) is used for both onions and leeks. Other FAO product categories are combinations of the individual product categories in our sample. For example, lemons and limes are one product category in the FAO data, whereas they are two separate commodities in the trade data. In this case, we apply the same production data to both lemons and limes as a proxy for exporter production.

Price data are collected from several sources. The US producer price ($usprice_{kt}$) for fresh fruits and vegetables are obtained from FAOSTAT (United Nations, 2014). The average global *fob* unit-value ($gprice_{kt}$) is also obtained from the COMTRADE database and is computed as the total trade value from all countries (reporter name) to the world (partner name) divided by total quantity. Because of distinct market segments between domestic and export oriented fresh fruit and vegetable production in many exporting countries, we attempted to use the unit-value of exports from UN Commodity Trade Statistics Database (COMTRADE) as the export price ($exprice_{okt}$) rather than the producer price reported in the FAO data. In cases where there is no reported data for a given country-commodity-year triplet in the COMTRADE database, but reported imports in the USITC database, we used the import unit-value (customs value divided by import quantity) as the export price. However, given the large variation in unit-export prices across countries for several commodities in our sample, we decided not to include the export price in our logistic regressions.

Information on US phytosanitary treatments over the period 1996-2008 is obtained from the APHIS *Fresh Fruits and Vegetables Import Manual* (USDA, APHIS, 2009a; Peterson, *et al*., 2013). The information in these manuals is used by regulatory officials stationed at land borders, airports, and sea ports of entry. The manuals contain information on the regulatory requirements under which exports of a given fresh fruit or vegetable from a given country can enter the United

States. The manuals are released several times a year reflecting the implementation of any new regulations or amendments to existing regulations. Because we utilize annual trade data in this analysis, the last edition for a given year is used to match treatments and lists of approved products. Because regulatory requirements do not change frequently within a year, drawing information from the last APHIS manual published in a given year ensures that all changes in phytosanitary requirements are accounted for without having to track intra-year changes across each edition. Changes in phytosanitary requirements are identified by comparing the treatment requirements and list of approved products across two consecutive years.

Approved phytosanitary treatments include methyl bromide fumigation, cold treatment, water treatment, heat treatment, irradiation, or a combination of these treatments. To gain insight on the frequency with which phytosanitary treatments are applied in our sample, Table 5 tabulates the number of country/commodity/year triplets where at least one treatment is required over the period 1996-2009. Overall, nearly 20 percent of all triplets have at least one treatment requirement. There is also considerable variation in the types of treatments required, with cold treatment (for fruits) methyl bromide fumigation (mainly for vegetables) being the most frequency applied treatment option. The next most frequently applied treatments are water treatment (vegetables) and a combination of methyl bromide fumigation and/or cold treatment (fruits).

Because of the limited number of observations for some treatment categories, we will begin be estimating an "average" effect of phytosanitary treatments on the probability of exporting to the US by defining a binary variable $treat_{okt}$ that equals 1 if any phytosanitary treatment is required on commodity k shipped from region o in time t and 0 otherwise. This approach will provide over 1,000 total observations with a phytosanitary treatment and should improve identification of any effect on the probability of exporting. But because some of these different treatment options could differ in the cost of compliance and therefore have different impacts on the probability of exporting, we will also estimate a more flexible specification that includes four different treatment categories: methyl bromide fumigation (MB), cold treatment (COLD), water treatment (WTR), and methyl bromide fumigation and/or cold treatment/refrigeration (MB/COLD).

Macroeconomic data on *GDP* and exchange rated are obtained from the International Macroeconomic Data Set developed by the Economic Research Service (USDA/ERS, 2014). We use the real per-capita GDP, in 2010 dollars, as our measure of *GDP*. Similarly, we use the real exchange rates, again measures in 2010 dollars, as our measure of er_{ot}.

A fully balanced panel would contain 41,860 observations (70 exporters X 46 product categories X 13 years). However, a number of zero trade flow observations are excluded from the sample. First, some country/commodity pairs are ineligible for entry into the United States under APHIS rules due to pest concerns or the inability of exporters to implement approved pest mitigation strategies. Second, many zero trade flows are associated with countries that are not able to produce a given commodity due to climatic or biological factors (i.e, bananas cannot be grown in Canada). FAO production data are used to identify these occurrences. Third, even if production is possible, if a country does not export a given commodity to any country during the sample period, that country/commodity pair is also excluded from the sample. In other words, we assume there is no 'potential' for trade for countries that have never exported a particular product. Finally, for some observations, data are missing for some independent variables (namely exporter production). The final sample includes 6,792 observations. Table 6 presents the summary statistics.

A final empirical equation is what is the appropriate value of exports needed for a country-commodity pair to be considered an active participant in the US market? Do observed trade flows with a relative low value really represent commercial shipments of that particular commodity or could it possibly be a shipment of specialty items? As a robustness check for our model, we consider three different threshold levels of exports that determine whether y_{okt} is equal to one or not: if the *fob* (customs) value is greater than zero; if the *fob* value is greater than $25,000, and if the *fob* value is greater than $50,000. As shown in Table 6, there is a significant difference in frequency that y_{okt} equals one using a threshold level of zero or $25,000. If the threshold is set equal to zero, approximately 37.5% of all country-commodity-year triplets are zero trade flows. If the threshold is set at $25,000, almost one-half of all country-commodity-year triplets are zero trade flows. The difference in the number of zero trade flows is much smaller between the $25,000 and the $50,000 threshold.

4. Results

We will first focus on the version of equation (2) that estimated an average effect of phytosanitary treatments. The marginal effects for each variable on the probability of exporting, across the three different export threshold levels, are reported in Table 7. Being a "consistent" exporter to the US has a relative large and statistically significant impact of the probability that a country will export a given commodity. Across all three thresholds, if a country exported commodity *k* in the previous year, the probability that it will export that commodity again this year is approximately 0.3, all else constant. The impact of consistency decays when considering longer lags, with countries that have exported commodity *k* in the previous two or three years having a 10% greater chance of exporting this year. If a country that has exported commodity *k* in each of the last three years has a 50% chance of exporting that commodity in the current year, all else constant.

Two other independent variables with statistically significant marginal effects across all three threshold levels are the US price of commodity *k* ($usprice_{kt}$) and real per-capita GDP (GDP_{ot}) in the exporting country. Higher commodity prices in the US increase the probability that a country will export commodity *k* to the US, all else constant. However, the marginal effect of a $1 per metric ton increase in the US price is very small, approximately 0.00003. An increase of $800 per metric ton, or roughly doubling the average US price in the sample, would increase the probability that a country exports commodity *k* by approximately 0.025. Similarly, while an increase in real per-capita GDP in the exporting country reduces the probability of exporting commodity *k* to the US, the marginal effect is also small. A $1 increase in real per-capita GDP would decrease the probability by about 0.000002. Thus, a $1600 increase in real per-capita GDP, or about 10 percent of the sample mean, would decrease the probability of exporting by approximately 0.003.

The marginal effects of several independent variables are only statistically significant for one or two threshold levels. While an increase (appreciation) in the exporting country's currency relative to the US dollar has a negative effect on the probability of exporting commodity *k* to the US, this effect is only statistically significant for the threshold levels of $25,000 and $50,000. However, given a marginal effect of approximately -0.00004 for a one-unit increase in the exchange rate, it would take large exchange rate swing to have a large effect on the probability of exporting. An increase in the bilateral tariff rate has a negative effect on the probability of exporting, but it is only statistically significant at the 10% significance level when the threshold level is $25,000 and marginally insignificant when the threshold level is zero dollars. One possible explanation for these results is that the US bilateral tariffs on fresh fruits and vegetables are low, with an average ad valorem equivalent of 2.7 percent. A one percentage point increase in the bilateral tariff (e.g., 0.01) will reduce the probability of exporting by 0.001. An increase in the availably supply (production) of commodity *k* has a positive effect on the probability of exporting to the US, but it is only statistically significant for the threshold level of zero dollars. In that case, a 1,000 metric ton increase in production would increase the probability of exporting to the US by 8.6×10^{-6}, or a very small increase. Finally, the level of exchange rate volatility ($vare_{ot}$) has a positive effect on the probability of exporting to the US, which is the opposite sign of what was expected. However, the marginal effect is just barely significant (*p*-value of 0.1) for the $25,000 threshold, while the *p*-values for the other two thresholds are greater than 0.8.

There are several independent variables whose estimated marginal effects are not statistically significant across all three thresholds. Perhaps most surprising, is that transport costs did not have a statistically significant effect on the probability of exporting to the US, all else constant. One possible reason is that differences between the *cif* and *fob* values in the USITC data may not always be a good estimate of transport costs. While on average, the implied ad valorem transport costs 1.30 seems plausible, this value ranges from 1.002 to 2.86 in the sample. In addition, the level of US production ($prod_{USkt}$) and the volatility of US production ($varp_{USkt}$) of commodity *k* did not have a statistically significant effect on the probability of exporting to the United States. These results could reflect that a significant portion of US imports of fresh fruits and vegetables are counter-seasonal to US production to provide a year around supply of fresh product to US consumers. Finally, the volatility of the production of commodity *k* in the exporting country ($varp_{okt}$) did not have a statistically significant effect on the probability of exporting to the United States. On possible explanation is that the volatility is measured based on total production of commodity *k* in a given country. A better measure would be the volatility of production destined for export markets.

We now turn to a discussion of the effects of phytosanitary treatments on the duration of trade. From Table 7, we can see that average phytosanitary treatment (*treat*) marginal effect is very small in absolute value with relatively large *p*-values across all thresholds. This suggests that either phytosanitary treatments do not affect trade duration or that some treatments may be associated with positive effects while others may be associated with negative effects on duration. To investigate this latter possibility, we estimate a more flexible specification that includes four different treatment categories: methyl bromide fumigation (MB), cold treatment (COLD), water treatment (WTR), and methyl bromide fumigation and/or cold treatment/refrigeration (MB/COLD) and report the estimated marginal effects in Table 8. While none of the estimated marginal effects are statistically significant, the coefficients for MB, COLD, and MB/COLD are negative across all three export thresholds. One possible explanation is that number of observed country-commodity-year triplets with a required phytosanitary treatment is relative small for these three treatment options, making it difficult to accurately identify the effect of these treatments on the probability of exporting to the United States.

The estimated marginal effect for water treatment is positive and statistically significant across all thresholds. In our sample, water treatment is only required on mangoes exported from Central and South American countries, as well as Haiti and the Dominican Republic, which are the main mango exporters to the United States. Across the zero, $25,000 and $50,000 export threshold levels, mango exporters with a required water treatment are associated with 91 percent, 88 percent, and 87 percent positive trade flows while mango exporters without a required water treatment are associated with 73 percent, 46 percent, and 46 percent positive trade flows. While these comparisons do not hold all else constant, the differences likely explain the positive marginal effect for water treatments. It should be pointed out that without the option of using a water treatment to mitigate pest risks concerns, these may not have received permission from USDA/APHIS to export mangoes to the United States. Thus in the case of mangoes, the use of a phytosanitary treatment may be trade and duration facilitating.

5. Conclusions

The trade relationships between the US and exporters of fresh fruits and vegetables are often very dynamic, with numerous entry and exits in and out of US markets. Defining duration as the number of consecutive years that a country exports a specific fresh fruit or vegetable commodity, the average duration for fresh fruits was 5.0 years while the a duration for fresh vegetables was 4.5 years over the 25 year period of 1989-2013. In addition, there were on average 2 spells of exporting for a given country-commodity pair.

Given the dynamic nature observed in US fresh fruit and vegetable imports, this paper attempted to identify the key factors that affect the duration of trade in US fresh fruit and vegetable imports. A logit model was specified to determine how different factors affect the probability that a country exports a given fresh fruit or vegetable product category to the US in a given year. Using this approach allowed us to control for multiple independent variables and avoid the data censoring problem common in proportional hazard models.

Our results indicate that "consistency" in exporting has the largest impact on trade duration for fresh fruits in vegetables. Countries that exported a given commodity in the previous year, had a 30% chance of exporting that commodity in the current year, all else constant. While the impact of consistency decays when considering longer lags, countries that have exported a given commodity in the each of the previous three years has a 50% chance of exporting that commodity in the current year, all else constant. This would suggest that building supply chains not only within the exporting country but with US wholesalers and retailers may be one of the most important factors in determining the duration of trade in fresh fruits and vegetables.

While higher US producer prices have a positive impact on the probability of exporting and exporter per-capita GDP, the bilateral exchange rate between the exporter's currency and the dollar, and US bilateral tariffs have negative effects on the probability of exporting, the relative magnitudes of the effects are small. Interestingly, transport costs did not have a statistically significant effect on the probability of exporting to the US, all else constant. Nor did the level of production and the variability of production in the exporter country and the in the US affect the probability of exporting.

In our sample, we did not find evidence that phytosanitary treatment requirements significantly reduced the probability of exporting fresh fruits and vegetables to the United States. While the estimate marginal effects for methyl bromide fumigation, cold treatment, and a combination of cold treatment and fumigations were negative, the coefficients were not statistically significant. This could reflect the limited number of observations for these treatments did not allow our model to accurately identify the marginal effects. In contrast, water treatments, mainly applied to US imports of fresh mangoes from Central and South America and the Caribbean, we found a positive and statistically significant effect on the probability of exporting to the United States. So while Peterson, *et al.* (2013) found a negative effect of treatment requirements on the magnitude of trade, we find no evidence of a negative effect on the probability of exporting. This might suggest that if an exporter is able to overcome the compliance costs of a phytosanitary treatment, it will not affect the duration of trade.

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Table 1. Average Number of Spells and Duration by Category, 1989-2013

	Number of Spells			Duration (years)	
Commodity	Mean	Std. Dev.	Maximum	Mean	Std. Dev.
Apples	1.6	0.98	4	5.0	7.91
Apricots	2.1	1.80	7	3.5	6.98
Asparagus	1.8	1.33	6	7.5	9.41
Avocados	1.8	1.07	4	5.1	8.38
Bananas	1.7	0.97	5	7.0	9.01
Brussels sprouts	2.0	1.79	6	6.2	9.45
Cabbage	2.0	1.60	6	3.6	6.36
Carrots	1.6	1.24	6	3.6	6.47
Cauliflower/Broccoli	1.5	0.81	4	4.0	6.72
Cherries	1.8	1.04	4	3.3	5.61
Cranberries/Blueberries	1.7	1.08	5	3.9	6.75
Cucumbers	1.8	1.16	5	4.5	7.57
Currants	2.2	1.47	5	2.2	2.46
Eggplant	2.1	1.14	5	3.8	5.86
Fresh beans	2.5	1.57	7	3.4	5.44
Garlic	2.3	1.45	7	4.2	6.43
Globe artichokes	2.3	1.39	5	3.1	3.85
Grapefruit	2.0	1.22	5	4.5	7.45
Grapes	1.6	1.11	5	5.5	8.28
Head lettuce	2.2	1.40	6	4.7	8.04
Jicamas pumpkins	2.2	1.20	5	5.6	8.45
Kiwifruit	1.6	0.89	4	4.8	6.82
Leaf lettuce	2.1	1.44	6	5.0	7.68
Leeks	1.9	1.30	6	4.8	6.96
Lemons	2.4	1.47	5	4.6	6.63
Limes	1.9	1.36	5	5.2	7.48
Mandarins	1.8	1.22	5	6.4	7.88
Mangoes	2.0	1.29	5	5.8	7.86
Melons	1.8	0.84	4	6.8	6.67
Mushrooms/Truffles	2.1	1.44	7	4.5	6.11
Okra	2.3	1.37	6	3.7	4.58
Onions	2.3	1.58	6	4.9	7.24
Oranges	2.0	1.67	7	5.2	7.90
Papayas	2.0	1.25	6	4.5	7.64
Peaches/Nectarines	1.7	0.88	4	4.3	7.09
Pears/Quinces	1.4	0.96	5	7.8	9.77
Peppers	2.4	1.76	8	4.4	6.86
Pineapples	2.1	1.37	5	5.2	7.61
Plums/Sloes	2.1	1.21	6	3.4	4.64

Continued

Table 1. Continued

Commodity	Number of Spells Mean	Number of Spells Std. Dev.	Number of Spells Maximum	Duration (years) Mean	Duration (years) Std. Dev.
Potatoes	2.1	1.63	6	2.1	4.46
Raspberries/Blackberries	1.9	1.19	5	4.5	7.86
Spinach	1.7	1.15	5	4.0	7.20
Squash	1.8	1.04	4	6.8	9.54
Strawberries	2.1	1.30	6	3.8	5.87
Tomatoes	2.1	1.48	7	4.3	7.12
Average	2.0	1.34		4.8	7.19
Fruits	1.9			5.0	
Vegetables	2.1			4.5	

Table 2. Average Number of Spells and Duration by Country, 1989-2013

	Number of Spells		Duration (years)	
Country	Mean	Std. Dev.	Mean	Std. Dev.
Argentina	2.0	1.19	6.9	8.81
Australia	2.1	1.30	4.3	6.28
Brazil	2.0	1.22	3.3	4.64
Canada	1.9	1.47	15.4	10.57
Chile	2.2	1.45	11.5	10.66
China	2.8	1.75	4.5	5.86
Colombia	2.3	1.29	3.4	5.20
Costa Rica	2.6	1.68	6.1	8.11
Dominican Rep	1.8	1.17	9.6	9.68
Ecuador	2.2	1.26	5.2	7.88
France	2.2	1.23	3.2	4.66
Guatemala	2.2	1.25	10.0	8.89
Honduras	2.2	1.72	7.8	9.88
Israel	2.2	1.53	5.7	7.67
Italy	2.5	1.86	5.2	7.63
Jamaica	2.1	1.29	5.8	8.69
Japan	2.0	1.53	4.3	5.93
Mexico	1.5	1.07	19.3	9.08
Netherlands	2.5	1.44	4.9	7.52
New Zealand	2.3	1.65	9.6	9.54
Nicaragua	1.9	1.35	4.5	5.65
Panama	1.8	1.11	6.5	8.74
Peru	2.0	1.00	6.3	7.23
South Africa	1.5	0.76	7.2	7.36
Spain	2.4	1.41	5.3	7.37
Thailand	2.5	1.48	3.0	4.84
Turkey	3.1	1.77	2.8	3.79
Average	2.2		7.2	

Table 3. Concordance for Fresh Fruit and Vegetable Products to HS Codes

Product	HS Code	Aggregate Category[2]
Fresh fruits		
Apples	80810	Fruit4
Apricots	80910	Fruit4
Avocados	80440	Fruit2
Bananas	8030020	Fruit2
Cherries	80920	Fruit3
Cranberries/Blueberries	81040	Fruit3
Currants	81030	Fruit3
Grapefruit	80540	Fruit1
Grapes	80610	Fruit4
Kiwifruit	81050	Fruit4
Lemons	8053020/8055020[1]	Fruit1
Limes	8053040/8055040	Fruit1
Mandarins	80520	Fruit1
Mangoes	8045040 + 8045060	Fruit2
Melons	80719	Fruit5
Oranges	80510	Fruit1
Papayas	80720	Fruit2
Peaches/Nectarines	80930	Fruit4
Pears/Quinces	80820	Fruit4
Pineapples	80430	Fruit2
Plums/Sloes	80940	Fruit4
Raspberries/Blackberries	81020	Fruit3
Strawberries	81010	Fruit3
Watermelons	80711	Fruit5
Fresh Vegetables		
Asparagus	70920	Veg1
Brussels spouts	70420	Veg1
Cabbage	7049020	Veg1
Carrots/Turnips	70610	Veg2
Cauliflower/Broccoli	70410	Veg1
Cucumbers	70700	Veg3
Eggplant	70930	Veg3
Beans	70820	Veg4
Garlic	70320	Veg2
Globe artichokes	70910	Veg1
Head lettuce	70511	Veg1
Jicamas/Pumpkins	7099005	Veg3
Leaf lettuce	70519	Veg1
Leeks	70390	Veg2
Mushrooms/Truffles	70951 + 70952 + 70959	Veg2
Okra	7099014	Veg4

Table 3. Continued

Product	HS Code	Aggregate Category
Fresh Vegetables		
Onions	70310	Veg2
Peppers	70960	Veg4
Potatoes	70190	Veg2
Spinach	70970	Veg1
Squash	7099020	Veg3
Tomatoes	70200	Veg4

[1] HS code change for lemons and limes occurred in 2002,

[2] The aggregate fruit and vegetable categories were created based on the following groupings: Fruit1 – citrus, Fruit2 – tropical fruits, Fruit3 – berries, Fruit4 – temperate fruits, Fruit5 – melons, Veg1 – Brassicas/lettuce/spinach, Veg2 – Allium/roots/tubers, Veg3 – Cucurbits, and Veg4 – other vegetables.

Table 4. Country and Aggregate Region Concordance

Country/Region	Country/Region	Country/Region
Africa[1]	China	Japan
Cote d'Ivoire	China	Korea
Egypt	Hong Kong	Mexico
Ghana	Taiwan	Morocco
Argentina	Eastern Europe	Netherlands
Australia	Bulgaria	New Zealand
Baltic	Greece	Nicaragua
Denmark	Hungary	Panama
Estonia	Macedonia	Peru
Poland	Republic of Moldova	Portugal
Sweden	Romania	SE Asia
Belgium-Luxembourg	Russia	Indonesia
Belize	Serbia/Montenegro	Malaysia
Brazil	Ecuador	Philippines
Canada	El Salvador	Singapore
Other Caribbean	France	Thailand
Bahamas	Germany	Vietnam
Dominican Republic	Guatemala	South Africa
Grenada	Honduras	Other South America
Haiti	India	Bolivia
St Lucia	India	Uruguay
St Vincent & Grenadines	Pakistan	Spain
Trinidad & Tobago	Sri Lanka	Switzerland
Chile	Israel	Turkey
Colombia	Italy	United Kingdom
Costa Rica	Jamaica	Venezuela

[1] Countries listed under a regional identifier are grouped together when creating a set of aggregate region-commodity dummy variables. For example, Cote d’Ivoire, Egypt, and Ghana are included in an aggregate Africa region.

Table 5. Frequency of Phytosanitary Treatments

Phytosanitary Treatment	Frequency
Methyl bromide fumigation	377
Water treatment	108
Heat treatment	17
Pest specific/host variable	37
Cold treatment	545
Fumigation plus refrigeration of fruits	33
Methyl bromide fumigation and cold treatment	119
Cold treatment or fumigation plus refrigeration of fruits	78
Irradiation	8
Other	1
Total	1,323

Source: USDA, APHIS, 2009a

Table 6. Summary Statistics

Variable	Mean	Std. Dev.	Median	Min.	Max.
All positive trade values					
Trade this period (y_{okt})	0.625	0.484		0	1
Trade last period (y_{okt-1})	0.615	0.487		0	1
Trade two period ago (y_{okt-2})	0.604	0.489		0	1
Trade three periods ago (y_{okt-3})	0.593	0.491		0	1
All trade values > $25,000					
Trade this period (y_{okt})	0.506	0.500		0	1
Trade last period (y_{okt-1})	0.495	0.500		0	1
Trade two period ago (y_{okt-2})	0.481	0.500		0	1
Trade three periods ago (y_{okt-3})	0.469	0.499		0	1
All trade values > $50,000					
Trade this period (y_{okt})	0.463	0.499		0	1
Trade last period (y_{okt-1})	0.451	0.498		0	1
Trade two period ago (y_{okt-2})	0.437	0.496		0	1
Trade three periods ago (y_{okt-3})	0.427	0.495		0	1
SPS treatment ($treat_{okt}$)	0.195	0.396	0	0	1
Trade cost ($tcost_{okt}$)	1.304	0.229	1.254	1.002	2.862
Bilateral tariff ($tariff_{okt}$)	1.027	0.075	1	1	2
Exporter production, 1000 MT ($prod_{okt}$)	534.7	1,583.2	83.5	0.002	26,217
Variation in exporter production ($varp_{okt}$)	0.1	0.102	0.07	0	1.239
US production, 1000 MT ($prod_{USkt}$)	2,073.1	3,288.9	854.6	1.8	23,294
Variation in US production ($varp_{USkt}$)	0.068	0.058	0.051	0.00021	0.467
US production price, $/MT ($usprice_{kt}$)	810.9	628.8	558	108	4,458
Global price, $/MT ($gprice_{kt}$)	936.0	758.1	674.6	107.2	6,793
GDP ($2010) ($GDP_{ot}$)	17,244	15,905	8,966	639.9	71,487
Bilateral exchange rate (er_{ot})	1,079.4	5,118.7	7.799	0.5	43,170
Variation in exchange rate ($vare_{ot}$)	0.054	0.050	0.041	0.00035	0.720

Table 7. Marginal Effects on Probability of Exporting, Average Phytosanitary Treatment Effect

	Custom Value > 0		Customs Value > $25,000		Customs Value > $50,000	
Variable	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
$y_{okt\text{-}1}$	0.266	0	0.334	0	0.313	0
$y_{okt\text{-}2}$	0.105	0	0.093	0	0.102	0
$y_{okt\text{-}3}$	0.096	0	0.082	0	0.080	0
$treat_{okt}$	-0.00077	0.966	0.0069	0.645	0.0074	0.59
$tcost_{okt}$	0.017	0.507	0.020	0.353	0.020	0.292
$tariff_{okt}$	-0.106	0.144	-0.104	0.087	-0.052	0.385
$prod_{okt}$	8.62E-06	0.067	3.83E-06	0.302	1.66E-06	0.56
$varp_{okt}$	-0.0018	0.967	0.035	0.328	0.038	0.249
$prod_{USkt}$	5.03E-07	0.769	1.76E-06	0.233	1.35E-06	0.308
$varp_{USkt}$	0.086	0.315	0.070	0.31	0.085	0.172
$usprice_{kt}$	3.80E-05	0.009	3.08E-05	0.014	2.17E-05	0.061
$gprice_{kt}$	4.88E-06	0.673	5.51E-06	0.571	7.25E-06	0.44
GDP_{ot}	-3.57E-06	0.002	-2.01E-06	0.041	-2.07E-06	0.037
er_{ot}	-2.82E-06	0.198	-4.14E-06	0.037	-4.69E-06	0.035
$vare_{ot}$	0.0095	0.916	0.120	0.10	0.017	0.796
Observations	6,792		6,792		6,792	

Table 8. Marginal Effects on Probability of Exporting, Individual Phytosanitary Treatment

	Custom Value > 0		Customs Value > $25,000		Customs Value > $50,000	
Variable	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
$y_{okt\text{-}1}$	0.265	0	0.332	0	0.312	0
$y_{okt\text{-}2}$	0.105	0	0.093	0	0.102	0
$y_{okt\text{-}3}$	0.095	0	0.081	0	0.079	0
mb_{okt}	-0.020	0.5	-0.023	0.376	-0.027	0.294
$cold_{okt}$	-0.024	0.386	-0.006	0.79	-0.013	0.511
$water_{okt}$	0.087	0.094	0.076	0.102	0.075	0.087
$mb/cold_{okt}$	-0.068	0.279	-0.032	0.526	-0.028	0.527
$tcost_{okt}$	0.014	0.567	0.019	0.381	0.019	0.324
$tariff_{okt}$	-0.112	0.126	-0.117	0.059	-0.069	0.262
$prod_{okt}$	9.39E-06	0.051	4.37E-06	0.249	1.95E-06	0.5
$varp_{okt}$	-0.0048	0.912	0.034	0.353	0.036	0.287
$prod_{USkt}$	8.79E-07	0.616	1.87E-06	0.218	1.55E-06	0.256
$varp_{USkt}$	0.092	0.286	0.074	0.284	0.094	0.136
$usprice_{kt}$	3.91E-05	0.007	3.20E-05	0.01	2.23E-05	0.053
$gprice_{kt}$	4.25E-06	0.712	4.48E-06	0.645	6.20E-06	0.511
GDP_{ot}	-3.48E-06	0.003	-1.94E-06	0.048	-1.98E-06	0.046
er_{ot}	-2.84E-06	0.195	-4.21E-06	0.034	-4.74E-06	0.034
$vare_{ot}$	0.0053	0.953	0.119	0.104	0.017	0.8
Observations	6,792		6,792		6,792	