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# The Impact of Quarantine Policies on the Quality of Imports

by

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**Abstract**

In a contribution to the sparse literature on the impacts on consumers of quarantine restrictions, an innovative approach to analysing the effects of these policies on the prices and quality of imported products is proposed. Specifically, various index number decompositions at different aggregation levels are considered for extracting quality changes from changes in the value of an imported good. Consistent with theory, an empirical application to mango imports for Australia reveals an increase in the quality of the imported bundle after the introduction of a new quarantine restriction. We believe this to the first empirical evidence of the quality impact of biosecurity restrictions on imports.

*Key words:* Quarantine, trade barriers, index numbers, quality change.
*JEL classification:* C43, Q18, Q57, F13, D40

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# 1 Introduction

The rapid increase in international trade volumes over recent decades has been perpetuated to a significant extent by the long-term reduction in traditional protectionist barriers to trade. For example, the effective rate of protection for even a relatively open trading country like Australia declined from over 30 per cent to under 5 per cent between 1970 and 2001 (Leigh, 2002). It has been argued that this decline in traditional forms of protectionist barriers has been replaced by an increase in the use of other measures, such as biosecurity restrictions as pseudo-tariff barriers. Indeed, this was part of the motivation for the 1994 World Trade Organization (WTO) agreement on Sanitary and Phytosanitary (SPS) measures. While the impacts of traditional barriers to trade have been studied extensively, the purpose of this paper is to analyse the effects of changes in biosecurity policy on international trade. Specifically, an empirical application examines the price and quality effects of changes to the quarantine restrictions for mango imports into Australia.

The shift from using tariff to non-tariff barriers to trade started to get more attention by economists in the 1980s, (e.g. Feenstra, 1984, 1988; Aw and Roberts, 1986). This was due to the increasing use by the United States of arrangements such as orderly marketing arrangements (OMAs) and voluntary export restraints (VERs). This led to the development of techniques to try and evaluate the economic impact of these barriers to trade. In particular, the OMAs and VERs were identified as the causes of substantial and rapid increases in prices of goods to consumers.

Earlier work by Falvey (1979) found that these non-tariff barriers to trade will lead to a substitution into more expensive export products by the exporting country. As OMAs and VERs were primarily directed at low-cost supplying countries, they tended to divert import demand to higher-cost non-controlled countries. These two effects combine to lead to increases in the average price of imported goods.

Aw and Roberts (1986) proposed the use of an index number method to separate out the different effects of non-tariff barriers on the value of import volumes. We adapt and extend the approach. Specifically, we are able to use the log-additive property of the Törnqvist

(1936) index number formula to obtain a more detailed decomposition than explored by Aw and Roberts. In addition, we check the robustness of this decomposition through the use of an alternative index number formula, the Fisher Ideal index (Fisher, 1922) and the decomposition proposed by Kohli (2003). Using historical dating of a quarantine policy change, it is possible to get interesting decompositions of the associated changes in trade volumes, including the contribution of quality change.

Drawing on the established trade literature, the following section describes the theoretical background for examining price and quality impacts of quarantine restrictions. In section 3, the Australian policy context is discussed, along with a description of the data set for mango imports. Section 4 presents a method for separating price and quality effects of trade restrictions with results reported from an empirical application to mango imports to Australia. Section 5 compares this decomposition to a Fisher index decomposition and section 6 concludes.

## 2 Theoretical Background

Alchian and Allen (1964) suggest that in the presence of approximately equal transport costs on different grades of the same good, consumers further away from a production location would receive a higher grade consumption bundle. This is the classic "shipping the good apples out" argument. This line of reasoning suggests that in the presence of equal additional charges (such as transport costs) on different grades of the same good, the higher grade good becomes relatively cheaper.[1]

Gould and Segall (1969) dispute this result and suggest that it only holds in the two commodity world. Borcherding and Silberberg (1978), however, prove that so long as the two goods are close substitutes, the original Alchain and Allan result holds in a variety of cases. Bauman (2003) generalises the Borcherding and Silberberg (1978) result to the n-

[1] A simple example from Alchian and Allan illustrates this point: "Suppose for example that a good apple costs 10 cents and a poor one costs 5 cents locally... we can say that a good apple costs two poor apples. Now suppose that it costs 5 cents to ship an apple east. Then in the east good apples cost 15 cents and poor apples 10 cents... two good apples now cost 3, not 4 poor apples."

good world, even when the two goods are not close substitutes. Further, it is generalised to include cases where transport costs involve the consumer travelling to the product; the empirical work of Bertonazzi, Maloney and McCormick (1993) demonstrates that tourists tend to purchase better seats at football games than locals.

While initially the premise discussed above was applied to the effect of transport costs, Borcherding and Silberberg (1978) note that this could apply to any per unit tax on comparable goods. Thus the substitution effects of per-unit tariffs could be studied using this framework. For example, Bureau, Ramos and Salvatici (2005) use this framework in analysing the effects of tariffs on beef exports to the European Union and find a bias in favour of countries which export high quality beef as the result of tariffs. However, the framework is designed to apply to a fixed cost that will be a higher proportion of an cheaper product. As such an ad valorem tariff does not fit this framework, but a specific tariff does (Falvey, 1979).

Falvey (1979) proposes that the framework can be used to explain the quality shifts as a result of quantitative restrictions. He notes that while much is made of exporters actively shifting to the higher quality product, the response is driven by demand. The reasoning is that quantitative restrictions are assumed to involve the purchase of one of a restricted number of import licences. As the licence is equal in cost for both the higher grade commodity and the lower grade, the "apples" argument discussed above holds as consumers are faced with equal per unit price increases on different grades of the same product. Consumers will demand the higher grade commodity in higher proportion as its relative price falls and thus the imported bundle increases in quantity.

In related empirical work, Aw and Roberts (1986) analysed of the effect of VERs on the composition of footwear imports to the United States over the period 1977–1981, specifically following the imposition of VERs on two low-cost suppliers, Taiwan and Korea.[2] A sizeable shift in quality over the life of the import restriction was found in the imports from the countries facing the restrictions. That is, Korea and Taiwan's export bundles increased in quality. Using hedonic regression techniques, Feenstra (1984, 1988) found similar improvements in

[2]Voluntary Export Restraints (VERs) are a quantitative restriction. They are usually considered as anything but voluntary.

quality for Japanese car imports into the US after the introduction of a quota constraint. Note that such hedonic regression techniques require detailed information on product characteristics, which are often unavailable for broad classes of products. Such is the typical case for agricultural products, making the Aw and Roberts approach more attractive for this context.[3]

Quarantine restrictions impose costs on exporting nations in order to ensure compliance. For example, a common quarantine requirement whereby exporters are required to inspect random packages of an agricultural commodity imposes a per unit cost that does not depend on the grade or quality of the item inspected. However, to our knowledge, the price and quality change effects of quarantine restrictions have not been assessed with the same rigour as other trade restrictions. Thus, this paper aims provide an empirical assessment to fill this notable gap in the international trade literature.

# 3 Australian Quarantine Policy and Data

The World Trade Organisation (1994) Sanitary (animal and human) and Phytosanitary (plant) (SPS) agreement requires its members to adhere to stringent standards in the application of quarantine measures on imports. While the agreement recognises the autonomy of its members and the place of quarantine policy in border protection, it requires these quarantine measures to be scientific and justifiable. The Nairn Report (1996) on Australian quarantine policy echoed these sentiments and signified a domestic policy shift towards the principles outlined in the SPS agreement. While the discussion in Bunting (2009) suggests that the application of these policies has been mixed, there has been significant attention given to scientific risk review since the report's release.

Mango quarantine policies, contrary to the expected result of the new regulations, became more intensive. On the 14th of September 1996, the Australian government banned imports

[3]A characteristic which would be of interest in the current context of considering quality change of an agricultural product would be whether or not the imports are classified as organic. Unfortunately, this information is not available.

of fresh mangoes from Fiji. Two days later, the ban was extended to imports of mangoes from India. Fresh mango fruit was imported in large quantities at that time from India, Philippines, Fiji and Mexico. The common treatment for pests such as fruit fly for arriving mangoes was ethylene dibromide. Fears for the safety of Australian workers handling this treated fruit resulted in a ban on this treatment. Countries wishing to export fruit to Australia were required to use the more costly Vapour Heat Treatment (VHT). The result of this change in policy was the cessation of exports to Australia by India and Fiji of fresh mangoes and the temporary withdrawal of Philippine fresh mango fruit.

The data set for this paper is an exhaustive list of all imports of mangoes (fresh and dried) to Australia by month over the period $1991 - 2005$, covering years pre- and post-policy change. From this, the largest exporters only have been chosen, these being the Philippines, Mexico, Thailand, Fiji and India.[4] Data were provided with no breakdown of whether a consignment was fresh or dried. The data were subsequently sorted into fresh and dried imports based on importing patterns, country of origin and price, and aggregated to annual terms in order to abstract from seasonal fluctuations.[5]

Table 1 presents the import quantities by class (fresh or dried) and source country, in kilograms. It can be seen that the new regulations effectively removed fresh mango imports from Fiji and India, as well as the Philippines for most years following the policy change. In addition, there is a significant reduction in imports of fresh mangoes from Mexico for several years, coincident with a large increase in imports of dried mangoes, which were not directly affected by the new quarantine policy. Quantity shares by country for fresh and dried mango imports are plotted in figures 1 and 2, respectively. From figure 1 it can be seen that Mexico had around 40% of the fresh mango import market in 1991, but dominates the market following the introduction of the quarantine restrictions. From figure 2 we can see

[4]The other twenty nations in the data set contribute less than 1 per cent of total imports over the period.

[5]The data were purchased from the Australian Bureau of Statistics. Imports from Thailand could be classified as dried as Thailand is unable to export fresh mangoes to Australia. Dried mangoes from Mexico were shipped through processors in the U.S. Filipino mangoes followed a very straightforward seasonal pattern allowing easy classification. Data covering a longer period would risk having the effect of the discrete policy change considered here being diluted by other policies, as well as by longer term market and environmental conditions.

Table 1: Import Quantities by Class and Source: Kilograms

| | Fresh | | | | Dried | | |
|---|---|---|---|---|---|---|---|
| Year | Fiji | India | Philippines | Mexico | Philippines | Thailand | Mexico |
| 1991 | 36,742 | 714 | 161,536 | 136,802 | 1,502 | 10,597 | 36,543 |
| 1992 | 19,280 | 2,409 | 145,947 | 76,294 | 1,860 | 12,262 | 24,740 |
| 1993 | 10,326 | 9,195 | 134,878 | 143,332 | 480 | 17,540 | 48,821 |
| 1994 | 12,887 | 10,978 | 74,950 | 173,315 | 2,230 | 5,853 | 71,258 |
| 1995 | 11,794 | 15,594 | 111,924 | 89,973 | 273 | 22,165 | 69,539 |
| 1996 | 551 | 10,987 | 24,355 | 257,375 | 2,520 | 14,103 | 189,624 |
| 1997 | 235 | 6,532 | 45,940 | 107,657 | 2,500 | 28,104 | 133,522 |
| 1998 | 32 | 0 | 0 | 49,961 | 1,000 | 27,235 | 109,397 |
| 1999 | 0 | 0 | 0 | 58,280 | 2,304 | 44,620 | 58,324 |
| 2000 | 0 | 0 | 1,102 | 26,390 | 600 | 50,154 | 114,504 |
| 2001 | 0 | 0 | 0 | 9,700 | 3,166 | 80,263 | 51,310 |
| 2002 | 0 | 0 | 24,252 | 34,554 | 2,078 | 69,994 | 40,085 |
| 2003 | 0 | 0 | 0 | 134,295 | 5,815 | 76,399 | 108,076 |
| 2004 | 0 | 0 | 0 | 139,837 | 4,326 | 270,012 | 223,664 |
| 2005 | 0 | 0 | 0 | 175,473 | 6,683 | 389,223 | 124,915 |

that although fresh imports from the Philippines effectively disappeared (besides attempts to re-enter the market in 2000 and 2002), the Philippine's share of dried mango imports remained small and relatively stable. Mexico's share of dried mango imports fell, while becoming the dominant import supplier of fresh mangoes.

# 4 Method and Empirical Estimates

We begin by defining two indexes of price change. The first is the unit value index between periods $t-1$ and $t$, $P_U^{t-1,t}$, which is the period $t$ average price divided by the period $t-1$ average price:

$$P_U^{t-1,t} = \frac{V^t/Q^t}{V^{t-1}/Q^{t-1}}, \tag{1}$$

where $V^t$ is the value of goods for period $t$, $Q^t$ is the corresponding quantity of goods, and $V^{t-1}$ and $Q^{t-1}$ are similarly defined for period $t-1$.

The second price index is the Törnqvist (1936) index, $P_T^{t-1,t}$, which in logarithmic form

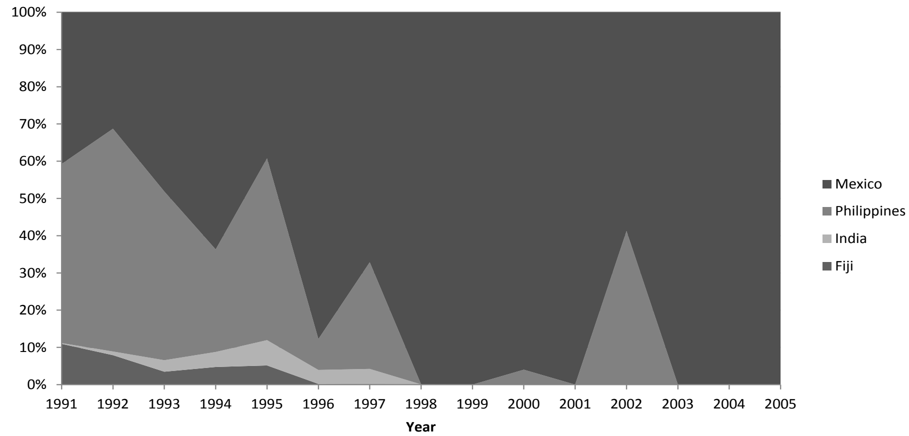


Figure 1: Import Quantity Shares by Source Country, Fresh Mangoes

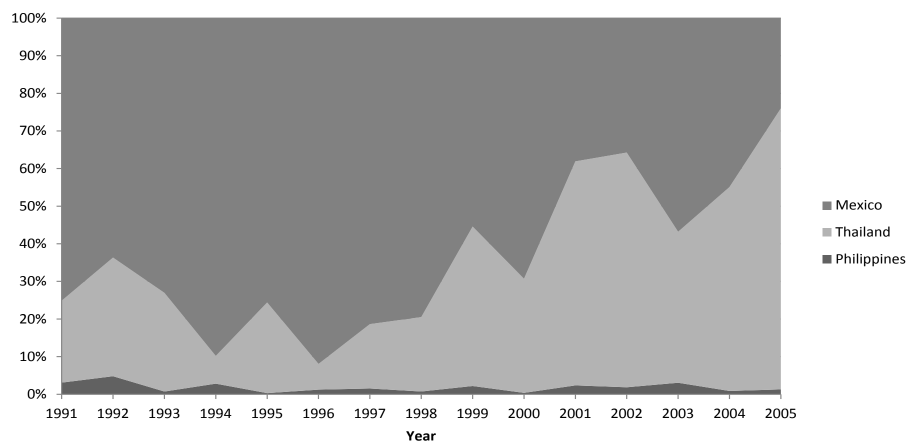


Figure 2: Import Quantity Shares by Source Country, Dried Mangoes

can be written as follows:

$$\ln P_T^{t-1,t} = \frac{1}{2}\sum_{i=1}^{N}(s_i^t + s_i^{t-1})\ln(p_i^t/p_i^{t-1}) \qquad (2)$$

where $p_i^t$ is the price of good $i = 1, \ldots, N$ in period $t$, $s_i^t = p_i^t q_i^t / \sum_i p_i^t q_i^t$ is the period $t$ value share of good $i$, and $p_i^{t-1}$ and $s_i^{t-1}$ are the corresponding prices and shares for period $t-1$, respectively.

Consider the following value change decomposition:

$$V^{t-1,t} = V^t/V^{t-1} = C^{t-1,t} \cdot P_T^{t-1,t} \cdot Q^{t-1,t}. \tag{3}$$

In equation (3), $V^t$ is the value of trade for period $t$, $P_T^{t,t-1}$ is the Törnqvist price index from (2), $Q^{t-1,t} = Q^t/Q^{t-1}$ where $Q^t$ is the trade volume in period $t$ and $C^{t-1,t}$ is an index of quality change. Note that $Q^t = \sum_i q_i^t$ is an aggregate measure of trade which simply adds physical units, regardless of quality. This introduces a bias term so that the product of the quantity index $Q^{t-1,t}$ and the price index $P_T^{t-1,t}$ do not exactly equal the value change index $V^t/V^{t-1}$. This is due to substitution effects between products that are not captured by the simple index, $Q^{t-1,t}$. Hence the "quality change" index, $C^{t-1,t}$, which is determined residually using (3) as follows:

$$C^{t-1,t} \equiv \frac{V^{t-1,t}/Q^{t-1,t}}{P_T^{t-1,t}} = \frac{P_U^{t-1,t}}{P_T^{t-1,t}} \tag{4}$$

Thus, using $C^{t-1,t}$ from (4), the value change in (3) equals the Törnqvist price index, $P_T^{t-1,t}$ times quality-adjusted quantity change, $C^{t-1,t} \cdot Q^{t-1,t}$. That is, the trade value may change between periods with no actual change in prices or volumes, but with a substitution towards high-priced suppliers.

Aw and Roberts divided both sides of (3) by the quantity index $Q^{t-1,t}$ to get a decomposition of the unit value index of (1) into quality and Törnqvist price index terms. However the decomposition in (3) suggests an extension of this technique. The log-additive property of the Törnqvist index allows for a further decomposition of (3) beyond that considered by Aw and Roberts. Specifically, as is clear from (2), $P_T^{t-1,t}$ can be decomposed into indexes of individual price component contributions.

The results from applying the decomposition in (3) to our data set are presented in table 2. Fresh and dried mangoes are treated as distinct goods, as are the goods from each country, so that $i = 1, \ldots, N$ indexes all goods from all the sample countries; for example dried mangoes from India are treated as a separate good from fresh mangoes from India, and similarly for fresh Indian mangoes versus fresh Mexican mangoes.[6] As there are two types of mango and five countries in the sample, $N = 10$. Note that the results are in index form, so that subtracting one and multiplying by 100 gives percentage changes. Thus an index value greater than one indicates positive growth, while a value less than one represents negative growth.

From table 2, it can be seen that eight of the fourteen years had positive quality changes, i.e. a value of $C^{t-1,t}$ greater than one. Looking further, it is clear that the most notable quality increases came immediately after the quarantine regulation was imposed in 1996, with a 21% increase in 1997. The import bundles for 1999, 2001 and to a lesser extent 1998 also demonstrate sizeable positive changes in quality. Thus it seems that in response to an equal appreciation in the unit prices of goods of differing qualities, consumers have shifted their consumption to the higher quality bundle as the relative prices have changed, as predicted by theory.

Further, it can be seen that this result is in opposition to a trend toward demand for lower quality import bundles that prevailed prior to the imposition of this policy change, possibly due to falling transport costs. Figure 3 presents an alternative view of the results from table 2. Specifically, it plots the cummulative indexes, so that each year's observation shows the growth over the period since 1991 up to that year. First note that column two divided by column four of table 2 yields the unit value index of equation 1. The unit value change is alternatively the product of the Törnqvist price index and the quality change index, as can be seen from a rearrangement of equation (4). From figure 3, it can be seen that over the period $1997 - 2001$ there has been a significant increase in the unit value price index. This is driven by an appreciation in the Törnqvist index, which means that the individual components of the bundle have appreciated in price, and this effect is magnified by the

[6] We note that for fresh mangos, due to the change in quarantine policy, the data set has the "new and disappearing goods" problem that is typical of detailed data sets of consumer goods. Here, the price relative $(p_i^t/p_i^{t-1})$ in equation (2) is set equal to one if there is no observation on imports from a country in one of the adjacent periods. As will be seen from table 3, when considering dried mangos which do not have this problem, and table 4, when considering disaggregate results for Mexico which is represented in both fresh and dried mango imports in every sample period, the qualitative conclusions regarding quality change are consistent whether or not there are new and disappearing goods in the analysis.

Table 2: Value Change Decomposition, Mango Imports, Törnqvist Price Index

| Year | $V^{t-1,t}$ | $C^{t-1,t}$ | $Q^{t-1,t}$ | $P_T^{t-1,t}$ | $\tilde{P}_{TF}^{t-1}$ | $\tilde{P}_{TD}^{t-1}$ |
|---|---|---|---|---|---|---|
| 1992 | 0.739 | 1.039 | 0.736 | 0.966 | 0.978 | 0.988 |
| 1993 | 1.116 | 0.989 | 1.289 | 0.875 | 0.877 | 0.998 |
| 1994 | 0.822 | 0.916 | 0.964 | 0.930 | 0.990 | 0.940 |
| 1995 | 1.111 | 1.117 | 0.914 | 1.088 | 1.100 | 0.989 |
| 1996 | 1.235 | 0.817 | 1.555 | 0.972 | 0.918 | 1.059 |
| 1997 | 0.853 | 1.211 | 0.650 | 1.084 | 1.053 | 1.029 |
| 1998 | 0.744 | 1.032 | 0.578 | 1.247 | 1.087 | 1.147 |
| 1999 | 0.768 | 1.099 | 0.872 | 0.801 | 0.914 | 0.877 |
| 2000 | 1.297 | 0.991 | 1.179 | 1.111 | 1.056 | 1.052 |
| 2001 | 0.976 | 1.257 | 0.749 | 1.036 | 1.055 | 0.982 |
| 2002 | 1.224 | 0.938 | 1.184 | 1.102 | 0.943 | 1.168 |
| 2003 | 1.278 | 0.831 | 1.899 | 0.809 | 0.977 | 0.828 |
| 2004 | 1.993 | 1.075 | 1.965 | 0.944 | 1.118 | 0.844 |
| 2005 | 1.161 | 1.054 | 1.092 | 1.009 | 0.963 | 1.048 |
| Geometric Means | | | | | | |
| 1992-2005 | 1.054 | 1.019 | 1.043 | 0.991 | 0.999 | 0.991 |
| 1992-1996 | 0.986 | 0.970 | 1.054 | 0.964 | 0.970 | 0.994 |
| 1997-2001 | 0.908 | 1.114 | 0.780 | 1.045 | 1.031 | 1.013 |
| 2002-2005 | 1.379 | 0.970 | 1.482 | 0.960 | 0.998 | 0.962 |

Notes: $V^{t-1,t}$, is the value change index for mangoes, $Q^{t-1,t}$ is the quantity index and $C^{t-1,t}$ is the quality index. $P_T^{t-1,t}$ is the Törnqvist price index of (2), and $\tilde{P}_{TF}^{t-1,t} \times \tilde{P}_{TD}^{t-1,t} = P_T^{t-1,t}$ from (5), where F denotes fresh and D denotes dried.

appreciation in quality. So not only have importers switched to a higher quality bundle, but the individual components of the bundle have increased in price during the post-quarantine period.

As can be seen from the geometric means in table 2 for the period 1992 to 1996, which is prior to the introduction of the new quarantine regulations, it is clear that there is an overall decrease in the quality of the imported bundle; the quality change index was 0.970 on average over this period, indicating a fall in quality of around 3% per year from 1991. However, in the period 1997 – 2001, there is evidence of a sharp appreciation in quality,

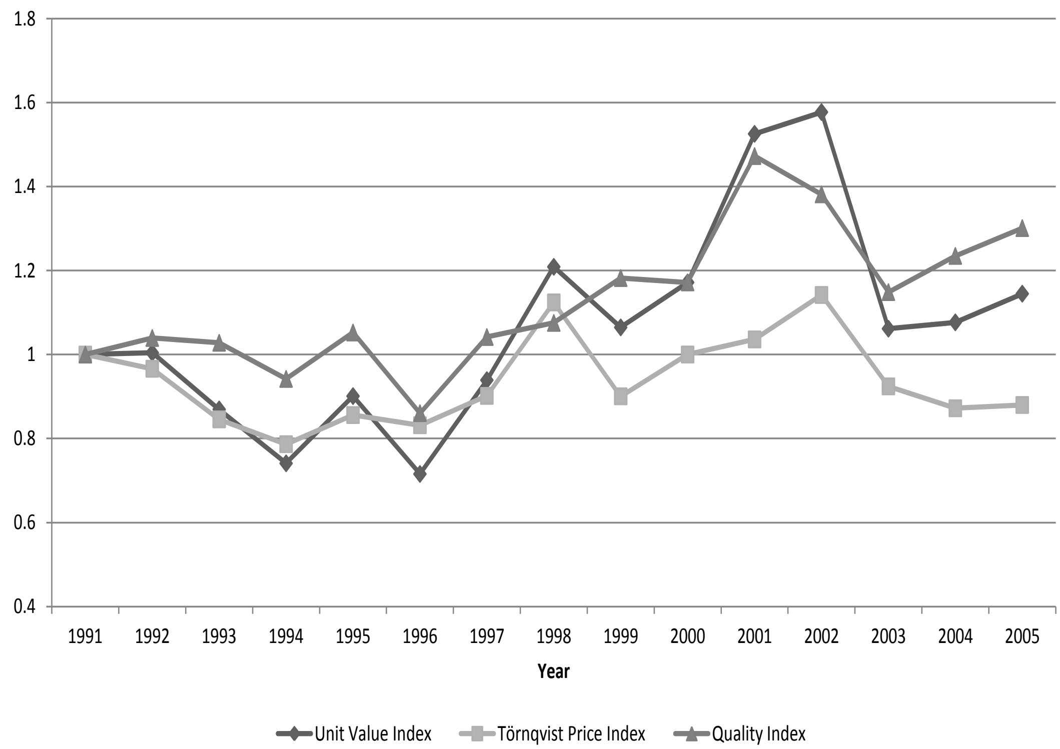


Figure 3: Cummulated Price and Quality Indexes

with an average increase of more than 11%. Finally, from 2002 − 2005, there is an average annual decline in quality of of around 3%, driven by the declines in quality in 2002 and 2003. These declines were recovered in the following two years, so that from figure 1 we can see that quality has increased by 30% over the sample, and by more than 50% since 1996 when the quarantine restriction was introduced.

The deterioration in quality for 2002 and 2003 may be the most difficult result to explain. Although the Philippines recommenced exporting fresh mangoes to Australia in 2002, no new regulation was introduced in this period. However, it could be hypothesized that the effect of this quarantine regulation would not continue to increase the quality of the bundle in perpetuity. The bundle would adjust over a period of time and then reach its peak. Following the peak, the effect of reductions in transport costs may again become influential.

In an extension of the approach of Aw and Roberts, a final set of results in table 2 derive from the property of the Törnqvist index that allows it to be easily disaggregated into its various components. In this case, partial Törnqvist indexes for fresh and dried mangoes are calculated to determine whether individual product groups are responsible for this result or whether it is a product-wide effect. From equation (2), we can write

$$P_T^{t-1,t} = \tilde{P}_{TF}^{t-1,t} \cdot \tilde{P}_{TD}^{t-1,t} \tag{5}$$

where $\tilde{P}_{Tn}^{t-1,t} = \exp[(1/2)\sum_{j=1}^{M}(s_{nj}^t + s_{nj}^{t-1})\ln(p_{nj}^t/p_{nj}^{t-1}]$ for $n = F, D$, where shares are calculated over all goods, $s_{nj}^t = p_{nj}^t q_{nj}^t / \sum_{i=1}^{N} p_i^t q_i^t$, so that $\tilde{P}_{TF}^{t-1,t}$ is a partial index which gives the contribution of fresh mango prices to the aggregate price index and $\tilde{P}_{TD}^{t-1,t}$ is similarly the contribution from dried mango prices. As there are five countries in our sample, $M = 5$.

From the last two columns in table 2 we see the results from decomposing the Törnqvist price index, $P_T^{t-1,t}$, into the two partial indexes as in equation (5). For the period 1997-2001, it can be seen that the price increases in fresh mangos was driving the aggregate increase in prices; aggregate prices increased 4.5%, with the contribution of fresh mango prices being 3.1%, i.e. $3.1/4.5 \approx 70\%$ of the total price change. That is, the use of this more detailed decomposition tells us which goods contributed most to price changes, and as such is potentially a very useful extension in a variety of policy contexts. Indeed, here we find that it is the good which is subject to the new quarantine policy which is driving the aggregate price change in mango imports.

In table 3 we consider treating each category of mango (fresh and dried) separately. The quarantine restriction only applies to fresh mangoes, so while there are implications for the broad class of mango imports (as the unprocessed product is the same) it is also of interest to consider treating fresh and dried mangoes as completely separate products. The Törnqvist price indexes for fresh and dried mangoes, $P_{TF}^{t-1,t}$ and $P_{TD}^{t-1,t}$ respectively, have the same form as in the partial indexes in (5), but with the shares defined only over the respective category of goods; that is $s_k^t = p_k^t q_k^t / \sum_{k=1}^{K} p_k^t q_k^t$ so that $\sum_k^K s_k = 1$ for each of the categories, fresh and dried.

From the quantity index $Q_F^{t-1,t}$ in table 3 we can note that there was a substantial decrease in the quantity of fresh mango imports in the period $1997 - 2001$, with an average fall of

Table 3: Decomposition of Value Change by Mango Class, Törnqvist Price Index

| | Fresh | | | | Dried | | | |
|---|---|---|---|---|---|---|---|---|
| Year | $V_F^{t-1,t}$ | $C_F^{t-1,t}$ | $Q_F^{t-1,t}$ | $P_{TF}^{t-1,t}$ | $V_D^{t-1,t}$ | $C_D^{t-1,t}$ | $Q_D^{t-1,t}$ | $P_{TD}^{t-1,t}$ |
| 1992 | 0.728 | 1.030 | 0.726 | 0.973 | 0.790 | 1.057 | 0.799 | 0.936 |
| 1993 | 1.029 | 0.997 | 1.221 | 0.846 | 1.496 | 0.877 | 1.720 | 0.991 |
| 1994 | 0.820 | 0.909 | 0.914 | 0.987 | 0.827 | 0.894 | 1.187 | 0.779 |
| 1995 | 1.074 | 1.121 | 0.843 | 1.137 | 1.222 | 1.097 | 1.159 | 0.961 |
| 1996 | 0.836 | 0.771 | 1.279 | 0.847 | 2.288 | 0.875 | 2.242 | 1.166 |
| 1997 | 0.743 | 1.216 | 0.547 | 1.117 | 0.958 | 1.142 | 0.796 | 1.054 |
| 1998 | 0.366 | 0.876 | 0.312 | 1.339 | 1.027 | 1.002 | 0.839 | 1.222 |
| 1999 | 0.756 | 1.000 | 1.166 | 0.649 | 0.771 | 1.190 | 0.765 | 0.847 |
| 2000 | 0.724 | 1.100 | 0.472 | 1.395 | 1.447 | 0.867 | 1.570 | 1.063 |
| 2001 | 0.605 | 0.959 | 0.353 | 1.790 | 1.024 | 1.280 | 0.815 | 0.981 |
| 2002 | 4.044 | 1.068 | 6.062 | 0.625 | 1.006 | 1.006 | 0.832 | 1.202 |
| 2003 | 1.607 | 0.764 | 2.284 | 0.921 | 1.176 | 0.896 | 1.697 | 0.773 |
| 2004 | 1.582 | 1.000 | 1.041 | 1.520 | 2.167 | 1.043 | 2.617 | 0.794 |
| 2005 | 1.063 | 1.000 | 1.255 | 0.847 | 1.191 | 1.072 | 1.046 | 1.062 |
| Geometric Means | | | | | | | | |
| 1992-2005 | 0.957 | 0.979 | 0.955 | 1.024 | 1.173 | 1.014 | 1.185 | 0.977 |
| 1992-1996 | 0.888 | 0.958 | 0.973 | 0.952 | 1.223 | 0.955 | 1.335 | 0.959 |
| 1997-2001 | 0.618 | 1.024 | 0.506 | 1.194 | 1.023 | 1.086 | 0.918 | 1.026 |
| 2002-2005 | 1.818 | 0.951 | 2.062 | 0.928 | 1.322 | 1.002 | 1.402 | 0.941 |

Notes: $V_n^{t-1,t}$, $n = F, D$, is the value change index for where $F$ denotes fresh mangoes and $D$ denotes dried mangoes. Similarly for the quantity change indexes, $Q_n^{t-1,t}$ and the quality change indexes $C_n^{t-1,t}$. The price indexes $P_{Tn}^{t-1,t}$ are Törnqvist indexes.

almost 50% and falls in excess of 50% in each of 1998, 2000 and 2001. Over the same period there were also falls in the quantity index for dried mango imports, $Q_D^{t-1,t}$, but not of the same magnitude.[7] At the same time, prices for fresh mangoes rose by an annual average of 19.4% and quality rose by an average of 2.4%. The price of dried mangoes rose by an annual average of 2.6% while quality rose by an average of 8.6%. In the subsequent period, 2002-2005, the price of dried mangoes fell with almost no change in quality, while the price of fresh mangoes fell by an average of 7% and quality fell by 5%.[8]

[7] See table 1 and figures 1 and 2 for further details.

[8] As can be seen from tables 2 and 3, the year-on-year series can be quite variable. As in all analyses of

Table 4: Decomposition of Value Change by Country of Origin, Törnqvist Price Index

| | Mexico | | | | Philippines | | | |
|---|---|---|---|---|---|---|---|---|
| Year | $V_M^{t-1,t}$ | $C_M^{t-1,t}$ | $Q_M^{t-1,t}$ | $P_{TM}^{t-1,t}$ | $V_P^{t-1,t}$ | $C_P^{t-1,t}$ | $Q_P^{t-1,t}$ | $P_{TP}^{t-1,t}$ |
| 1992 | 0.537 | 0.952 | 0.583 | 0.967 | 0.924 | 1.009 | 0.907 | 1.010 |
| 1993 | 1.588 | 0.900 | 1.902 | 0.928 | 0.775 | 0.917 | 0.916 | 0.923 |
| 1994 | 0.934 | 0.862 | 1.273 | 0.851 | 0.772 | 1.206 | 0.570 | 1.122 |
| 1995 | 0.851 | 1.146 | 0.652 | 1.139 | 1.255 | 0.914 | 1.454 | 0.944 |
| 1996 | 2.287 | 0.923 | 2.802 | 0.884 | 0.351 | 1.323 | 0.240 | 1.108 |
| 1997 | 0.640 | 1.055 | 0.540 | 1.125 | 1.530 | 0.872 | 1.802 | 0.973 |
| 1998 | 0.935 | 1.123 | 0.661 | 1.260 | 0.074 | 3.086 | 0.021 | 1.161 |
| 1999 | 0.542 | 0.895 | 0.732 | 0.827 | 1.857 | 0.813 | 2.304 | 0.992 |
| 2000 | 1.296 | 1.034 | 1.208 | 1.037 | 0.690 | 0.936 | 0.739 | 0.997 |
| 2001 | 0.589 | 1.196 | 0.433 | 1.137 | 1.726 | 0.931 | 1.860 | 0.997 |
| 2002 | 1.087 | 0.921 | 1.223 | 0.966 | 4.174 | 0.540 | 8.317 | 0.930 |
| 2003 | 2.656 | 0.892 | 3.247 | 0.917 | 0.332 | 1.439 | 0.221 | 1.043 |
| 2004 | 1.677 | 1.053 | 1.500 | 1.062 | 0.770 | 1.034 | 0.744 | 1.001 |
| 2005 | 0.895 | 1.046 | 0.826 | 1.035 | 1.878 | 1.211 | 1.545 | 1.004 |
| Geometric Means | | | | | | | | |
| 1992-2005 | 1.037 | 0.995 | 1.040 | 1.003 | 0.860 | 1.068 | 0.796 | 1.012 |
| 1992-1996 | 1.091 | 0.952 | 1.209 | 0.949 | 0.754 | 1.062 | 0.697 | 1.018 |
| 1997-2001 | 0.756 | 1.056 | 0.672 | 1.067 | 0.758 | 1.138 | 0.652 | 1.022 |
| 2002-2005 | 1.443 | 0.975 | 1.490 | 0.993 | 1.189 | 0.993 | 1.205 | 0.994 |

Notes: $V_n^{t-1,t}$, $n = M, P$, is the value change index for where $M$ denotes Mexican mangoes and $P$ denotes Filipino mangoes. Similarly for the quantity change indexes, $Q_n^{t-1,t}$ and the quality change indexes $C_n^{t-1,t}$. The price indexes $P_{Tn}^{t-1,t}$ are Törnqvist indexes.

Table 3 shows that each of the individual subcategories of mangoes follow the same pattern as in table 2. That is, a general quality decline in the pre-quarantine period, and a quality increase in the five years period 1997-2001 after the change in quarantine policy.

Table 4 presents results from looking at two countries separately, both of which had a presence in both mango import categories and were represented in the total import bundle throughout the sample period: Mexico and the Philippines. It is clear that there is a definite

an agricultural commodity, flux is inherent due to temporary environmental factors such as weather; this can complicate the interpretation of the possible effects of policy changes. Use of multi-year averages should mitigate such problems of interpretation.

trend towards increased quality in the period following the imposition of the regulation for both countries. After a one year lagged effect, the response of quality change for the Philippines in 1998 is extremely large; a 300% increase in quality, associated with a 98% fall in quantity due to the introduction of the quarantine restriction. Even with a slight general decline in import bundle quality from Mexico over the sample, there is evidence of increased quality over the period $1997 - 2001$. This is a further demonstration of the effect of quarantine policies on the quality of the import bundle, which has been shown to hold at different levels of aggregation.

## 5 A Fisher Index Decomposition

Key in the results in the previous section is the use of the Törnqvist index formula. To explore whether our results are simply an artefact of the index formula used, we consider a different index and related decomposition as a means of sensitivity testing. Specifically, we consider the Fisher (1922) Ideal index, which has been shown to have many desirable properties; see Fisher (1922) and Diewert (1976, 1992).

The Törnqvist index has a simple and natural disaggregation that was exploited in the above analysis. As shown in Reinsdorf, Diewert and Ehmann (2002), Kohli (2003), Balk (2004), and Hallerbach (2005), the Fisher index has no corresponding unique decomposition, and there is no consensus on the appropriate decomposition; Dumagan (2002) argues that use of the Fisher index is inappropriate in a setting where index aggregation and disaggregation is required.

This section follows the elegant but little-known decomposition method of Kohli (2003) who demonstrates that the Fisher index can in fact be decomposed in a similar manner to the Törnqvist index when calculated as a geometric mean of its components. The Fisher index thus has a decomposition which is simple and very similar to the Törnqvist decomposition of section 4.

As in section 4 we consider decomposing value change:

$$V^{t-1,t} = V^t/V^{t-1} = \mathcal{C}^{t-1,t} \cdot \mathcal{P}_F^{t-1,t} \cdot Q^{t-1,t}, \tag{6}$$

where $V^{t-1,t}$ is an index of value change, $\mathcal{C}^{t-1,t}$ is an index of quality change, $Q^{t-1,t}$ is the same index of quantity change as in (3), and $\mathcal{P}_F^{t-1,t}$ is a Fisher index of price change, rather than the Törnqvist index in (3).[9] We use the price index version of the Fisher quantity index formula suggested by Kohli (2003):

$$\mathcal{P}_F^{t-1,t} = \prod_{i=1}^{N} \left(\frac{p_i^t}{p_i^{t-1}}\right)^{\frac{1}{2}(\sigma_{i,t-1,t}^L + \sigma_{i,t-1,t}^P)}, \tag{7}$$

where $\sigma_{i,t-1,t}^L$ is defined as follows:

$$\sigma_{i,t-1,t}^L \equiv \frac{s_i^{t-1} \cdot m\left(\frac{p_i^t}{p_i^{t-1}}, \mathcal{P}_L^{t,t-1}\right)}{\Sigma_{i=1}^N s_i^{t-1} \cdot m\left(\frac{p_i^t}{p_i^{t-1}}, \mathcal{P}_L^{t-1,t}\right)},$$

with $m(a,b) = \frac{a-b}{ln(a)-ln(b)}$ being the logarithmic mean of $a$ and $b$, and $\mathcal{P}_L^{t,t-1}$ is the Laspeyres index of price change:

$$\mathcal{P}_L^{t-1,t} = \frac{\Sigma(p_i^t q_i^{t-1})}{\Sigma(p_i^{t-1} q_i^{t-1})} = \prod_{i=1}^{N} \left(\frac{p_i^t}{p_i^{t-1}}\right)^{\sigma_{i,t-1,t}^L}. \tag{8}$$

Similarly, $\sigma_{i,t-1,t}^P$ is defined as follows:

$$\sigma_{i,t-1,t}^P \equiv \frac{s_i^t \cdot m\left(\frac{p_i^{t-1}}{p_i^t}, \frac{1}{\mathcal{P}_P^{t,t-1}}\right)}{\Sigma_{i=1}^N s_i^t \cdot m\left(\frac{p_i^{t-1}}{p_i^t}, \frac{1}{\mathcal{P}_P^{t,t-1}}\right)},$$

where $\mathcal{P}_P^{t-1,t}$ is the Paasche index of price change:

$$\mathcal{P}_P^{t-1,t} = \frac{\Sigma(p_i^t q_i^t)}{\Sigma(p_i^{t-1} q_i^{t-1})} = \prod_{i=1}^{N} \left(\frac{p_i^t}{p_i^{t-1}}\right)^{\sigma_{i,t-1,t}^P}. \tag{9}$$

[9]We use caligraphic script for the price and quality change indexes to distinguish them from the corresponding indexes in section 4. Quantity and value indices are the same as in section 4.

Table 5: Value Change Decomposition, Mango Imports, Fisher Price Index

| Year | $V^{t-1,t}$ | $\mathcal{C}^{t-1,t}$ | $Q^{t-1,t}$ | $\mathcal{P}_P^{t-1,t}$ | $\mathcal{P}_L^{t-1,t}$ | $\mathcal{P}_F^{t-1,t}$ |
|---|---|---|---|---|---|---|
| 1992 | 0.739 | 1.006 | 0.736 | 0.997 | 1.00 | 0.999 |
| 1993 | 1.116 | 0.881 | 1.289 | 0.984 | 0.981 | 0.983 |
| 1994 | 0.822 | 0.875 | 0.964 | 0.989 | 0.960 | 0.974 |
| 1995 | 1.111 | 1.217 | 0.914 | 1.000 | 0.998 | 0.999 |
| 1996 | 1.235 | 0.792 | 1.555 | 0.991 | 1.014 | 1.003 |
| 1997 | 0.853 | 1.308 | 0.650 | 1.007 | 1.000 | 1.003 |
| 1998 | 0.744 | 1.220 | 0.578 | 1.052 | 1.058 | 1.055 |
| 1999 | 0.768 | 0.943 | 0.872 | 0.931 | 0.937 | 0.934 |
| 2000 | 1.297 | 1.076 | 1.179 | 1.020 | 1.026 | 1.023 |
| 2001 | 0.976 | 1.268 | 0.749 | 1.044 | 1.011 | 1.027 |
| 2002 | 1.224 | 1.052 | 1.184 | 0.984 | 0.982 | 0.983 |
| 2003 | 1.278 | 0.717 | 1.899 | 0.944 | 0.934 | 0.939 |
| 2004 | 1.993 | 1.068 | 1.965 | 0.948 | 0.951 | 0.950 |
| 2005 | 1.161 | 1.057 | 1.092 | 1.004 | 1.008 | 1.006 |
| Geometric Means | | | | | | |
| 1992-2005 | 1.054 | 1.019 | 1.043 | 0.992 | 0.989 | 0.991 |
| 1992-1996 | 0.986 | 0.944 | 1.054 | 0.992 | 0.990 | 0.991 |
| 1997-2001 | 0.908 | 1.155 | 0.780 | 1.010 | 1.005 | 1.008 |
| 2002-2005 | 1.379 | 0.961 | 1.482 | 0.970 | 0.969 | 0.969 |

Notes: $V^{t-1,t}$, is the value change index for mangoes. Similarly for the quantity change index, $Q^{t-1,t}$ and the quality change index $\mathcal{C}^{t-1,t}$. The price index $\mathcal{P}_F^{t-1,t}$ is a Fisher index of price change.

In calculating the Fisher index using equation (7), it is clear that it is the geometric mean of Laspeyres and Paasche indexes of (8) and (9), and is also the geometric mean of the individual contributions to aggregate price change.

The results from this approach are presented in table 5. It is clear that the results largely mirror those of the earlier Törnqvist index approach. Given that this change in price index formula does not impact on the value and quantity changes, note that the differences are only in the price index and quality indexes. The differences are minor in some years, the years with major differences reflecting the significant change in the import basket in those years. The result of quality appreciation holds in the period directly following the import restriction.

The results for the disaggregated (by mango class and country) models, while still comparable to the earlier Törnqvist results of tables 3 and 4, are more markedly different; see table A1 and A2 of the Appendix. The more extreme changes are emphasised by the level of disaggregation. In the case of fresh mangoes, the years with relatively low volatility remain similar, however in the case of the period $1994-1997$, there is less comparability. This reflects the significant changes in the import bundle in these years.

Dried mango results behave in a similar manner across the two methodologies. This reflects the relative consistency of the import bundle in this class. Dried mangos were imported from the same three countries over the entire period, namely Thailand, the Philippines and Mexico; see table 1 and figure 2.

At the lowest level of aggregation, the country level, there is a more marked contrast between the Fisher and Törnqvist results. Especially in the years of highest flux, $1995-2000$. It is clear that at the lowest level of aggregation, and in conditions of significant flux, the results from the Törnqvist and Fisher indexes diverge. However, the geometric means in table A2 show that the import bundles from both nations still appreciated in quality over the period $1997-2001$.

The Fisher price index is advocated in empirical studies in the presence of extreme price values by Lent (2004), who argues that the Fisher index is more robust in the presence of outliers with a low elasticity of substitution. However, in the presence of a high elasticity of substitution, the Törnqvist performs better. Hence, depending on the context, the Fisher price index based decomposition of (7) may yield different results from the Törnqvist decomposition of (2), especially at lower levels of aggregation, bringing into question the robustness of the single-index Aw-and-Roberts-type decomposition analysis, and the resulting policy conclusions.

# 6 Conclusions

Addressing the very sparse literature on the impacts on consumers of biosecurity restrictions, the primary purpose of this paper has been to empirically examine the impact of quarantine restrictions on the quality of the imported agricultural products. This implied testing the Alchian and Allen (1964) proposition on implications for the composition of imports from an increase in per-unit costs. This proposition, which predicts an increase in quality, has been widely shown to hold in the context of transport costs, per-unit tariffs and quantitative restrictions on imports. However, no theoretical or empirical studies were found that link this proposition to quarantine policy. Quarantine policy changes in this context—due to e.g., the required change from a cheaper to a more expensive chemical treatment—can be seen to act similarly to an increase in transport charges or tariff rates.

Using data on Australian mango imports, the results confirm that this indeed appears to be the case. In the five year period following a quarantine policy change, a significant increase in the quality of the import bundle was found. This is in contrast to what appears to be a long term slow decline in the quality of the import bundle, a result very similar to that found by Aw and Roberts (1986) for U.S. footwear imports. Further, disaggregation by product class yields a similar result, showing that both fresh and dried mangoes appreciated in quality over the period with increased quarantine restrictions, although no change in regulation was observed for dried mangoes. Why did dried mangoes follow fresh mangoes in having quality increases when not faced with similar quarantine restrictions? An explanation is that dried and fresh mangoes are not substitute goods in that they tend to not be imported at the same time; fresh mangoes tend to be imported during the northern summer and dried mangoes tend to follow 2-3 months later. Also, their end uses are different. One argument is that changes in global regulations regarding the use of ethylene dibromide has increased the costs to growers and some of these costs are incorporated into the price of dried mangoes, hence the increase in both price and quality.

This paper also sought to extend the index number methodology of Aw and Roberts (1986). It has been shown that using the log-additive property of the Törnqvist index can provide a decomposition of partial price effects for individual product categories. The comparison of the Törnqvist and Fisher disaggregation methodologies in an empirical setting provides another contribution of this paper, and finds that at lower levels of aggregation results can be very different. This brings into question the robustness of the disaggregated results of Aw and Roberts, and suggests that the alternative index decompositions be used as a robustness check on results before drawing policy conclusions.

# Appendix: Fisher Index Decompositions

Table A1: Decomposition of Value Change by Mango Class, Fisher Price Index

| | Fresh | | | | Dried | | | |
|---|---|---|---|---|---|---|---|---|
| Year | $V_F^{t-1,t}$ | $\mathcal{C}_F^{t-1,t}$ | $Q_F^{t-1,t}$ | $\mathcal{P}_{F,F}^{t-1,t}$ | $V_D^{t-1,t}$ | $\mathcal{C}_D^{t-1,t}$ | $Q_D^{t-1,t}$ | $\mathcal{P}_{F,D}^{t-1,t}$ |
| 1992 | 0.728 | 1.008 | 0.726 | 0.995 | 0.790 | 1.028 | 0.799 | 0.963 |
| 1993 | 1.029 | 0.881 | 1.221 | 0.958 | 1.496 | 0.878 | 1.720 | 0.990 |
| 1994 | 0.820 | 0.895 | 0.914 | 1.002 | 0.827 | 0.770 | 1.187 | 0.905 |
| 1995 | 1.074 | 0.124 | 0.843 | 1.032 | 1.222 | 1.111 | 1.159 | 0.949 |
| 1996 | 0.836 | 0.697 | 1.279 | 0.937 | 2.288 | 0.988 | 2.242 | 1.033 |
| 1997 | 0.743 | 1.330 | 0.547 | 1.022 | 0.958 | 1.174 | 0.796 | 1.025 |
| 1998 | 0.366 | 0.970 | 0.312 | 1.209 | 1.027 | 1.120 | 0.839 | 1.093 |
| 1999 | 0.756 | 1.001 | 1.166 | 0.648 | 0.771 | 1.068 | 0.765 | 0.944 |
| 2000 | 0.724 | 1.079 | 0.472 | 1.422 | 1.447 | 0.893 | 1.570 | 1.031 |
| 2001 | 0.605 | 0.927 | 0.353 | 1.851 | 1.024 | 1.277 | 0.815 | 0.984 |
| 2002 | 4.044 | 1.269 | 6.062 | 0.526 | 1.006 | 1.132 | 0.832 | 1.068 |
| 2003 | 1.607 | 0.788 | 2.284 | 0.894 | 1.176 | 0.751 | 1.697 | 0.923 |
| 2004 | 1.582 | 1.000 | 1.041 | 1.520 | 2.167 | 0.908 | 2.617 | 0.912 |
| 2005 | 1.063 | 1.000 | 1.255 | 0.847 | 1.191 | 1.054 | 1.046 | 1.081 |
| Geometric Means | | | | | | | | |
| 1992-2005 | 0.957 | 0.991 | 0.955 | 1.002 | 1.173 | 0.999 | 1.185 | 0.991 |
| 1992-1996 | 0.888 | 0.927 | 0.973 | 1.023 | 1.223 | 0.947 | 1.335 | 0.967 |
| 1997-2001 | 0.618 | 1.052 | 0.506 | 0.983 | 1.023 | 1.099 | 0.918 | 1.014 |
| 2002-2005 | 1.818 | 1.000 | 2.062 | 1.000 | 1.322 | 0.950 | 1.402 | 0.993 |

Notes: $V_n^{t-1,t}$, $n = F, D$, is the value change index for where $F$ denotes fresh mangoes and $D$ denotes dried mangoes. Similarly for the quantity change indexes, $Q_n^{t-1,t}$ and the quality change indexes $\mathcal{C}_n^{t-1,t}$. The price indexes $\mathcal{P}_{F,N}^{t-1,t}$ are Fisher indexes where N represents mango class

Table A2: Decomposition of Value Change by Country of Origin, Fisher Price Index

| | Mexico | | | | Philippines | | | |
|---|---|---|---|---|---|---|---|---|
| Year | $V_M^{t-1,t}$ | $\mathcal{C}_M^{t-1,t}$ | $Q_M^{t-1,t}$ | $\mathcal{P}_{F,M}^{t-1,t}$ | $V_P^{t-1,t}$ | $\mathcal{C}_P^{t-1,t}$ | $Q_P^{t-1,t}$ | $\mathcal{P}_{F,P}^{t-1,t}$ |
| 1992 | 0.537 | 0.950 | 0.583 | 0.969 | 0.924 | 1.016 | 0.907 | 1.003 |
| 1993 | 1.588 | 0.923 | 1.902 | 0.905 | 0.775 | 0.909 | 0.916 | 0.931 |
| 1994 | 0.934 | 0.847 | 1.273 | 0.867 | 0.772 | 1.199 | 0.570 | 1.129 |
| 1995 | 0.851 | 1.097 | 0.652 | 1.190 | 1.255 | 0.904 | 1.454 | 0.954 |
| 1996 | 2.287 | 0.955 | 2.802 | 0.854 | 0.351 | 1.305 | 0.240 | 1.123 |
| 1997 | 0.640 | 1.620 | 0.540 | 0.733 | 1.530 | 0.890 | 1.802 | 0.954 |
| 1998 | 0.935 | 1.223 | 0.661 | 1.157 | 0.074 | 2.710 | 0.021 | 1.323 |
| 1999 | 0.542 | 0.747 | 0.732 | 0.991 | 1.857 | 1.000 | 2.304 | 0.806 |
| 2000 | 1.296 | 1.094 | 1.208 | 0.980 | 0.690 | 0.664 | 0.739 | 1.407 |
| 2001 | 0.589 | 0.190 | 0.433 | 1.143 | 1.726 | 1.507 | 1.860 | 0.616 |
| 2002 | 1.087 | 1.263 | 1.223 | 0.704 | 4.174 | 0.352 | 8.317 | 1.425 |
| 2003 | 2.656 | 0.925 | 3.247 | 0.884 | 0.332 | 2.840 | 0.221 | 0.529 |
| 2004 | 1.677 | 0.995 | 1.500 | 1.124 | 0.770 | 1.000 | 0.744 | 1.035 |
| 2005 | 0.895 | 1.059 | 0.826 | 1.023 | 1.878 | 1.000 | 1.545 | 1.216 |
| Geometric Means | | | | | | | | |
| 1992-2005 | 1.037 | 1.045 | 1.040 | 0.954 | 0.860 | 1.085 | 0.796 | 0.996 |
| 1992-1996 | 1.091 | 0.951 | 1.209 | 0.950 | 0.754 | 1.055 | 0.697 | 1.025 |
| 1997-2001 | 0.756 | 1.140 | 0.672 | 0.988 | 0.758 | 1.192 | 0.652 | 0.975 |
| 2002-2005 | 1.443 | 1.053 | 1.490 | 0.920 | 1.189 | 1.000 | 1.205 | 0.987 |

Notes: $V_n^{t-1,t}$, $n = M, P$, is the value change index for where $M$ denotes Mexican mangoes and $P$ denotes Filipino mangoes. Similarly for the quantity change indexes, $Q_n^{t-1,t}$ and the quality change indexes $\mathcal{C}_n^{t-1,t}$. The price indexes $\mathcal{P}_{F,N}^{t-1,t}$ are Fisher indexes with N representing country of origin.

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