**Maximum Residue Limits: Protectionism or Food Safety?**

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Abstract

Maximum residue limits (MRLs) for pesticides are an example of trade regulations that can be viewed as not only necessary, but also protectionist. Utilizing agricultural trade and MRL data from a variety of sources, hypotheses regarding protectionist behavior are tested in different econometric settings. The nature of the data, which has many round numbers, prompts the use of ordered logit and probit regressions. Results indicate rich, food importing countries employing fewer people in agriculture and spending a higher percent of their GDP on public health favor stricter regulations. Patterns of protectionism at the commodity and country-level were not found, though isolated examples may exist. One logical explanation is simply that regulators successfully erect MRLs to reflect the government's priorities regarding health while still maintaining a reasonable level of harmonization. If protectionism is present, it is neither obvious nor widespread.

# 1 Introduction

Policies like tariffs and import quotas are easily targeted for removal during trade negotiations. For that very reason, new forms of protectionism have been developed. The problem with identifying these new forms as protectionism is that they can easily be framed in a positive light. Anti-dumping legislation can appear protectionist, but competitors depressing markets by "dumping" product below cost is a real fear to some producers. Country of origin labeling (COOL) can be justified as a tool for informing consumers, and it can be intended as a scare tactic to promote domestic industry. Health regulations on agricultural commodities, even though framed as food safety, can be used as administrative barriers to trade.

This paper considers a subset of cases within health regulations. Are the pesticide maximum residue limits (MRLs) on agricultural commodities administrative barriers to trade? Or are they consumer-protection regulations? Clearly some regulation is necessary, but the lack of harmonization in residue limits gives reason to question the motives underlying countries' use and specification of MRLs.

MRLs differ substantially across countries and commodities. Differences in MRLs may be due to significantly different objectives. Perhaps residue limits are stricter for specific, politically sensitive commodities within a country. Another possibility is that strict MRLs are applied to all agricultural commodities to protect the entire industry. Even more broadly, net exporting countries could simply prefer a gentler regulatory climate than importers, similar to a seller preferring looser regulations than a buyer in markets where product quality is hard to discern.

Using regression analysis over 73 countries and 1594 MRLs, the following hypotheses are examined (FAS, 2012):

- MRL strictness depends on the trade balance and/or production level for a country's specific commodities, class of commodities, or entire agricultural industry.
- Richer countries prefer stricter MRLs because they are more health aware, not necessarily because they are wealthy.
- More commonly used pesticides will have stricter MRLs.

Available MRLs for fresh agricultural commodities will be tested for any distinct patterns regarding the strictness of these regulations between countries. In testing these hypotheses, the nature of the data is quite important. As one might expect, there appears to be a fair amount of rounding, default values, and grouping in the MRL data. This paper addresses these complications using a sequence of econometric tools.

## 1.1 Background

MRLs are standards set by individual countries for traded agricultural commodities. A MRL establishes the maximum amount of pesticide residue in parts per million (ppm) that a country permits on a specific commodity.[1] MRLs regulate the active ingredient in the pesticide, or class of

[1] The Food and Agricultural Organization of the United Nations (FAO) defined a pesticide as: *"… any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or*

active ingredients, rather than entire pesticide product in all four of the main pesticide categories including herbicides, fungicides, insecticides, and bactericides.

MRLs have come under particular scrutiny in the last decade, as they can be viewed as both a tool for promoting consumer health and for engaging in trade protectionism. Several papers have attempted to quantify the gains associated with the harmonization of standards for specific MRLs, indicating that there are considerable benefits to a uniform set of regulations (Drogue and DeMaria, 2010; Wilson and Otsuki, 2001; Wilson and Otsuki, 2002). For example, Wilson and Otsuki (2001) estimate that adopting a worldwide standard for Aflatoxin B1 could increase the value of cereal and nut trade by $6.1 billion, a 51% increase from the 1998 levels.

Uniform standards in the food trade have been a global issue since the Codex Alimentarius Commission (CAC) met for the first time in 1963. Created by the FAO and the World Health Organization (WHO), the CAC determines the Codex Alimentarius for its 180 member governments. The Codex includes standards for food additives, veterinary drug MRLs, and pesticide MRLs. It is also referenced in the World Trade Organization's (WTO) Agreement on Sanitary and Phytosanitary measures (SPS Agreement), meaning it has at least symbolic power in resolving trade disputes (Codex, 2012). In practice, the Codex acts merely as a guide and most countries have set up their own specific MRLs, citing scientific evidence. For example, only 25 out of the 73 countries in this study have MRLs identical to the Codex. Regulatory departures from the Codex MRLs are typically stricter, but a few countries loosen their MRLs relative to the Codex.

Since 2008, European Union (EU) member countries have maintained uniform MRLs for agricultural products. This uniformity is the result of harmonization programs dating as far back as 1993 (Chan, 2000). The European Food Safety Authority (EFSA) was primarily responsible for providing advice to the European Commission in drafting these regulations and continues to act as a

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*substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruit. Also used as substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport (FAO, 2002).”*

monitoring organization (EFSA, 2012). These EU MRLs are strict when compared to the standards in most other countries and the Codex.

Despite the unification efforts and potential gains to trade, MRLs still vary widely across the world. This poses the question, why are some MRLs, like the EU's, stricter? Are the scientific analyses based on field trials, the limit of determination (LOD), and acceptable daily intakes (ADI) truly resulting in such different conclusions by different countries? Do higher income countries have tighter standards because they can afford to, as wealthy citizens may demand relatively cleaner food and be willing to pay a higher price? Or is it the case that some countries are protecting their agricultural industries? Russia's 2010 relaxation of "unnecessary restrictive measures" in apples, pears, grapes, citrus, and stonefruit may provide evidence of protectionism, but it could also be an isolated case (Maxwell, 2010).

## 1.2 Literature Review

This paper contributes to the broad literature of regulation and trade protectionism by investigating the motivations for strict regulations with regards to MRLs. MRL analyses have typically placed a limited number of countries trading one or at most two primary commodities in a gravity model. Utilizing bilateral trade data, they estimate the trade losses resulting from these MRLs.

Wilson and Otsuki (2001) review the aflatoxin B1 MRL for 15 importing and 31 exporting countries. Their analysis estimates the elasticity of bilateral trade flows for cereals and nuts using a gravity model with fixed effects. They find that the MRL is trade restricting and extrapolate that relaxation and harmonization of the MRL could increase the value of cereal and nut trade by $6.1 billion. Wilson and Otsuki (2002) then construct another study concerning MRLs in the banana trade for 30 countries. Once again a gravity model is employed and they find that a 10% increase in stringency of the chlorpyrifos to cause a corresponding 1.48% decrease in banana imports.

Drogue and DeMaria (2010) continue the theme of gravity models by implementing a similarity index for the MRLs in apples and pears utilizing seven importers and exporters. This similarity index is adapted from the original Jaffe (1986), and has seen similar applications with respect to agricultural regulations. One such example is seen in the GMO regulation literature with Vigani, Raimondi, and Olper (2010). Drogue and DeMaria find that restrictive MRLs for apples and pears are trade diverting, but to widely different extents.

The original Wilson and Otsuki papers had no need for a similarity index because they directly added the particular MRL regulations as regressors. Drogue and DeMaria utilize over 200 pesticide MRLs between the two commodities, necessitating a tool to summarize that information. A similarity index is constructed in this paper as well, to summarize the information contained in 1594, distinct MRLs.

These empirical studies rely on the theoretical model in Fischer (2000) where tighter regulations imply greater costs, but can be used to restrict foreign access to the market. Fischer finds that small domestic industries will be the most likely to benefit from tighter regulations, as larger exporters will be more likely to give up on a small market with expensive compliance costs. In the context of MRLs and protectionism, the model indicates importing countries with a relatively small domestic industry and demand for the agricultural commodity should receive substantial political pressure to enact restrictive MRLs.

## 2 Data

To establish a link between strict MRLs and trade protectionism, data from a variety of sources are required. MRL data are required along with systems for summarizing the strictness of these MRLs for regression analysis. Country-level indicators including health expenditures and trade data are potential explanatory variables. Pesticide usage and detection data are necessary to evaluate which pesticides will be of the greatest concern to regulators. The following sections detail the sources and breadth of these data.

## 2.1 MRL Data

Data regarding current maximum residue limits are obtained from the Foreign Agricultural Service's (FAS) online MRL database. This database catalogues both pesticide and veterinary drug MRLs for over 300 fruit, vegetable, and nut commodities. Due to the magnitude of the database, the analysis is confined to the trade of fresh horticultural products as defined by the FAS. The selected dataset includes 178 of the 272 approved EPA pesticides (see Appendix A for list of included pesticides), 17 fresh fruit or vegetable commodities, and 75 MRL standards (73 countries; Codex and EU) for a total of 119,550 data points. Not every commodity includes MRLs for all 178 pesticides (FAS, 2012).

The MRL dataset contains observations for 73 countries. There are only 27 unique sets of MRLs (23 countries; 4 multi-country standards). In fact, 50 of the countries follow one of four regulatory standards. 26 countries are in accordance with the Codex recommendations. 17 countries follow the EU's uniform MRLs. 5 countries follow the Gulf Cooperation Council (GCC) set of standards. Finally, the US and Mexico have harmonized MRLs. See Appendix B for included countries and groupings.

Detection rates of certain pesticides for apples, asparagus, grapes, oranges, pears, and strawberries are obtained from the Agricultural Marketing Service's Pesticide Data Program (PDP). These data only concern the U.S. food supply. Nevertheless they provide an indication of which pesticides are being used and the extent of their use for a major producer and exporter of these crops. Transforming the PDP data, pesticides are classified into one of three groups. The pesticide was either not tested for, or it was tested for but not detected, or it was tested for and detected (AMS, 2012). The following analysis assumes that pesticides tested for and detected are the most commonly used and important pesticides. MRLs for pesticides that are not being monitored are less likely to be enforced.

## 2.2 Trade Data and Indices

The FAS's Production, Supply, and Distribution (PSD) online database provides country-level trade flows for 15 fresh commodities groups. Appendix C documents how the 17 commodities from the MRL database are matched to the 15 fresh commodity groups. These data include annual imports, exports, supply, and production and are compiled for 2005, the most recent year with observations for all 15 fresh commodities (FAS, 2012).

Unfortunately, annual data are not sufficiently frequent to investigate any implications of seasonality in the "fresh" category. Often exporters import when outside their harvest window. However, this seasonality should not disrupt the analysis significantly. The identified hypotheses do not require more frequent data to test. Annual trade flows are sufficiently informative to establish the major importers and exporters.[2]

The final components of the dataset are a number of 2005 health, income, and trade indicators from the FAO's FAOSTAT database and the World Bank's World Development Indicators (WDI) database (FAO, 2012; World Bank, 2012).

## 2.3 Data Transformations and Methods

Four analyses are performed on the selected data to test the hypotheses concerning protectionism. The first considers pairwise correlations between MRLs for 27 unique regulatory regimes. Then three sets of regressions are performed to determine whether the trade data or other included variables have explanatory power with regards to the strictness of the MRLs. The following subsections detail the data transformations and methods necessary for the regression analysis, including the construction of two indices of the relative strictness of MRLs. The execution of the ordered logit and probit regressions is detailed due to the summarization required in presenting the results.

[2] Quarterly data would have nevertheless been useful to determine which particular times during the year producers compete to sell a commodity, or if they even compete at all. It is possible that some MRLs are high because there is a lack of competition between the domestic and international markets due to seasonality.

### 2.3.1 Commodity-Level Indices of MRL Strictness

Two commodity-level indices of MRL strictness are implemented, denoted *AVG* and *MAX*, based on *STRICTNESS*, which converts the actual MRLs into percentages reflecting how strict a particular country's MRL is with respect to the average MRL for that pesticide on a commodity. This allows comparison of MRLs across commodities and pesticides. For example, pesticide *x* is regulated for commodity *y* by four countries. These MRLs are 0.1, 0.2, 0.3, and 0.6. Thus the average MRL is 0.3. This means that the *STRICTNESS* values will be 3, 1.5, 1, and 0.5, respectively. *AVG* represents the average *STRICTNESS* value for a country, by commodity. *MAX* represents the maximum *STRICTNESS* value for a country, also by commodity. The following formulas summarize this written description:

$$STRICTNESS_{i,j,k} = \text{Avg. MRL}_{j,k} / \text{Individual MRL}_{i,j,k}$$

The indices *i*, *j*, and *k* denote country, commodity, and pesticide, respectively. Should country *i* be missing a MRL for pesticide *k* on commodity *j*, $STRICTNESS_{i,j,k} = 0$. This result logically follows from the equation above, as no limit would imply an infinite denominator. Thus, *AVG* and *MAX* are constructed with the new *STRICTNESS* variable as follows:

$$AVG_{i,j} = \sum_{k=1}^{K} STRICTNESS_{i,j,k} / K$$

$$MAX_{i,j} = \text{Max}\,(STRICTNESS_{i,j,k})$$

### 2.3.2 Country-Level Indices of MRL Strictness for Fresh Commodities

If the commodity-level FAS trade data are not used, all of the remaining data are country-level. In these country-level regressions, the indices *AVG* and *MAX* are too specific. This problem necessitates a country-level index of MRL *STRICTNESS*. Thus, the variable *AVG2* is proposed:

$$AVG2_i = \frac{\sum_{k=1}^{K} \sum_{j=1}^{J} STRICTNESS_{i,j,k}}{J * K}$$

A corresponding index for the *MAX* variable is omitted because the strictest MRL in a sample of 1594 is often an outlier. Also, country-level regressions with the maximum MRL as the dependent variable tend to have little explanatory power.

### 2.3.3 Reporting of Ordered Logit and Probit Regressions

As mentioned previously, there is relatively little variation within the MRL data. Often there will only be two or three unique MRLs for a particular pesticide in the entire sample of 73 countries. These MRLs also tend to group around simple numbers. For example, MRLs like 0.05 ppm and 0.1 ppm are common, as opposed to uncommon MRLs like 0.18 ppm and 0.0123 ppm.

This pattern of grouping MRLs around round numbers, which would result from non-scientific, bureaucratic rounding, requires the use of ordered logit and probit regressions. The 73 MRLs for a particular pesticide on a commodity, one for each country, are regressed against the explanatory variables. There exist data on 1594 pesticide-commodity combinations though, necessitating a means of summarizing the results. Thus, 1594 individual regressions are performed and the results summarized by counting the percentage of variables found to be positively or negatively significant in a 95% confidence interval.

Some relevant details are overlooked by summarizing results in this fashion. These ordered logit and probit regressions do not have a consistent number of cut points because there may be a different number of unique MRLs in each regression. For example, an ordered logit or probit regression of Abamectin apple MRLs on the country-level indicators has only 1 cut point because it has only 2 unique MRLs over all 73 countries. The regressions also involve MRLs of widely differing magnitude, making interpretation of coefficients an even more difficult task. However, a count of how many times an explanatory variable was determined to be significant out of the potential 1594 can at least provide a relative measure of a variable's explanatory power. Sub-samples are utilized to test for patterns regarding how much a pesticide is used.

## 3 Results

Results indicate countries with a high percentage of total imports in agriculture tend to prefer stricter MRLs. Countries with greater employment in agriculture and countries that produce the regulated commodities tend to have looser MRLs. Higher incomes and public health expenditures are also associated with stricter MRLs.

### 3.1 MRL Correlations

There are 23 countries with unique MRLs in addition to the 50 countries included in one of the four multi-country regulatory regimes (Codex, EU, GCC, US and Mexico). Simple correlation coefficients for the 23 unique countries show Indonesia (0.39), Malaysia (0.84), Thailand (0.97), the United Arab Emirates (0.96), and Vietnam (0.70) are most closely correlated with the Codex standards. Switzerland (0.54) is correlated with the EU. Canada (0.39) and Honduras (0.71) are correlated with the US and Mexico. See Appendix D for complete table of correlations.

The 15 remaining countries with MRLs that are least classifiable into the regulatory regimes are Argentina, Australia, Brazil, Chile, China, Honduras, India, Israel, Japan, Korea, New Zealand, Russia, Singapore, South Africa, and Turkey. Of these, Argentina, Brazil, and Turkey possess correlation coefficients greater than 0.50 with each other and could be considered another loose grouping of countries. China and India have relatively higher (looser) MRLs while Japan and Russia have relatively lower (stricter) MRLs. These countries are noteworthy because they have very large trade volumes and don’t adhere closely to any regulatory regime.

### 3.2 OLS and Ordered Regression

The following three subsections report results for regressions performed at three different levels of aggregation, from most aggregated to least. The first section reports results for OLS regressions with a country-level MRL index. The second reports results for OLS regressions with a commodity-level MRL index. The final section details the results of 1594 ordered logit and probit regressions, one for each MRL in the dataset. Appendix E lists all of the tested independent variables because the regressors that are consistently insignificant will be omitted from the final specifications.

Some of the independent variables employed in this section are clearly correlated. Income-related regressors like per capita GDP, public expenditures on healthcare, and personal expenditures on healthcare are expected to be positively correlated. Likewise, infant mortality and percent employment in agriculture are probably negatively correlated with those variables. The following table (Table 1) reports the correlations among these variables.

**Table 1**: Correlations Between Tested Variables

| | | (1) | (2) | (3) | (4) |
|---|---|---|---|---|---|
| (1) | Health expenditure per capita (current US$) | 1 | | | |
| (2) | Health expenditure, public (% of GDP) | 0.80 | 1 | | |
| (3) | GDP per capita (current US$) | 0.66 | 0.39 | 1 | |
| (4) | Infant mortality (% boy and girl) | -0.48 | -0.41 | -0.53 | 1 |
| (5) | Employment in agriculture (% of total employment) | -0.42 | -0.32 | -0.48 | 0.49 |

To mitigate the issue of correlated regressors in the following regressions, only per capita GDP, percentage employment in agriculture, and public health expenditure are included simultaneously. These specific variables are chosen because they are the least correlated, and will be useful for testing the hypothesis regarding how income and health awareness contribute to the strictness of MRLs.

3.2.2 Country-Level Regressions Using OLS

These regressions utilize the average MRLs by country over all the fresh commodities in the dataset and exclude the use of commodity specific variables. Results are reported in Table 1:

| **Table 2:** OLS With Country Level Production | |
|---|---|
| *Independent Variables* | *Dep. Var.* |
| | *AVG2* |
| Food imports (% of merchandise imports) | 0.33* |
| | (0.20) |
| Employment in agriculture (% of total employment) | 0.086 |
| | (0.095) |
| Health expenditure, public (% of GDP) | 1.46*** |
| | (0.48) |
| GDP per capita (current US$) | 0.00013* |
| | (0.000067) |
| Constant | -8.57** |
| | (3.50) |
| Observations | 44 |
| R-squared | 0.52 |
| ***, **, * denote significance @ α=0.01, 0.05, and 0.1 | |
| Standard errors reported in parentheses | |

The most consistently significant variable is public health expenditures as a percentage of GDP. Per capita GDP and the relative size of agricultural imports to all imports are significant as well, though occasionally not in regressions including more explanatory variables. A country's percentage employment is not significant in the reported results, but is nevertheless retained due to its significance in other tested specifications. Export, net trade, and tariff variables detailed in Appendix E are insignificant across specifications.

It is possible that some of the inconsistency in significance of explanatory variables could be the result of their weak correlations. It could also be that MRL strictness is not explained as well by an aggregated index. Finally, there is the consideration that some of the explanatory variables have weak explanatory power despite their emergence in the final specification.

### 3.2.1 Commodity-Level Regressions Using OLS

The second set of regressions analyzes the MRLs and trade data at a commodity-level. Results are reported in Table 2:

| **Table 3:** OLS With Commodity Level Production | | |
|---|---|---|
| *Independent Variables* | *Dependent Variable* | |
| | *AVG* | *MAX* |
| Production Dummy | -3.81** | -124.0* |
| | (1.91) | (66.71) |
| Food imports (% of merchandise imports) | 1.71** | 50.16** |
| | (0.70) | (24.28) |
| Employment in agriculture (% of total employment) | -0.14** | -5.02** |
| | (0.068) | (2.36) |
| Health expenditure, public (% of GDP) | 4.72*** | 127.9*** |
| | (0.38) | (13.14) |
| GDP per capita (current US$) | 0.00060*** | 0.019*** |
| | (0.000050) | (0.0017) |
| Constant | -4.92* | -55.29 |
| | (2.56) | (89.12) |
| Observations | 178 | 178 |
| R-squared | 0.58 | 0.48 |
| ***, **, * denote significance @ α=0.01, 0.05, and 0.1 | | |
| Standard errors reported in parentheses | | |

The final specification includes only one commodity-level variable, the dummy variable for production. Several specifications were estimated with variables representing the average tariff, weighted tariff, net trade for each commodity and sector, and the relative size of production to imports and exports. However, these variables all yielded insignificant results and are therefore excluded from the final specification.

The retained variables are significant across multiple specifications. It appears that countries possessing local production of the commodity and considerable employment in the agricultural sectors tend to have looser MRLs. Those countries importing a greater percent of agricultural goods, spending relatively more of their GDP on public health, and generating higher per capita incomes tended to have stricter MRLs.

### 3.2.3 MRL-Level Regressions Using Ordered Logit and Probit

The final set of regressions utilizes ordered logit and probit regressions for each commodity-pesticide combination in the data. Table 4 details the percentage of ordered logit regressions a regressor was found to be significant at the 5% level in from the entire sample of 1594 unique

MRLs matching each of the 73 countries. The table summarizes the results of 1594 regressions with 73 observations in each regression.[3]

| **Table 4:** Significant % of Ordered Logit Regressions with α=0.05, Full Sample | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0759 | 0.0176 | 0.9065 |
| Food exports (% of merchandise exports) | 0.0031 | 0.1066 | 0.8902 |
| Employment in agriculture (% of total employment) | 0.0107 | 0.0100 | 0.9793 |
| Health expenditure, public (% of GDP) | 0.4479 | 0.0151 | 0.5370 |
| GDP per capita (current US$) | 0.0075 | 0.0000 | 0.9925 |
| Tariff rate, applied, simple mean, all products (%) | 0.0314 | 0.1970 | 0.7716 |

None of the variables is consistently statistically significant and the models as a whole tend not to have significant explanatory power. Public health expenditure is most often significant, negatively so roughly 50% of the time. Despite their consistent insignificance, the variables for employment in agriculture and per capita GDP are retained in the reported specification due to their prior significance in the OLS regressions. Agricultural exports as a percentage of total exports and the mean tariff rate are included because of their higher than average, though still low, rate of significance.

Table 5 reduces the sample to pesticides monitored in the PDP. Table 6 further reduces the sample to pesticides monitored in the database and that were detected above the LOD (limit of detection) at least once. Each reduction in the sample should logically restrict the pesticide list to more important MRLs, as these are the pesticides actually being used and tested for.

| **Table 5:** Significant % of Ordered Logit Regressions with α=0.05, PDP Database | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0956 | 0.0102 | 0.8942 |
| Food exports (% of merchandise exports) | 0.0068 | 0.1195 | 0.8737 |
| Employment in agriculture (% of total employment) | 0.0171 | 0.0205 | 0.9625 |
| Health expenditure, public (% of GDP) | 0.5051 | 0.0034 | 0.4915 |
| GDP per capita (current US$) | 0.0034 | 0.0000 | 0.9966 |
| Tariff rate, applied, simple mean, all products (%) | 0.0614 | 0.2014 | 0.7372 |

[3] Results for the ordered probit regressions are not reported for brevity, but are almost identical with a margin of difference of one or two percentage points.

| **Table 6:** Significant % of Ordered Logit Regressions with α=0.05, Restricted PDP | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.1118 | 0.0197 | 0.8684 |
| Food exports (% of merchandise exports) | 0.0132 | 0.1447 | 0.8421 |
| Employment in agriculture (% of total employment) | 0.0263 | 0.0395 | 0.9342 |
| Health expenditure, public (% of GDP) | 0.5132 | 0.0000 | 0.4668 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0855 | 0.1645 | 0.7500 |

The percentage of significant observations increases for all variables as the samples are restricted to the more important pesticides, but the increase is typically small and only a few percent. This weak trend may reflect that pesticides seeing greater exposure would be easier to explain with the chosen explanatory variables.

To test for patterns specific to each commodity, the same procedure is repeated individually for the six commodities in the PDP (see Appendix F for results). The same patterns are present across all six commodities. Asparagus exhibited a particularly high percentage of regressions indicating the public health expenditure variable was significant, 87.5% of the sample for both the logit and probit regressions. Asparagus and strawberries had the highest percentage of regressions indicating the tariff variable was significant, 25% each for both sets of regressions. Once again the percentage of significant regressors tends to increase as the sample is restricted to pesticides that are more common and thus more likely to be closely regulated.

## 3.4 Interpretations

The most consistently significant explanatory variables across all specifications are public health expenditure, percentage of agricultural imports, GDP per capita, and percent employment in agriculture, in that order. Greater values of these first three variables explain stricter MRLs, while higher percent employment in agriculture reduces the strictness of MRLs. The production dummy variable in the commodity-level regressions is also significant with a positive value predicting looser MRLs.

The signs on the explanatory variables are as expected. Rich countries spending more on public health, importing more food, and possessing less local industry tend to enact stricter food regulations or MRLs. These findings support the identified hypotheses that MRL strictness depends on trade balances and/or production levels, richer countries prefer stricter MRLs because of health awareness and wealth effects, and that more important pesticides will have stricter MRLs.

With regards to the first hypothesis, it appears that the balance of trade and export levels are not major determinants of MRL strictness, though the amount of food imports and size of the local agricultural industry are significant. The significance of these variables favors a story of countries erecting strict MRLs to diminish food competition. However, variables representing a country's tariffs and duties don't consistently show significance in any of the regressions sets. Thus MRL strictness does not appear to be associated with any other protectionist behavior.

The breadth of the sampled data could be a detriment to this analysis. Many countries do not test for residues of pesticides that are no longer commonly used. As noted in the final set of regressions, restricting the sample from all available pesticides and fresh commodities to the more important pesticides and commodities increased the explanatory power of the model. It seems reasonable to assume that if a country is attempting to protect a market, it would only focus on commonly used pesticides rather than obsolete ones.

## 4 Conclusion

Trade protectionism has a long history as a topic of spirited debate. Economists tend to support free trade, but modern protectionist tools have "muddied the water" in the sense that it is becoming harder to tell which policies actually unfairly restrict trade. Even if a policy is trade restricting, it may still be justified. For example, a strict limit on imports with residues of a dangerous pesticide can save lives. This paper utilizes pairwise correlations between countries' MRLs and three types of regressions to identify the driving forces behind strict MRLs and test for systematic proof of protectionism in MRLs.

Results indicate MRLs are influenced by both protectionist and socioeconomic forces. The primary factors identified in the regression analysis are government health awareness, food imports, size of the local agricultural industry, and wealth.  It can be argued that the relationship between greater food imports and strict MRLs, particularly in countries' possessing some domestic production, is an indicator of protectionism.  However, MRLs also tend to reflect the health priorities of countries and their citizens ability to afford higher quality food.  If anything, MRLs appear to be what they are more out of bureaucratic convenience than out of protectionism.

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Appendix A:

| List of Regulated Pesticides | | | |
|---|---|---|---|
| 1,3-Dichloropropene | Dimethomorph | Indaziflam | Prohexadione calcium |
| 1-Naphthaleneacetamide | Dinotefuran | Indoxacarb | Propargite |
| 1-Naphthaleneacetic acid | Diphenylamine | Inorganic bromide* | Propiconazole |
| 2,4-D | Disulfoton | Iprodione | Propyzamide |
| Abamectin | Diuron | Isoxaben | Pymetrozine |
| Acequinocyl | Dodine | Kasugamycin | Pyraclostrobin |
| Acetamiprid | d-Phenothrin | Kresoxim-methyl | Pyraflufen-ethyl |
| Acifluorfen | Emamectin | Lambda Cyhalothrin | Pyrethrins |
| Aldicarb | Endosulfan | Linuron | Pyridaben |
| Aviglycine | EPTC | Malathion | Pyrimethanil |
| Azinphos-methyl | Esfenvalerate | Mancozeb | Pyriproxyfen |
| Azoxystrobin | Ethephon | Mandipropamid | Quinoxyfen |
| Benoxacor | Ethoxyquin | Maneb | Rimsulfuron |
| Beta-cyfluthrin | Etoxazole | Mepiquat chloride | Saflufenacil |
| Bifenazate | Famoxadone | Meptyldinocap | Sethoxydim |
| Bifenthrin | Fenamidone | Mesotrione | Simazine |
| Boscalid | Fenarimol | Metalaxyl | S-metolachlor |
| Bromacil | Fenbuconazole | Metaldehyde | Spinetoram |
| Buprofezin | Fenbutatin-oxide | Metconazole | Spinosad |
| Captan | Fenhexamid | Methanearsonic acid | Spirodiclofen |
| Carbaryl | Fenpropathrin | Methidathion | Spiromesifen |
| Carbon disulfide | Fenpyroximate | Methomyl | Spirotetramat |
| Carfentrazone-ethyl | Ferbam | Methoxyfenozide | Streptomycin |
| Chlorantraniliprole | Flonicamid | Metiram | Sulfentrazone |
| Chlorothalonil | Fluazifop-P-butyl | Metrafenone | Sulfur dioxide |
| Chlorpyrifos | Fluazinam | Metribuzin | Tebuconazole |
| Clethodim | Flubendiamide | Mevinphos | Tebufenozide |
| Clofentezine | Fludioxonil | Myclobutanil | Terbacil |
| Clopyralid | Flumioxazin | Naled | Tetraconazole |
| Clothianidin | Fluopicolide | Napropamide | Thiabendazole |
| Cryolite | Fluoxastrobin | Norflurazon | Thiacloprid |
| Cyazofamid | Fluroxypyr | Novaluron | Thiamethoxam |
| Cyfluthrin | Flutriafol | O-phenylphenol | Thiazopyr |
| Cymoxanil | Folpet | Oryzalin | Thiophanate-methyl |
| Cyprodinil | Forchlorfenuron | Oxamyl | Thiram |
| DCPA | Formetanate hydrochloride | Oxydemeton-methyl | Trifloxystrobin |
| Deltamethrin | Fosetyl-Al | Oxyfluorfen | Trifloxysulfuron |
| Diazinon | Gamma Cyhalothrin | Oxytetracycline | Triflumizole |
| Dicamba | Glufosinate-ammonium | Paraquat dichloride | Trifluralin |
| Dichlobenil | Glyphosate | Pendimethalin | Zeta-Cypermethrin |
| Dicloran | Halosulfuron-methyl | Penoxsulam | Zinc phosphide |
| Dicofol | Hexythiazox | Permethrin | Ziram |
| Difenoconazole | Hydrogen Cyanide | Phosmet | Zoxamide |
| Diflubenzuron | Imazalil | Phosphine | *resulting from fumigation with methyl bromide |
| Dimethoate | Imidacloprid | Piperonyl Butoxide | |

Appendix B:

| Country List | | | | | | | |
|---|---|---|---|---|---|---|---|
| US | Bermuda | Egypt | Hong Kong | Korea | Pakistan | South Africa | United Kingdom |
| Algeria | Brazil | El Salvador | India | Kuwait | Panama | Spain | Venezuela |
| Angola | Canada | Finland | Indonesia | Lebanon | Peru | Sweden | Vietnam |
| Argentina | Chile | France | Ireland | Malaysia | Philippines | Switzerland | |
| Australia | China | Fr. Pac. Islands | Israel | Mexico | Poland | Taiwan | |
| Bahamas | Colombia | Fr. West Indies | Italy | Netherlands | Portugal | Thailand | |
| Bahrain | Costa Rica | Germany | Jamaica | Neth. Ant. | Qatar | Trinidad Tobago | |
| Bangladesh | Denmark | Greece | Japan | New Zealand | Russia | Tunisia | |
| Barbados | Dom. Rep. | Guatemala | Jordan | Nicaragua | Saudi Arabia | Turkey | |
| Belgium | Ecuador | Honduras | Kenya | Oman | Singapore | UAE | |

| Country Groupings | | | |
|---|---|---|---|
| Codex | | EU | GCC |
| Algeria | Hong Kong | Belgium | Bahrain |
| Angola | Jordan | Denmark | Kuwait |
| Bahamas | Kenya | Finland | Oman |
| Bangladesh | Lebanon | France | Qatar |
| Barbados | Netherland Antilles | French Pacific Islands | Saudi Arabia |
| Bermuda | Nicaragua | French West Indies | |
| Colombia | Pakistan | Germany | |
| Costa Rica | Panama | Greece | |
| Dominican Republic | Peru | Ireland | |
| Ecuador | Philippines | Italy | |
| Egypt | Trinidad | Jamaica | West |
| El Salvador | Tunisia | Netherlands | Mexico |
| Guatemala | Venezuela | Poland | United States |
| | | Portugal | |
| | | Spain | |
| | | Sweden | |
| | | United Kingdom | |

Appendix C:

| Matching Commodities | | |
|---|---|---|
| MRL | | FAS |
| Apples | | Apples |
| Apricots | | Apricots |
| Asparagus | | Asparagus |
| Avocados | | Avocados |
| Cherries | | Cherries |
| Citrus | | Citrus, other |
| Grapefruit | | Grapefruit |
| Grapes | | Grapes |
| Lemons | | Lemons and Limes |
| Limes | | Oranges |
| Oranges | | Peaches and Nectarines |
| Peaches | | Pears |
| Nectarines | | Plums and Prunes |
| Pears | | Strawberries |
| Plums | | Tangerines and Mandarins |
| Strawberries | | |
| Tangerines | | |

## Appendix D:

Pairwise Correlations of Distinct MRL Sets

| | Codex | EU | US | Argent. | Austr. | Bahrain | Brazil | Canada | Chile | China | Hond. | India | Indon. | Israel | Japan | Korea | Malay. | NZ | Russia | Singap. | S. Africa | Switz. | Taiwan | Thailand | Turkey | UAE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EU | -0.0113 | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| US | -0.0338 | -0.0362 | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| Argent. | -0.0106 | -0.0181 | 0.1032 | 1 | | | | | | | | | | | | | | | | | | | | | | |
| Austr. | 0.0334 | -0.01 | 0.0258 | 0.0033 | 1 | | | | | | | | | | | | | | | | | | | | | |
| Bahrain | 0.0046 | 0.183 | -0.0088 | -0.0089 | -0.015 | 1 | | | | | | | | | | | | | | | | | | | | |
| Brazil | -0.0132 | -0.0206 | 0.0682 | 0.4815 | 0.0451 | -0.0167 | 1 | | | | | | | | | | | | | | | | | | | |
| Canada | 0.0516 | -0.0318 | 0.3895 | 0.1451 | 0.0069 | -0.0079 | 0.2906 | 1 | | | | | | | | | | | | | | | | | | |
| Chile | 0.1807 | 0.0559 | 0.0359 | -0.0067 | 0.045 | 0.1675 | -0.0144 | 0.0342 | 1 | | | | | | | | | | | | | | | | | |
| China | 0.0078 | 0.0568 | 0.0035 | -0.0072 | -0.0212 | 0.0653 | -0.0119 | 0.0077 | 0.0683 | 1 | | | | | | | | | | | | | | | | |
| Hond. | 0.178 | -0.0649 | 0.7107 | 0.1372 | -0.0229 | -0.039 | 0.0847 | 0.0339 | 0.0141 | -0.0343 | 1 | | | | | | | | | | | | | | | |
| India | 0.1872 | 0 | -0.0173 | -0.0041 | 0.0271 | 0.0286 | -0.002 | 0.0021 | 0.006 | 0.0479 | 0.0033 | 1 | | | | | | | | | | | | | | |
| Indon. | 0.3888 | 0.0512 | -0.0177 | -0.0092 | -0.0169 | 0.1046 | -0.0212 | -0.0002 | 0.061 | 0.0487 | 0.0541 | 0.0251 | 1 | | | | | | | | | | | | | |
| Israel | 0.1757 | -0.028 | -0.0161 | 0.0737 | 0.0193 | -0.0369 | 0.2621 | 0.0126 | 0.0014 | -0.0203 | 0.017 | 0.1076 | 0.0149 | 1 | | | | | | | | | | | | |
| Japan | 0.0064 | -0.0137 | 0.0158 | -0.0154 | -0.0084 | 0.0094 | 0.0437 | 0.0109 | 0.0308 | -0.0158 | 0.0211 | -0.0183 | -0.0172 | 0.0437 | 1 | | | | | | | | | | | |
| Korea | 0.0517 | 0.0695 | 0.0468 | -0.0157 | -0.024 | 0.0747 | 0.0326 | 0.066 | 0.1083 | 0.0863 | -0.0306 | 0.0421 | 0.0169 | 0.0607 | 0.0739 | 1 | | | | | | | | | | |
| Malay | 0.8402 | -0.0124 | 0.0423 | 0.3466 | 0.021 | 0.0126 | 0.1876 | 0.0849 | 0.1492 | 0.0141 | 0.2462 | 0.1511 | 0.3308 | 0.1941 | -0.0029 | 0.029 | 1 | | | | | | | | | |
| NZ | 0.0661 | -0.0309 | -0.0328 | -0.0171 | 0.0099 | -0.0197 | -0.0115 | -0.0103 | -0.0019 | 0.181 | -0.018 | 0.0213 | -0.0046 | 0.0167 | -0.0101 | 0.0048 | 0.0842 | 1 | | | | | | | | |
| Russia | 0.0143 | 0.1373 | 0.2272 | -0.0094 | -0.0035 | 0.0061 | -0.0074 | 0.1704 | 0.0233 | 0.1236 | -0.0088 | 0.0228 | 0.0442 | -0.0203 | -0.0156 | 0.1371 | 0.0075 | -0.0044 | 1 | | | | | | | |
| Singap. | 0.1959 | -0.0065 | -0.0226 | 0.001 | 0.01 | 0.0072 | -0.0079 | 0.0159 | 0.0464 | 0.0336 | 0.0022 | 0.0702 | 0.1309 | 0.0258 | 0.0059 | 0.0432 | 0.1605 | 0.0251 | -0.0034 | 1 | | | | | | |
| S. Africa | -0.1071 | 0.2883 | -0.0411 | -0.0197 | 0.0342 | 0.1033 | -0.0198 | -0.0316 | 0.0415 | 0.0404 | -0.0455 | -0.0321 | -0.0429 | -0.0596 | 0.0221 | 0.0866 | -0.1005 | -0.0361 | -0.0118 | -0.0361 | 1 | | | | | |
| Switz. | -0.0125 | 0.5392 | -0.0129 | 0.0932 | -0.0292 | -0.0321 | 0.0163 | -0.0191 | 0.0247 | 0.0378 | -0.0222 | -0.0014 | 0.1063 | -0.0015 | -0.0072 | 0.0558 | 0.0147 | -0.0177 | 0.1033 | -0.0017 | 0.22 | 1 | | | | |
| Taiwan | 0.0006 | 0.1039 | 0.0486 | -0.0038 | -0.0255 | 0.0775 | 0.0152 | -0.0087 | 0.0837 | 0.0812 | 0.0439 | -0.0134 | 0.0094 | 0.0575 | 0.0244 | 0.0653 | 0.0077 | -0.0209 | -0.0128 | -0.0066 | 0.1841 | 0.0389 | 1 | | | |
| Thailand | 0.9703 | 0.013 | -0.033 | -0.0063 | 0.0305 | 0.054 | -0.0139 | 0.0518 | 0.2064 | 0.0192 | 0.1681 | 0.1804 | 0.3821 | 0.1677 | 0.0031 | 0.0505 | 0.8145 | 0.0619 | 0.0134 | 0.1911 | -0.1071 | -0.0148 | -0.0015 | 1 | | |
| Turkey | -0.0365 | -0.0075 | 0.1082 | 0.6802 | 0.0067 | -0.0176 | 0.5143 | 0.1548 | -0.0073 | 0.0219 | 0.1425 | -0.0155 | -0.0055 | 0.0486 | -0.0174 | 0.0182 | 0.3646 | 0.0071 | 0.0223 | -0.0113 | -0.014 | 0.1187 | -0.0004 | -0.0362 | 1 | |
| UAE | 0.9602 | 0.003 | -0.034 | -0.0129 | 0.0342 | 0.0661 | -0.014 | 0.0538 | 0.197 | 0.0115 | 0.1604 | 0.1957 | 0.2704 | 0.1691 | 0.0078 | 0.0598 | 0.8063 | 0.0679 | 0.0169 | 0.2034 | -0.086 | -0.0136 | 0.005 | 0.9323 | -0.0382 | 1 |
| Vietnam | 0.697 | 0.0122 | -0.0358 | -0.0203 | 0.0464 | 0.0385 | -0.0159 | 0.0506 | 0.1993 | 0.0438 | 0.062 | 0.1781 | 0.3349 | 0.1498 | 0.0169 | 0.1362 | 0.577 | 0.0768 | 0.01 | 0.2058 | -0.1052 | 0.0053 | 0.0722 | 0.6768 | -0.0365 | 0.647 |

Appendix E:

| Tested Variables |
|---|
| Child employment in agriculture (% of economically active children ages 7-14) |
| Customs and other import duties (% of tax revenue) |
| Employment in agriculture (% of total employment) |
| Employment in industry (% of total employment) |
| Employment in services (% of total employment) |
| Exports by commodity (#) |
| Exports by commodity (% of total commodity exports) |
| Exports of goods and services (% of GDP) |
| Exports of goods and services (current US$) |
| Food exports (% of merchandise exports) |
| Food imports (% of merchandise imports) |
| GDP (current US$) |
| GDP per capita (current US$) |
| Health expenditure per capita (current US$) |
| Health expenditure, public (% of GDP) |
| Imports by commodity (#) |
| Imports by commodity (% of total commodity imports) |
| Imports of good and services (% of GDP) |
| Imports of good and services (current US$) |
| Net commodity trade (% if imports plus exports) |
| Net food trade (% of imports plus exports) |
| Net total trade (% of imports plus exports) |
| Production by commodity (#) |
| Production by commodity (% of total commodity production) |
| Tariff rate, applied, simple mean, all products (%) |
| Tariff rate, applied, weighted mean, all products (%) |

Appendix F:

| **Apples:** Significant % of Ordered Logit Regressions with α=0.05, Full Sample | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0982 | 0.0446 | 0.8571 |
| Food exports (% of merchandise exports) | 0.0179 | 0.1339 | 0.8482 |
| Employment in agriculture (% of total employment) | 0.0089 | 0.0179 | 0.9732 |
| Health expenditure, public (% of GDP) | 0.4464 | 0.0179 | 0.5357 |
| GDP per capita (current US$) | 0.0089 | 0.0000 | 0.9911 |
| Tariff rate, applied, simple mean, all products (%) | 0.0714 | 0.1339 | 0.7946 |

| **Apples:** Significant % of Ordered Logit Regressions with α=0.05, PDP Database | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.1167 | 0.0167 | 0.8667 |
| Food exports (% of merchandise exports) | 0.0167 | 0.1833 | 0.8000 |
| Employment in agriculture (% of total employment) | 0.0167 | 0.0333 | 0.9500 |
| Health expenditure, public (% of GDP) | 0.4833 | 0.0000 | 0.5167 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0833 | 0.1500 | 0.7667 |

| **Apples:** Significant % of Ordered Logit Regressions with α=0.05, Restricted PDP | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.1667 | 0.0278 | 0.8056 |
| Food exports (% of merchandise exports) | 0.0278 | 0.1944 | 0.7778 |
| Employment in agriculture (% of total employment) | 0.0278 | 0.0556 | 0.9167 |
| Health expenditure, public (% of GDP) | 0.4722 | 0.0000 | 0.5278 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.1111 | 0.1111 | 0.7778 |

Appendix F (continued):

| **Asparagus:** Significant % of Ordered Logit Regressions with α=0.05, Full Sample | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.1111 | 0.0000 | 0.8889 |
| Food exports (% of merchandise exports) | 0.0000 | 0.1111 | 0.8889 |
| Employment in agriculture (% of total employment) | 0.0444 | 0.0000 | 0.9556 |
| Health expenditure, public (% of GDP) | 0.5556 | 0.0000 | 0.4444 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0000 | 0.3333 | 0.6667 |

| **Asparagus:** Significant % of Ordered Logit Regressions with α=0.05, PDP Database | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.1667 | 0.0000 | 0.8333 |
| Food exports (% of merchandise exports) | 0.0000 | 0.1250 | 0.8750 |
| Employment in agriculture (% of total employment) | 0.0833 | 0.0000 | 0.9167 |
| Health expenditure, public (% of GDP) | 0.5417 | 0.0000 | 0.4583 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0000 | 0.2917 | 0.7083 |

| **Asparagus:** Significant % of Ordered Logit Regressions with α=0.05, Restricted PDP | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.2500 | 0.0000 | 0.7500 |
| Food exports (% of merchandise exports) | 0.0000 | 0.3750 | 0.6250 |
| Employment in agriculture (% of total employment) | 0.2500 | 0.0000 | 0.7500 |
| Health expenditure, public (% of GDP) | 0.8750 | 0.0000 | 0.1250 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0000 | 0.2500 | 0.7500 |

Appendix F (continued):

| **Grapes:** Significant % of Ordered Logit Regressions with α=0.05, Full Sample | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0893 | 0.0268 | 0.8839 |
| Food exports (% of merchandise exports) | 0.0000 | 0.0893 | 0.9107 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0268 | 0.9732 |
| Health expenditure, public (% of GDP) | 0.4107 | 0.0000 | 0.5893 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0536 | 0.1429 | 0.8036 |

| **Grapes:** Significant % of Ordered Logit Regressions with α=0.05, PDP Database | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0984 | 0.0328 | 0.8689 |
| Food exports (% of merchandise exports) | 0.0000 | 0.0656 | 0.9344 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0492 | 0.9508 |
| Health expenditure, public (% of GDP) | 0.4426 | 0.0000 | 0.5574 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0984 | 0.1803 | 0.7213 |

| **Grapes:** Significant % of Ordered Logit Regressions with α=0.05, Restricted PDP | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.1053 | 0.0526 | 0.8421 |
| Food exports (% of merchandise exports) | 0.0000 | 0.0789 | 0.9211 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0789 | 0.9211 |
| Health expenditure, public (% of GDP) | 0.3947 | 0.0000 | 0.6053 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.1316 | 0.1053 | 0.7632 |

Appendix F (continued):

| **Oranges:** Significant % of Ordered Logit Regressions with α=0.05, Full Sample | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0723 | 0.0000 | 0.9277 |
| Food exports (% of merchandise exports) | 0.0000 | 0.0843 | 0.9157 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0000 | 1.0000 |
| Health expenditure, public (% of GDP) | 0.5060 | 0.0120 | 0.4819 |
| GDP per capita (current US$) | 0.0120 | 0.0000 | 0.9880 |
| Tariff rate, applied, simple mean, all products (%) | 0.0482 | 0.2410 | 0.7108 |

| **Oranges:** Significant % of Ordered Logit Regressions with α=0.05, PDP Database | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0612 | 0.0000 | 0.9388 |
| Food exports (% of merchandise exports) | 0.0000 | 0.0612 | 0.9388 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0000 | 1.0000 |
| Health expenditure, public (% of GDP) | 0.4898 | 0.0204 | 0.4898 |
| GDP per capita (current US$) | 0.0204 | 0.0000 | 0.9796 |
| Tariff rate, applied, simple mean, all products (%) | 0.0612 | 0.1633 | 0.7755 |

| **Oranges:** Significant % of Ordered Logit Regressions with α=0.05, Restricted PDP | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0000 | 0.0000 | 1.0000 |
| Food exports (% of merchandise exports) | 0.0000 | 0.0000 | 1.0000 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0000 | 1.0000 |
| Health expenditure, public (% of GDP) | 0.4167 | 0.0000 | 0.5833 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0833 | 0.0833 | 0.8333 |

Appendix F (continued):

| **Pears:** Significant % of Ordered Logit Regressions with α=0.05, Full Sample | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0660 | 0.0189 | 0.9151 |
| Food exports (% of merchandise exports) | 0.0000 | 0.1415 | 0.8585 |
| Employment in agriculture (% of total employment) | 0.0283 | 0.0000 | 0.9717 |
| Health expenditure, public (% of GDP) | 0.4717 | 0.0189 | 0.5094 |
| GDP per capita (current US$) | 0.0094 | 0.0000 | 0.9906 |
| Tariff rate, applied, simple mean, all products (%) | 0.0283 | 0.1792 | 0.7925 |

| **Pears:** Significant % of Ordered Logit Regressions with α=0.05, PDP Database | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0909 | 0.0000 | 0.9091 |
| Food exports (% of merchandise exports) | 0.0000 | 0.2000 | 0.8000 |
| Employment in agriculture (% of total employment) | 0.0364 | 0.0000 | 0.9636 |
| Health expenditure, public (% of GDP) | 0.5636 | 0.0000 | 0.4364 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0182 | 0.2364 | 0.7455 |

| **Pears:** Significant % of Ordered Logit Regressions with α=0.05, Restricted PDP | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.1333 | 0.0000 | 0.8667 |
| Food exports (% of merchandise exports) | 0.0000 | 0.2667 | 0.7333 |
| Employment in agriculture (% of total employment) | 0.0333 | 0.0000 | 0.9667 |
| Health expenditure, public (% of GDP) | 0.7000 | 0.0000 | 0.3000 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0000 | 0.2333 | 0.7667 |

Appendix F (continued):

| **Strawberries:** Significant % of Ordered Logit Regressions with α=0.05, Full Sample | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0676 | 0.0000 | 0.9324 |
| Food exports (% of merchandise exports) | 0.0135 | 0.0405 | 0.9459 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0135 | 0.9865 |
| Health expenditure, public (% of GDP) | 0.5405 | 0.0000 | 0.4595 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0676 | 0.2973 | 0.6351 |

| **Strawberries:** Significant % of Ordered Logit Regressions with α=0.05, PDP Database | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0682 | 0.0000 | 0.9318 |
| Food exports (% of merchandise exports) | 0.0227 | 0.0682 | 0.9091 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0227 | 0.9773 |
| Health expenditure, public (% of GDP) | 0.4643 | 0.0000 | 0.5357 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.0682 | 0.2500 | 0.6818 |

| **Strawberries:** Significant % of Ordered Logit Regressions with α=0.05, Restricted PDP | | | |
|---|---|---|---|
| *Independent Variables* | *Significant* | | *Not Sig.* |
| | *(-)* | *(+)* | |
| Food imports (% of merchandise imports) | 0.0357 | 0.0000 | 0.9643 |
| Food exports (% of merchandise exports) | 0.0357 | 0.0357 | 0.9286 |
| Employment in agriculture (% of total employment) | 0.0000 | 0.0357 | 0.9643 |
| Health expenditure, public (% of GDP) | 0.4643 | 0.0000 | 0.5357 |
| GDP per capita (current US$) | 0.0000 | 0.0000 | 1.0000 |
| Tariff rate, applied, simple mean, all products (%) | 0.1071 | 0.2500 | 0.6429 |