An Economic Method for Empirically Assessing the 'Appropriate Level of Protection'

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Australia's membership of the World Trade Organisation has generated a need for analytical techniques demonstrating that the behaviour of its internal markets and regulatory authorities for food and food-related products conform with the provisions of the Agreement on Sanitary and Phytosanitary Measures (SPS Agreement). However, since quarantine has long been considered a scientific issue, it is as yet unclear what role economic models have to play in this process. This article shows how consumer welfare effects can be integrated with the traditional producer welfare effects in quantitative analytical models using the examples of the mango and tomato industries in Western Australia, both of which enjoy quarantine protection from interstate growers.

1. Introduction

With the expansion of international trade in recent times, increased emphasis is being placed on techniques to assess the use of quarantine as an instrument of protectionism. A major food exporting country like Australia has the potential to thrive in the global market place, but to do so it must be seen to be playing by the rules if costly retaliatory action by trading counterparts is to be avoided. As a signatory of the World Trade Organisation (WTO) Agreement, the federal government of Australia has a responsibility to ensure that any trade measures used in its internal

markets relating to Sanitary (human and animal health) and Phytosanitary (plant health) (SPS) measures are compliant with the regulations governing international trade. In particular, any such measure must be justified by a comprehensive risk assessment, and it is here that economics can make a useful contribution by examining the likely impacts of trade restrictions on domestic producer and consumer welfare.

The precise use of economic models in the examination and formulation of regulatory measures has not yet become clear. Traditionally, quarantine has been considered a subject of the biological sciences, so the primary decision criteria have been centred around the producer effects of pest introductions. However, since measures designed to ensure imported products are pest-free often involve costly sampling, chemical and temperature treatments they affect all consumers of those products by raising domestic prices, and therefore reducing the benefits from trade. Only recently have methods of integrating these trade effects with import risk assessments been discussed, but these have a variety of problems in terms of practical use in policy analysis and design. This analysis draws on these methods and attempts to overcome, or at least "side step" some of these problems by applying them in quantitative assessments of interstate protection measures for two horticultural commodities, mangoes and tomatoes, traded across State and Territory borders within Australia. Section 2 goes through pertinent international obligations before discussing some of the intricacies and difficulties of employing economic models in quarantine policy analysis. It then offers a means of overcoming these problems in quantitative work by way of a conceptual model, and section 3 introduces the case studies to which this model is then applied and discussed in section 4. The paper ends with a brief conclusion.

2. Developing the Economic Framework for Analysing Protection

2.1 International and State Quarantine Arrangements

In Australia, State and local government authorities often set food safety and animal and plant health regulations relating to interstate trade. The negotiation of the Agreement on Sanitary and Phytosanitary Measures (henceforth referred to as the SPS Agreement) to ensure SPS trade restrictions are based on scientific information implies decisions made at all levels of government could potentially lead to challenges by other WTO Members (Nairn *et al*,1997). In fact, Article 13 of the SPS Agreement specifically requires the federal government (as the signatory) to formulate and implement positive measures and mechanisms in support of the observance of the international provisions by all tiers of government (GATT, 1994; Miller, 1999). This motivated the signing of a Memorandum of Understanding between the Commonwealth of Australia and all States and Territories on the 21st of December 1995, in which parties agreed to conform with the provisions of the SPS Agreement (Commonwealth of Australia, 1995). These "provisions" are specified in Article 5 of the SPS Agreement (GATT, 1994), which begins:

> Members shall ensure that their sanitary and phytosanitary measures are based on an assessment, as
> appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into
> account risk assessment techniques developed by the relevant international organisations.

So, any measure applied to imported commodities by any level of government to protect human, animal or plant health must be based on sound scientific principles, and not maintained without sufficient scientific evidence. The only exception is where existing evidence is insufficient to prove or disprove an unacceptable level of pest importation risk, in which case a Member may adopt provisional measures to protect itself under what has become known as the *precautionary*

principle (Miller, 1999; Nunn, 2001).

While the scientifically based framework of the SPS Agreement is of potential benefit to Australian exporters in terms of pest protection, the obligations of the nation as an importing WTO Member to also abide by the SPS rules is not always recognised by domestic stakeholders, consumers or even State and Territory governments (Tanner, 2001). Since the Agreement acknowledges the right of a nation to determine a level of risk appropriate for its individual circumstances, a good deal of conjecture currently surrounds the appropriate role economic analysis has to play in rectifying this situation. From a State view point, it may be desirable (in terms of social welfare) to place restrictions or entry requirements on certain products to protect domestic industries from invasive pests, but this need not necessarily be WTO-legal. To expand on this dilemma requires an explanation of precisely how a trading entity manages quarantine risk, and how it arrives at (or at least implies) an appropriate level of protection.

2.2 Iso-risk and the Appropriate Level of Protection

When discussing allocation options for relatively scarce quarantine resources, it is important to have a means by which alternatives can be evaluated and compared. This represents a sizeable challenge for analysts due to the diversity of threatening organisms to agriculture and the range of techniques (potentially) employed to restrict their entry to a production system. The bulk of work completed on this issue to date has focused on methods of eliciting values for trade barriers by combining potential economic damage and the probability of that damage occurring through the importation of infested material (e.g. Kaplan and Garrick, 1981; Cohrssen and Covello, 1989, Miller *et al*, 1993; Orr, 1995; FAO, 1996; Che and Cook, 1999). Because this method of pest

risk evaluation relies solely on producer welfare implications, decisions made in regard to the allocation of quarantine resources based on such assessments tend to be biased. In terms of a practical resource allocation decision-making aid, this constitutes but one component of a much broader framework which captures both consumer and producer welfare implications.

It is generally accepted that pest risk, or *expected damage* related to a specific pest be defined as the product of the *economic consequences* of importing the organism concerned, and the *probability of introduction and establishment* of that organism (Bigsby, 2001). Assessments of the risks posed by specific goods[1] rely on expected damage assessments for each pest associated with it, and so the damage expected to result from the importation of a commodity is determined as the sum of expected damage for each and every pest for which it is a host.

$$\text{i.e.} \qquad \text{ED}_c = \sum_{i=1}^{n} \text{EC}_i \times p_i \qquad (1)$$

where;

ED_c = Expected Damage resulting as a direct consequence of importing a particular commodity *c*

EC_i = the economic consequences of an incursion of pest *i*

p_i = the probability of the entry and establishment of pest *i*, and

n = the number of pests for which *c* is a host.

A locus of varying combinations of EC and *p* which result in a given ED is referred to as an *iso-risk* line (Bigsby, 2001), being analogous to the concept of 'isoquants' in neo-classical

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[1] Here, *good* or *commodity* refers to a specific product and country/pathway combination (Bigsby and Whyte, 1999; Bigsby, 2001).

production economics. Figure 1 depicts three different iso-risk lines, IR_1 - IR_3, each corresponding to different values of ED. Both axis are shown on a log scale such that iso-risk
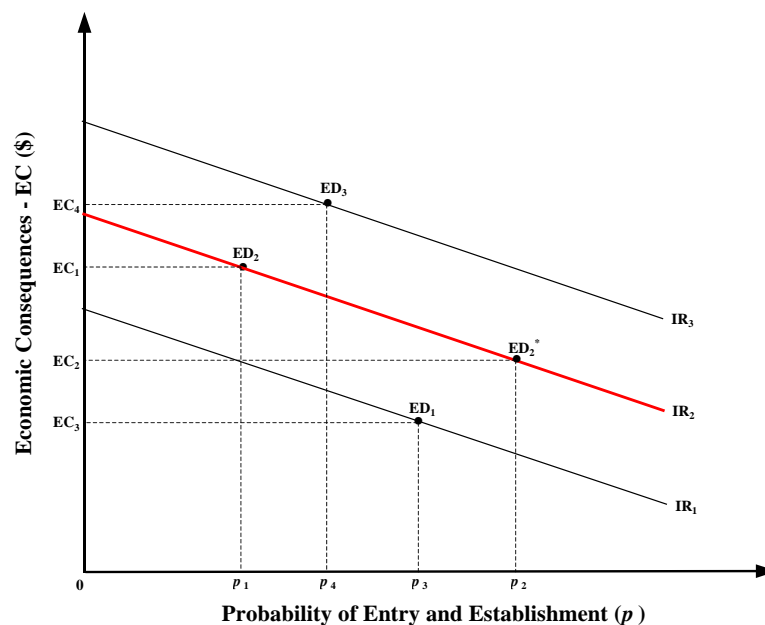
Figure 1 'Iso-Risk' Framework (Bigsby, 2001)

lines are linear, with EC (measured in dollars) plotted on the vertical axis and p (ranging between 1 and 0) on the horizontal axis (Bigsby and Crequer, 1999). Assuming that point estimates of ED (and therefore EC and p) can be determined[2], it is possible to show how two commodities can share a unique value upon an iso-risk line (e.g. IR_2) whilst having different values for EC and p, and thus present the same quarantine threat. Moreover, the further the iso-risk line from the

origin, the greater the quarantine risk presented. Hence, ED_2 presents the same quarantine threat as ED_2^*, a greater threat than ED_1, and a smaller threat than ED_3.

There are two main advantages of using such a method to assess commodity-based risk. Firstly, it allows all goods to be assessed using a common measure of potential risk, which in turn allows goods to be evaluated relative to one another on a common basis (Bigsby and Crequer, 1999). Secondly, the iso-risk framework can be used to openly express a standard by which pest threat can be assessed. For instance, if the iso-risk line for IR_2 is proclaimed a standard above which the risk presented by a commodity is unacceptably high, it is then possible to identify those commodities to be restricted, and those presenting a tolerable level of danger. Such a standard can be termed the *Appropriate Level of Protection* (ALOP), defined in Henson (2001) as "…that level of protection deemed to be acceptable and which the SPS measures applied [by a trading entity] aim to achieve". So, if the ALOP resembles that of Figure 1, the decision of whether or not to permit imports of the two commodities corresponding to ED_2 and ED_2^* is marginal since they fall on the frontier of acceptable risk. The decision relating to imports of the goods associated with ED_1 and ED_3 is more straight forward (at least conceptually). ED_1 represents a level of risk below that corresponding to the ALOP, and hence imports of the good concerned would be approved, whereas ED_3 represents an unacceptably high level of risk and there are grounds for restricting imports of the product concerned despite the risk of it entering being lower than the product represented by ED_1.

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[2] Due to the uncertainty surrounding estimates of both determinate variables, it is very difficult to arrive at a point estimate of ED. It is much more practical to form a probability distribution of possible outcomes based on the distributions of EC and *p*. Nevertheless, to keep things as simple as possible, assume a point estimate can be formed pertaining to a particular pest.

2.3 Integrating Expected Damage and Trade Benefit Analysis

While not defining ALOP as such, Article 5 of the SPS Agreement identifies those factors which would be deemed relevant from a WTO perspective in assessing quarantine risks. These "relevant economic factors" are specified in Paragraph 3 (GATT, 1994), which states:

> In assessing the risk to animal or plant life or health and determining the measure to be applied for achieving the appropriate level of sanitary or phytosanitary protection from such risk, Members shall take into account as relevant economic factors: the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease; the costs of control or eradication in the territory of the importing Member; and the relative cost-effectiveness of alternative approaches to limiting risks.

The omission of *consumer gains from trade* from this list is of paramount importance when attempting to use measures of societal welfare to examine the impact of quarantine policies on specific regional and national economies.

In the following discussion, let the term "social welfare" refer to *gains from trade*. Simply stated, this is the extra consumption benefits achieved through interstate trade less production costs brought about by competition. SPS measures affect markets by altering the conditions of competition between local and imported products, and consequently the prices domestic growers receive for their produce and consumers pay for the privilege of consuming them. Consider an exotic pest to WA which is endemic in the eastern States and/or Territories of Australia. The probability of the organism entering WA through interstate trade in host products in sufficient quantities to reproduce can be lessened by ensuring these commodities are subjected

to quarantine treatments before they are permitted to cross the border. But, the reduced risk comes at the cost of a welfare loss for consumers, so the net result is conceptually ambiguous. A static, single commodity, partial equilibrium framework, as shown in Figure 2, is often the most feasible tool for specific regulatory proposal analyses (Roberts, 2001), which demonstrates the magnitude of this *net welfare change*. Before proceeding however, it is necessary to state a number of simplifying assumptions.

First, assume the fruit or vegetable product in question is homogenous, there being no distinction made between individual varieties within a certain commodity type. Second, assume
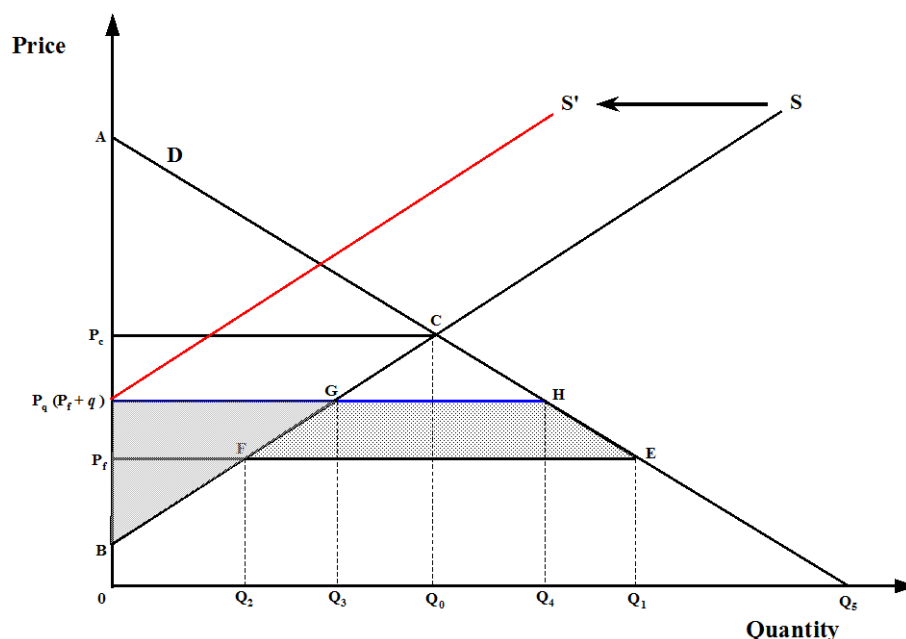
Figure 2 Net Social Welfare Loss Resulting from SPS Measures

the domestic market, that of WA, is perfectly competitive. Third, suppose the domestic price for the product is higher than in other producing States and Territories within Australia and overseas producers, so trade would take place in the absence of blanket restrictions. Fourth, assume the contribution of WA to total supply is insufficient to exert influence on the import price, the exchange rate and domestic markets for other commodities. Fifth, society has a neutral attitude to risk, and so demands no premium over and above an expected level to protect against damage resulting from pest importation. Sixth, assume pests are host specific, and only impact upon the costs of their host industry alone. Finally, where quarantine protocols require procedures such as chemical treatment to be undertaken upon importation into WA that the costs of these procedures are borne by the exporter, and are transferred to consumers via the price mechanism (James and Anderson, 1998).

If a market with these characteristics were suddenly to move from a protected state to one of free trade, consumers may be seen to gain in welfare at the expense of producers. If P_c

represents the closed economy, domestic equilibrium price and P_f the free trade price, CS increases by the area P_cCEP_f (i.e. from ACP_c to AEP_r) when trade is unimpeded, while PS decreases by the area P_cCFP_f (i.e. from BCP_c to BFP_r). Hence, the *net gains to trade* are represented by the triangle CEF. However, with absolutely no screening mechanisms to guard against a likely pest incursion, the probability of importing a pest species endemic in other growing centres through the exchange of host material is effectively maximised. So, it may be optimal for regulatory authorities to impose entry requirements on susceptible trade goods to reduce this probability which cost a certain amount *q*, pushing the price above the free trade level to P_q. At this higher price, CS will contract (relative to the free trade situation) by the area P_qHEP_f (i.e. from AEP_r to AHP_q), and PS will expand by P_cFGP_q (i.e. from BFP_r to BGP_q). There are still gains to trade since P_q lies below P_c, which are represented by the triangle CHG. However, since they are smaller than under a free trade regime, a net social welfare loss results from inflating prices above the free trade level, as represented by the area EFGH.

Under each scenario, the probability of importing a pest from other growing regions (chiefly the eastern States and Territories of Australia in the context of interstate trade) changes. Hence, the expected damage inflicted by exotic pest incursions depends on the presence or absence of measures to prevent their movement across state borders via host material. From an analytical perspective, it is these expected damages prevented by quarantine measures which must be weighed against the net welfare loss of artificially inflating prices. For instance, assume the consequences of pest entry to the market in question would be particularly catastrophic in that the entire domestic industry would be laid waste, and all domestic PS lost. Damage this severe would have the disastrous effect of moving the supply curve inwards from S to S′, thus dissolving

all domestic PS represented by the area BGP$_q$. So, efforts to determine the full extent of benefits and costs of quarantine must compare net welfare losses of quarantine (EFGH) to the change in the probability of importing a pest and incurring a loss equivalent to BGP$_q$ in Figure 2. While this portrays an extreme example, it serves to illustrate the workings of a benefit cost analysis using the partial equilibrium framework.

Attempts have recently been made to conceptualise the welfare effects of trade and pest risk across different commodities traded internationally. Snape and Orden (2001), for instance, present a simple diagram illustrating the 'traditional' risk focused verses benefit/cost approach to assessing the relative merits of trading goods potentially posing SPS risks. The monetary value of each product's iso-risk curve is plotted along the horizontal axis, while the gains from trade are shown on the vertical axis[3]. The ALOP is depicted as perpendicular to the horizontal axis corresponding to a pre-determined level of acceptable risk. Using this framework, the relative merits of importing products can be assessed by comparing the gains from trade with the expected level of damage under respective import conditions[4].

Nevertheless, such an exercise is not possible in practise since it is unclear just what level of expected damage constitutes an ALOP. This ambiguity stems from difficulties encountered in the risk assessment process through which its *critical value* is determined, for this merely provides a means of forming an approximation of pest risk based on scientifically plausible hypotheses rather than established facts (Somogyi, 1999). Consequently, risk assessment involves elements of value judgement, making it difficult to develop international guidelines on

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[3]The costs of treatment or testing should be taken into account in determining the gains from trade for any products tested or otherwise treated for quarantine purposes (Snape and Orden, 2001).

[4] See Snape and Orden (2001) for a comprehensive discussion.

appropriate evaluation techniques, or to reach an international consensus regarding an ALOP specification (Somogyi *et al*, 1999; Henson, 2001). This partly explains why no WTO Member has articulated its ALOP with any degree of precision (Gascoine, 2001).

A further explanation lies in political sensitivity to quarantine issues, particularly where human health and the environment are concerned. Conventional neo-classical demand analysis for health care is often challenged by the view that health is such an important good that it can not be traded off against other goods that society consumes. While it may not be the case that preferences for health are lexicographic[5], they may be relatively high (Besley, 1989). To infer just how high society values such goods by way of an explicit policy statement concerning the ALOP is to court political disaster. A similar dilemma arises when regulatory measures protect environmental resources as well as market goods. When compared to agricultural commodities with an easily expressed annual value, the natural environment (or its components) may have an annual value in terms of use, as well as existence, bequest or moral values which are dependant on its continued existence, and which could extend over generations in time (Mumford, 2000). Identifying and capturing these values using stated or revealed preference techniques which are both accurate and cost-effective is extremely difficult, but their exclusion from a regulatory decision-making process results in policies reflecting an inaccurate interpretation of social values.

2.4 An Operational Framework

Despite the problems inherent in the 'Snape-Orden' framework, it remains possible to use it in practise by concentrating on *measureables*. That is, rather than place the main focus of economic

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[5] Whereby consumer preferences for health are evaluated regardless of preferences for other goods and services.

analyses on the formation of expected damage estimates involving subjective probability and impact assessments, a more effective decision aid can be constructed using observable time series price and quantity data to measure of the gains from trade under different scenarios. If the welfare gains resulting from trade can be measured, it is possible to identify the minimum value of expected damage that would neutralise the economic impact of trade in a commodity susceptible to exotic pests. Using this approach, the objective of economic assessments becomes the estimation of that level of Expected Damage (ED) resulting from the importation of a commodity (c) which is required to exactly offset the gains from trade stemming from its importation (GT).

i.e. $$\max_{x} . \pi = px - c(x) \qquad (2)$$

In terms of the iso-risk framework described in section 2 (Figure 1), such an estimate will indicate the iso-risk line which is relevant to the commodity in question[6].

By assuming quarantine policies reflect WA's ALOP for interstate imports, the minimum value of ED_{ALOP} in Figure 3 can be estimated from the gains from trade under a quarantine restricted trade scenario. The value of the expected damage required to exactly offset the gains from trade in the product with interstate quarantine measures in place reflects that level of damage above which society is unwilling to risk importation. In the absence of a clear specification of the ALOP from relevant quarantine authorities, this method of approximating its true position provides useful information in discussing the welfare implications of quarantine

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[6] In many respects, this is similar to the approach adopted by Hinchy and Low (1990) and Hafi *et al* (1994) where an indication of the break even *probability* of pest incursion and establishment was provided.
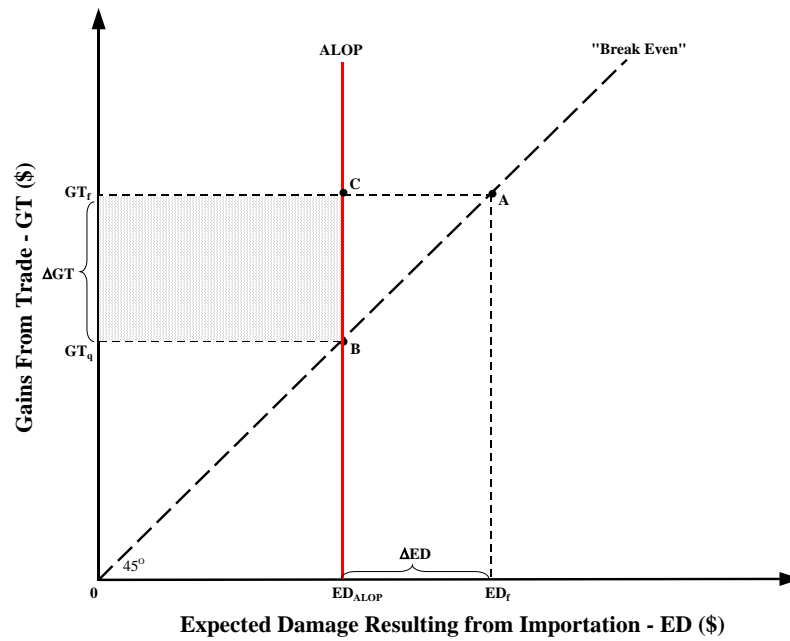
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Figure 3 Implied Acceptable Level of Protection (Snape and Orden, 2001)

policies, and provides some insight into perceived social preferences with regard to quarantine.

3. Details of Case Studies

3.1 Mangoes

3.1.1 The Domestic Industry and Interstate Quarantine Measures

The WA mango industry has been expanding significantly over the past ten years, but remains relatively small. In 1995/96 it accounted for around 5 per cent of national output, producing a total of 1,258 tonnes (ABS, 1998). This made it the third largest producer behind Queensland (85 per cent) and the Northern Territory (NT) (9 per cent) (White, 1997). Production is centred around two main regions, Carnarvon (890 tonnes, 1995/96) and Kununurra (550 tonnes). The former's production peaks from late December to February, while the latter is one of the earliest producers in Australia, peaking during October and November. Other growing centres include Broome (52.4 tonnes), Gingin (22 tonnes) and Derby (2.2 tonnes) (ABS, 1998). This dispersion of producers across the state causes a lengthy picking time, and a continuous supply to the Perth Market from October through to April (White, 1997).

Generally, WA is free from serious mango pests and diseases, although isolated occurrences of Bacterial Black Spot (*Xanthomonas campestris* pv. *Mangiferaeindicae*) and Anthracnose (*Colletotrichum gloeosporioides* Penz. Var. *minor*) are detected from time to time, as are several common fungal diseases. The only insect pest of significance to mangoes which is

endemic in the state is Mediterranean Fruit Fly (*Ceratitis capitara*)[7]. Pests exotic to WA but endemic in other states and territories of Australia include invertebrates such as Queensland Fruit Fly (*Bactrocera tryoni*), Mango Seed Weevil (*Sternochaetus mangiferae*), Mango Pulp Weevil (*Sternochaetus frigidus*), Northern Teritory Fruit Fly (*Bactrocera aquilonis*), European Red Mite (*Panonynchus ulmi*), Melon Thrips (*Thrips palmi*), Spiraling Whitefly (*Aleurodicus dispersus*), Mango Leaf Hopper (*Idioscopes niveosparsus* and *Idioscopes clypealis*), and diseases such as Mango Scab (*Elsinoe mangiferae*). These pests have the potential to severely hamper mango production in WA by adding to the marginal cost of production they become endemic in WA.

Up to the early 1990s, importation from the largest eastern states rivals were prohibited (Hawkins, 1994). The presence of exotic pests like Mango Seed Weevil (MSW) and Northern Territory Fruit Fly in the Northern Territory, and Queensland Fruit Fly (Q-fly) in Queensland meant that the risk of importing such pests was deemed too high. However, in 1994 a new set of protocols was introduced to permit imports from the former under certain circumstances. The quarantine requirements for imported product currently in place are strict, with specific preventative measures undertaken to reduce the risk of entry of all the pests mentioned above. Queensland imports remain prohibited. All costs are born by the interstate growers seeking to export mangoes into WA, the most significant of which are made up of post harvest sprays for fruit fly, and sampling costs for MSW (WAQIS, 1999).

3.1.2 Variables

An effort has been made in this study to maintain consistency in data sources for each case study

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[7] A pilot eradication programme is currently underway in the Broome region to provide information for future feasibility studies of more extensive campaigns.

since methods of collection can differ considerably. However, in several instances it has been necessary to use supplementary information from various sources to provide sufficient parameter estimates to place in the model. An outline of the most likely, or "best bet" values, and details of information sources is provided below:

Elasticity of Supply – estimating supply responses to changes in price is somewhat difficult. In an econometric study of the national demand for mangoes, Kane (1989) reports "…no research has been reported that vigorously and comprehensively analyses the roles of price, supply variation, income, fruit substitution, consumer awareness and promotion in the determination of consumer demand for fresh and manufactured mangoes". A brief econometrics exercise in White (1997) offers an estimate of **0.80** for the own-price elasticity of supply for mangoes in WA. Although the purpose of this study was merely conceptual, and focused primarily on the own-price elasticity of demand, it is adopted here[8].

Post-Quarantine Quantity Supplied - using ABS time series data supplemented by White (1997), an estimated proportion of total supply was formed based on a three year average from 1997-1994. Prior to 1994, interstate importation of mangoes was prohibited (Hawkins, 1994) due to the risks associated with exotic pests like MSW, Northern Territory Fruit Fly and Queensland Fruit Fly. However, in 1994 a new set of protocols was introduced to permit imports from the Northern Territory under strict conditions while Queensland imports remain prohibited. So, using post-1994 supply data and relative contributions to production from the Central and Kimberley statistical divisions, the former comprises of some 56 per cent

(**790 tonnes**) of total production, and the latter around 43 per cent (**610 tonnes**) (ABS, 1998; White, 1997).

Post-quarantine Price - was calculated (in real terms) as a five year average from the period following 1994 when imports from the eastern states were no longer prohibited using PMA and FAO data. On this basis the best bet value for P_q is **$1,800/tonne** (PMA, 2000b; FAO, 2000).

Closed Economy Price - taken as a five year average from the period following 1994 using PMA and FAO data. This gives the best bet value for P_c as **$1,950/tonne** (PMA, 2000b; FAO, 2000).

Free Trade, or National Price - is specified to approximate the marginal cost of mango production for eastern states rival growers. If there were no restrictions to trade, these producers would be inclined to take advantage of the WA market and increase supply to the point where all profits are diminished, and price equals AVC in the long run. White (1997) calculated the marginal cost of production and transport to local markets for producers in Carnarvon, Kununurra, Katherine in the Northern Territory, and Mareeba in Queensland. By substituting transport costs to Perth for local transport costs (i.e. Brisbane-Perth = $410/tonne; Sydney-Perth = $380/tonne (Harris Transport, pers comm, 4/10/99)) for eastern states producers, the lowest marginal cost was found to be in Queensland at around **$1,750/tonne**.

Wholesale and Retail Marketing Margins - The size of the marketing margins applied at the

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[8] The significance of this assumption, and hence the importance of the subjectiveness surrounding the best bet value is explored in Cook (2001). With relatively small price changes, the sensitivity of net welfare change resulting from the quarantine policy to the elasticity of supply is low.

wholesale and retail levels are difficult to verify, as is the manner in which they're applied. Sources close to the market indicate wholesale margins to be around **10-15 per cent** (Mercer Mooney; Quality Produce International; Central Fruit Sales; Etherington & Sons, pers comm, 23/11/99), and retail margins around **33 per cent** (Woolworths – Fresh Produce, pers comm, 22/11/99; Quality Produce International, pers comm, 23/11/99). Since further details of the idiosyncrasies of fruit marketing are difficult to extract, marketing margins are assumed constant in percentage terms. Consequently, the model infers that (generally) the price paid for mangoes "at the farm gate" is around 12.5 per cent below the wholesale price of fruit, which is in turn is approximately 33 per cent below the retail price.

3.2 Tomatoes

3.2.1 The Domestic Industry and Interstate Quarantine Measures

Tomatoes are one of the most important and valuable horticultural crops grown in WA (Burt, 1997). A total of around 220 hectares is devoted to growing tomatoes state-wide, and due the diversity and geographical spread of primary growing areas a year-round supply to the Perth market can be maintained. The Perth area contains approximately half of the total plantings, which take place between August right through until early February. These are mainly concentrated in the Wanneroo and Serpentine-Jarrahdale Local Government Areas (LGA), which produced 1,280 tonnes and 540 tonnes respectively in 1995/96. Numerous LGAs in the South West region of the state, including Donnybrook-Balingup and Harvey, collectively produced over 1,660 tonnes in the same year. Here, planting generally takes place between September through

to early December. The remainder is made up mainly by Geraldton (150 tonnes), where planting takes place from February to June/July, and Carnarvon (4,770 tonnes) planted between late February and mid-September (ABS, 1998). Between September and December tomatoes are also grown in the hills districts near Perth, and in the southern agricultural areas (Graham, 1994; Burt, 1997).

Several pests and diseases present in the tomato growing regions of other states are not present in WA, and so measures are taken to minimise the risk of these being introduced with consigned fruit. The four pests of primary concern for tomatoes are Q- Fly, European Red Mite (ERM), Melon Thrips and Spiralling Whitefly, although other species of quarantine significance include Cucumber Fly (*Bactrocera cucumis*) and *B. neohumeralis*. Specific treatments must be applied to imported tomatoes for each of these pests, the most costly of which are again associated with the prevention of fruit fly incursions (WAQIS, 1999).

3.2.2 Variables

Elasticity of Supply - Quantitative studies offering estimates of supply elasticities for tomatoes and tomato products in WA are not presently available, and very few international examples have been completed. Comparative static estimates are not available, but examples of dynamic estimation techniques being used to estimate tomato supply functions can be used as an approximation. In a study of the winter tomato supply in Florida, Shonkwiler and Emerson (1982) imply an own price elasticity of 0.92 using a *rational expectations hypothesis*, and 0.46 using a *cobweb* model. These can be used as rough upper and lower bounds. In contrast to Florida, much of the land used to grow tomatoes in WA is privately owned, and so growers would be expected to be more interested in alternative enterprises than

perhaps the opportunity cost of purchased inputs. Hence, in the case of WA tomato supply, a most likely elasticity of supply closer to the upper bound, say **0.80**, is specified.

Post-Quarantine Quantity Supplied - Using PMA time series data the total supply from each growing region was formed based on a five year average from 1994 to 1999. Although not the case with every commodity passing through the market, the source of tomatoes has been recorded over time. The Central district (principally Geraldton and Carnarvon) supply is specified at **10,800 tonnes**, the Swan Coastal Plain region at **8,700 tonnes**, and the South West region at **1,300 tonnes** (PMA, 2000a)

Post-quarantine Price - PMA time series data of tomato prices was used to form an estimate of P_q. The best bet value, based on a five year average from 1994 to 1999, was **$1,000/tonne** (PMA, 2000b).

Closed Economy Price - Reliable cost estimates for products undergoing quarantine treatments are not available, which makes the task of formulating a closed economy price for tomatoes somewhat difficult. Despite stringent procedures being in place for tomatoes moving in to WA from interstate, imports have continued (if sporadically) over the past 15 years[9]. In the absence of time-series price differentials in a closed and quarantine-restricted market, an approximate quarantine protocol-induced price rise of 10 per cent is specified, which roughly equates to that of the previous case study. The required quarantine procedures themselves differ for imported mangoes and tomatoes, but given the lack of adequate price information it will suffice as a broad estimate. The most likely value for P_q is assumed as **$1,080/tonne**.

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[9] Tomato imports averaged around 75 tonnes per year between 1994 and 1999, and primarily sourced from Queensland and New South Wales.

Free Trade, or National Price - specified to approximate the marginal cost of tomato production for eastern states rival growers. Fullelove *et al* (1999) calculated the marginal cost of production and transport to local markets for Queensland producers. By substituting transport costs to Perth for local transport costs (i.e. Brisbane-Perth = $390/palate, Harris Transport, pers comm, 3/2/00)) for eastern states producers, the estimated free trade price was found to be around **$960/tonne**.

Wholesale and Retail Marketing Margins – As mentioned in section 4.3, it is difficult to determine a best bet value for marketing margins applied at the wholesale and retail levels of production. Sources close to the market indicate wholesale margins to be in the order of **10-15 per cent** (Mercer Mooney, pers comm, 23/11/99; Quality Produce International, pers comm, 30/07/99; around **33 per cent** (Woolworths – Fresh Produce, pers comm, 22/11/99; Quality Produce International, pers comm, 23/11/99). As before, these are specified as fixed in percentage terms.

4. Results and Interpretation

Using the above parameters to calculate the size of domestic producer and consumer surplus under a closed economy, a free trade and a quarantine-restricted trade scenario, the results in Table 1 were obtained. These are reported as they relate to Figure 3 to aid interpretation.

Due to the relatively large size of the industry, the drop in the domestic price of tomatoes induced by free trade across State borders produces greater gains from trade than in the case for mangoes. Hence, the minimum value of ED_f required to offset these gains from trade is significantly larger for tomatoes. Similarly, the impact of interstate quarantine measures to prevent the entry and establishment of pests associated with each commodity is more severe in the case of tomatoes. This would suggest a more stringent protection strategy is in place for larger industries in that regulatory authorities are prepared to accept a more substantial net welfare loss to maintain a pest free status than for smaller industries. The results indicate that to have a negligible economic impact, SPS measures must achieve a reduction in ED equivalent to 12.8 per cent of the total (post quarantine) producer surplus in the case of tomatoes, and 9.5 per

Table 1 Results

	Mangoes	**Tomatoes**
Minimum Value of ED_f Required to Offset GT_f	$ 188,000	$1,853,500
Minimum Value of ΔED Required to Offset ΔGT	$ 55,700	$ 784,700
Implied ED_{ALOP}	$ 132,300	$1,068,900
Post-Quarantine PS	$ 588,900	$6,123,400
ΔED as a Percentage of Post-Quarantine PS	9.5%	12.8%

ED_{ALOP} as a Percentage of Post-Quarantine PS	22.5%	17.5%

cent in the case of mangoes.

When related back to the total PS for each industry the implied ALOP is of similar magnitude for both the small and large industries. Based on the results, it could be postulated that ED_{ALOP} for WA related to interstate trade in a horticultural product is approximately 20 per cent of the total domestic PS of the industry concerned. To express this in a slightly different manner, in order for the ED_{ALOP} currently used as a 'standard' by WA regulatory authorities to protect against invasive plant pests endemic in eastern State and Territory growing regions to have a neutral impact on net social welfare, there must be believed to be at least a 20 per cent chance of losing the entire PS of relevant crops as an economic consequence of pest entry and establishment caused through interstate trade.

It is not surprising to find that ED_{ALOP} is much larger (in terms of dollar value) for tomatoes. Such a finding perhaps reflects the extent of linkages larger industries have throughout the rural community when compared to others of a smaller size, and the consequences of aharmful event to those members of the community employed along the *value chain*[10]. However, the inflationary effects of quarantine measures will also have a much larger impact on net social welfare change since the average consumer demands more of it in comparison to other commodities, like mangoes. Whilst it may be easier to justify protection to small and developing industries (i.e. having a relatively minor impact on net social welfare[11]), the ED_{ALOP} implied in Table 1 would suggest that larger industries receive a higher degree of protection.

It must be conceded that the commodities examined here are but two of a larger number of

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[10] See Islam and Johnson (1997).
[11] See Cook and Fraser (2001).

horticultural commodities trade across State and Territory borders. Nevertheless, this overall level of protection appears high considering the relative scarcity of historical cases where an entire group of plant industries have been lost completely as a result of pest incursion(s). This is especially true for mangoes given that pests entering the State in contaminated fruit through the Perth market must overcome considerable geographic obstacles if they are to become established in WA growing areas. Such a result is in some ways predictable considering the national ALOP has been described as "very conservative" (AQIS, 1999, Tanner, 2001). However, it must also be recognised that embedded within this value for the ALOP are a willingness to pay for environmental and social protection, and a possible risk premium reflecting the risk averse attitudes of policy-makers and the society they represent. Furthermore, it also captures a willingness to protect against cross-industry impacts where pests are not host specific[12]. What the results can not reveal is the relative proportion attributable to each component of this protection. Although ostensibly a means of protecting domestic agricultural industries, these external economies created by interstate quarantine measures are woven in to the mix of economic effects.

5. Conclusion

Although traditionally an area of science, this study has shown that economics can potentially play a prominent role in the design and implementation of quarantine policies. Information constraints concerning the likelihood of pest introductions and establishment, and their impact in environments they have not previously been observed in make it particularly difficult to design appropriate protection strategies with limited resources. However, the methodology employed in

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[12] Recall pests were simplistically assumed host specific in this analysis.

this study offers a way around such a problem by focusing on the social welfare effects of existing (interstate) quarantine policies and determining an implied ED_{ALOP}. The two case studies presented here show how such an estimate can be formed with a minimum amount of information by avoiding data-intensive bioeconomic modelling techniques. By providing an estimate of the ED_{ALOP} on a case-by-case basis, the extent of expected pest damage being prevented by quarantine can be viewed in relation to the size of the industries it endeavours to protect. In the cases of mangoes and tomatoes, it was found that the level of protection was high in relation to the size of the domestic industries, and that in general the ED_{ALOP} implied by current interstate import protocols was in the order of 20 per cent of the domestic post-quarantine producer surplus.

However, external economies produced by interstate SPS measures make it very difficult to separate this value into its component parts. Not only does it reflect the value of the industries protected by quarantine, but also community attitudes to environmental health, rural community cohesion, cross-industry impacts and to risk. These external effects partly explain why no trading nation has yet specified a level of protection appropriate for its individual circumstances, and why the use of techniques to extract implied levels of protection are required in the analysis of SPS policies. While this paper has demonstrated how such techniques can be used to provide enlightening information concerning the effects of interstate quarantine measures, placing emphasis on both producer and consumer effects, the issue of separating out the direct and indirect effects of quarantine remains a sizeable analytical challenge.

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