Exploring the Regional and Size-Related Implications of Interstate Quarantine Policies for WA Fruit and Vegetable Growers

David Cook and Rob Fraser[*]

As a signatory of the World Trade Organisation Agreement, Australia has a responsibility to ensure that the behaviour of its internal markets for food and food-related products abide by the same rules and regulations as international trade. There is therefore an increasing need to demonstrate the validity of any measure which restricts competition between production centres to ensure against an appeal and/or retaliatory actions by trading counterparts. This paper explores two economic evaluation techniques which can be used to examine the welfare implications of quarantine policies imposed on interstate trade, and discusses practical applications of each with the aid of two case studies. One approach relies on an aggregated, industry-wide perspective, and is shown to be most appropriate when the cost characteristics of an industry's component growing regions are similar. The other focuses on spatial elements of a domestic industry, which is best used when there are significant cost differences between component producing regions. In addition to examining the accuracy of these techniques in policy analysis, the size characteristics of the industries they can be applied to are also analysed. Using the examples of the mango and tomato industries in Western Australia, both of which enjoy quarantine protection from interstate growers, it is shown that the consumer welfare implications of competition restrictions outweigh producer welfare implications in larger industries, and vice versa.

1. Introduction

In the modern climate of market globalisation and the expansion of international trade, increasing emphasis is being placed on methods of assessing the use of quarantine as an instrument of protectionism. As a major food exporter, Australia has the potential to flourish in the global market place, but it must be seen to be playing by the rules if it is to avoid retaliatory action by trading counterparts which will offset the gains to international trade. Being 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) measures are compliant with the rules and 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.

To date, there have been very few quantitative economic assessments performed on quarantine issues within Australia. Those which have been put forward have typically dealt with issues in aggregate, that is, at the level of industry. James and Anderson (1998), for example, employed a static, partial equilibrium framework to explore national banana quarantine issues. As yet however, there have been no direct comparisons drawn between industries with different size and spatial characteristics. Intuitively, policy-induced price changes in larger industries may have large consumer welfare implications relative to producer welfare, that in turn may affect the economic viability of quarantine policies. Furthermore, in a state such as Western Australia (WA) with a large land area, and climatic and geographical diversity, it is frequently the case that both large and small agricultural industries are fragmented into smaller production

regions, each of which is characterised by a different set of production circumstances. It follows that the

capacity of each region to absorb the impacts of varying degrees of competition may be quite different, as dictated by their production costs. These spatial differences within an industry are not captured by an aggregated assessment.

Respectively, these issues pose two important questions for economic analysts providing information to decision-making bodies about the full implications of interstate quarantine policies. Firstly, *does the size of a particular industry have a major bearing on the viability of competition-restricting quarantine regulations, or the ease with which they can be justified using a static, partial equilibrium trade model?* And secondly, *is an aggregated, industry-wide approach to modelling the effects of quarantine measures appropriate where there is significant variation in cost structure between production regions within a particular industry?* This paper seeks answers to both of these questions embedded in partial equilibrium analyses of two WA horticultural industries protected by interstate quarantine regulations, mangoes and tomatoes. The structure of the paper is as follows. Section 2 sets out the background to the issues addressed in the paper. Section 3 develops the models to be used in the analysis, including the specification of the aggregated and spatial approaches. This is followed by details of the results for the two case studies, mangoes (section 4) and tomatoes (section 5). These results are interpreted in section 6, and the paper ends with a brief conclusion.

2. Background

As a signatory of the WTO Agreement, established at Marrakesh on the 15th April 1994, the federal government of Australia has an obligation to ensure the nation's internal markets for agricultural products closely resemble those of international markets with respect to technical barriers to trade. Following the Uruguay Round of General Agreement on Tariffs and Trade (GATT) talks, concerns that the trend towards free trade may be offset by the use of alternative protection techniques began to surface. Whilst tariffs and quotas constituted the primary trade weapons of the protectionism of the late 1970s and the 1980s, the key instrument of what can perhaps best be described as *new protectionism* is quarantine. In response to the concerns about its use as a trade barrier an agreement on Sanitary and Phytosanitary (SPS) measures was negotiated to ensure that future SPS trade restrictions were based on scientific information (James and Anderson, 1998). In this agreement, henceforth refereed to as the SPS Agreement, is contained Commonwealth and State obligations and responsibilities relating to "…all sanitary and phytosanitary measures which may, directly or indirectly, affect international trade" (Article 1).

Annex A1 of the SPS Agreement specifically defines SPS measures as any measure applied:

(a) to protect animal or plant life or health within the territory of a Member from risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms;

(b) to protect human or animal life or health within the territory of a member from risks arising from additives, contaminants, toxins, or disease-causing organisms in foods, beverages or foodstuffs;

(c) to protect human life or health within the territory of a Member from risks arising from diseases carried by animals, plants or products thereof, or from the entry, establishment or spread of pests; or

(d) to prevent or limit other damage within the territory of a Member from the entry, establishment or spread of pests

(GATT, 1994)

Any such measure taken against one Member by another which directly or indirectly affects international trade may be challenged through the WTO dispute settlement process.

Since the food safety and animal and plant health regulations relating to interstate trade within Australia are often set by state and local government authorities, decisions made at all levels of government have the potential to be challenged. This is recognised in Article 13 of the SPS Agreement, which requires the central 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). Accordingly, a Memorandum of Understanding between the Commonwealth of Australia and all States and Territories (henceforth referred to simply as "the Memorandum") was signed on the 21st of December 1995 in which parties agreed to act in accordance with relevant obligations under the SPS agreement (Commonwealth of Australia, 1995). Article 11 of the Memorandum stipulates:

> States and Territories shall not apply any relevant sanitary and phytosanitary measures within their jurisdictions which would not conform with the provisions of the SPS Agreement.

The "provisions" referred to 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.

In a general sense then, any measure applied to imported products by any level of government to protect human, animal or plant health must be based on 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 (Miller, 1999).

To help bring the collective Australian quarantine system in line with these international provisions, a review of Australia's quarantine system was initiated by the Hon. Bob Collins, Minister for Primary Industries and Energy, in December 1995. The committee appointed to carry out the review was chaired by Emeritus Professor Malcolm Nairn, which presented its findings to the Minister in November 1996 in the form of a report titled *Australian Quarantine: A Shared Responsibility*, widely referred to as the Nairn review. The report put forward 109 recommendations on how Australia's quarantine system could be improved to comply with WTO regulations, concentrating on a range of areas such as environmental awareness, community awareness, risk analysis, consultation in policy-making, surveillance and preparedness.

With regard to risk analysis, the report makes it clear that the pursuit of a "zero risk" quarantine structure is nonsensical. The sheer abundance and diversity of quarantine pests makes zero risk an impossibility, so a much more realistic basis for Australia's quarantine system is "manageable risk". At the core of this concept is *risk analysis*, which is a general term to encompass the elements of:

- Risk Assessment – the process of identifying and estimating risks associated with a policy option and evaluating the likely consequences of taking those risks.

- Risk Management – the process of identifying, documenting and implementing measures to reduce these risks and their consequences; and

- Risk Communication – the process of interactive exchange of information and views concerning risk between analysts and stakeholders (Nunn, 1997; Nairn *et al*, 1996).

By utilising risk analysis techniques, the Nairn review suggested, quarantine could be targeted at areas representing the greatest risks and so produce the highest social and environmental returns with available funds. The report went on to suggest several fundamental principles to be included in the analytical process, which included:

- stakeholder/industry consultation

- objectivity and robustness in scientific methodology and political independence

- transparency

- consistency and harmonisation

- subject to appeal on process, and

- subject to periodic external review.

A successful risk assessment should, in essence, exhibit each of these principles if it is to facilitate a socially-optimal allocation of scarce quarantine resources.

An official response from the federal government to the Nairn review and its recommendations was not put forward until August 1997 (DPIE(1997)). This was to come in the form of a joint response to the Committee's report and the report of a National Task Force on Imported Fish and Fish Products presented to the government in December 1996 (DPIE (1996)[1]). While not accepting all the recommendations of the review committee, the response acknowledged the need for Australia's acceptance of the rules and guidelines of international trade to which it expects trading partners to adhere to. To bolster the national quarantine system, it indicated that additional funding of A$76 million would be delivered over the proceeding four years and be targeted towards increasing community awareness, manageable risk (science-based), protection of Australia's unique environment and recognition of the continuum of quarantine (Tanner and Nunn, 1998). The report also expressed the government's endorsement of the risk analysis process put forward by the Nairn review, with only a few minor changes[2].

It must be acknowledged that the appropriate role for economic analyses in determining manageable risk is subject to a considerable amount of conjecture. Perhaps the most significant explanation lies with the fact that WTO-consistency and economic efficiency are not necessarily complementary concepts. In a comprehensive discussion of this issues, James (1999) asserts that Risk Assessment should lie within the realms of science, and "Risk Management…is the proper (and WTO-legal) place for economic analysis…[since] there are no limits on factors which can be considered by authorities in risk management decisions". Although such a strict partitioning of the risk analysis process is by no means accepted practice, it is envisaged that the results presented here would be of optimal use if this were the case. Hence, the purpose of this research is to explore empirical issues arising where *economic analysis* forms part of a multi-faceted quarantine policy aid.

In cases where regulatory measures protect non-market goods as well as market goods, a narrow single commodity, partial equilibrium framework (often the most feasible tool for specific

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[1] The National Task Force on Imported Fish and Fish Products was established in June 1995 to examine issues related to imports of aquatic animals and their products. Particular emphasis was placed on quarantine issues raised in a significant scientific review of aquatic animal health and quarantine (Humphrey (1995)) and the recommendations of a national working party that examined this review (Nunn (1997)) (Tanner and Nunn, 1998).

[2] These included a decision not to establish the Australian Quarantine and Inspection Service (AQIS) as a statutory authority, and another not to establish a centre for quarantine-related risk analyses. In regard to the latter, the government's response indicated that AQIS and the Bureau of Resource Sciences (BRS) would continue to provide risk analysis services (DPIE, 1997; Tanner and Nunn, 1998).

regulatory proposal analyses (Roberts, 2000)) must be supplemented by other information. For instance, when compared to agricultural commodities with an easily expressed annual value, the natural environment presents a far more complex analytical challenge. For not only may it (or its components) have an annual value in terms of use, it may also have existence, bequest or moral values which are dependant on its continued existence, and which could extend over generations in time (Mumford, 2000). Similar issues may arise when dealing with human health and socioeconomic effects of quarantine. Identifying and capturing these values using stated or revealed preference techniques which are both accurate and cost-effective remains a considerable challenge for analysts. However, the exclusion of such information from a regulatory decision-making process would result in policies reflecting an inaccurate interpretation of social values, and consequently a sub-optimal quarantine risk management strategy.

3. The Model

The spreadsheet model used in this investigation was designed for use with a minimum amount of information. It comprises two sections, one performing an aggregate assessment, and the other a spatial assessment of the domestic economic consequences of interstate quarantine policy. Hence, it is able to provide policy analysis at both a *macro* and the *micro* economic level.

The first section provides an aggregated assessment of the impact of interstate quarantine requirements. It uses time series price and quantity data from the Perth wholesale fruit and vegetable market, *inter* and *intra*-state production costs, estimates of demand and supply elasticities and marketing margins, and calculates the net welfare effects of quarantine protocols from an industry perspective. It does so by calculating *Producer Surplus* (PS) and *Consumer Surplus* (CS) under a closed economy, a free trade, and a quarantine-restricted trade scenario[3]. By comparing these, the model estimates the change in net economic welfare induced by quarantine protocols for agricultural commodities, which in turn is used to form an estimate of the expected production gains (as a result of quarantine procedures restricting the entry of destructive pests to WA) required for the policy to break even. This is based heavily on the model presented in James and Anderson (1997) which was used to assess national economic welfare implications of restricting banana imports to Australia.

The second section of the spreadsheet model is used to explore the effects of quarantine policies in specific growing areas. It uses domestic production cost information to calculate regional industry profit under the same three scenarios outlined above. Effectively, this analysis transforms the aggregated analysis to a level closer to an individual grower's perspective. It can be used to indicate a price below which losses will be minimised by local growers if they simply cease all production. In doing so, the model provides an indication of the viability of the enterprises concerned in the respective growing areas, and their resilience in the face of quarantine policy changes and different degrees of interstate competition.

3.1 Simplifying Assumptions

To maintain a level of simplicity conducive to the effective communication of results to multidisciplinary decision-making bodies, it is useful to employ several assumptions concerning the nature of fruit and vegetable markets in WA. While more complex methodologies can be

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[3] Only under certain strong assumptions (ie. quasilinear utility for consumers) can the concepts of CS and PS be used to measure exact welfare change. Nevertheless, they are often used as an approximation in applied work to generate valuable insights into "real world" welfare implications (Varian, 1992). In the closed economy situation, Figure 1 (p. 7) shows CS as the area AE_cP_c, and PS as OE_cP_c. Measuring changes to these areas induced by quarantine policy changes provides an approximate measure of welfare change.

used to examine the impact of pests, using techniques such as Markov chains to model the dynamics of pest spread and impact[4], constraints on input data and extension limit the effectiveness of these in practice. Instead, the emphasis here is on (potentially) pest-affected markets, rather than the nature and dynamics of pest impact. It is assumed:

(1) The domestic markets for fruit and vegetable products (at least those modelled) are perfectly competitive. Growers within a production region have access to the same technologies and production information, and are equally proficient in production;

(2) WA is a "price-taker" in that the size of its fruit and vegetable industries are insufficient for domestic market variability to directly influence national (or international) market prices;

(3) Modelled products are homogenous, there being no distinction made between individual varieties of the same product type;

(4) Consumers and producers exhibit a neutral attitude to risk[5];

(5) Potentially imported agricultural pests attack one host exclusively, with no polyphagous tendencies which might affect other industries;

(6) Under quarantine restricted trade, the onus is on importing centres to abide by certified protocols, bearing any necessary costs in order to do so (James and Anderson, 1998).

3.2 The Aggregate Benefits of Interstate Quarantine Protocols

The following discussion[6] is centred around the domestic market for the commodity x as depicted in Figure 1. Consider firstly a closed WA economy where no trade in x takes place with the eastern states of Australia (or international centres). Ignoring the D_R, D_W and S^* curves initially, assume local suppliers face a downward sloping demand curve (D_F) for their product in the domestic market, and an upward sloping supply curve (S). The intersection of these two curves (at E_c) determines the domestic, or closed economy producer price (P_c) and quantity supplied at this price (Q_c), and is termed the *closed economy* equilibrium.

Before moving on, it is necessary to incorporate marketing margins into the model to properly examine the social welfare implications of interstate quarantine restrictions. Most WA fruit and vegetable growers sell their wares on the Perth market through a market agent[7], who in turn sells them to retail outlets, from which they are purchased by consumers. The size of the marketing margins applied at each stage and the manner in which they're applied is difficult to verify. Sources close to the market indicate wholesale margins to be in the order of 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). Further details of the idiosyncratic nature of fruit marketing are difficult to extract, and hence marketing margins are assumed constant in percentage terms. Consequently, the model infers that (generally) the price paid for x "at the farm gate" is around 12.5 per cent below the wholesale price of fruit and vegetables, which in turn is approximately 33 per cent below the retail price.

Figure 1 shows the demand curves for x at the wholesale and retail level as D_W and D_R respectively. For the most part the D_W curve can be ignored since demand at the retail level is of primary concern. Looking once more at the closed economy equilibrium, when the producer
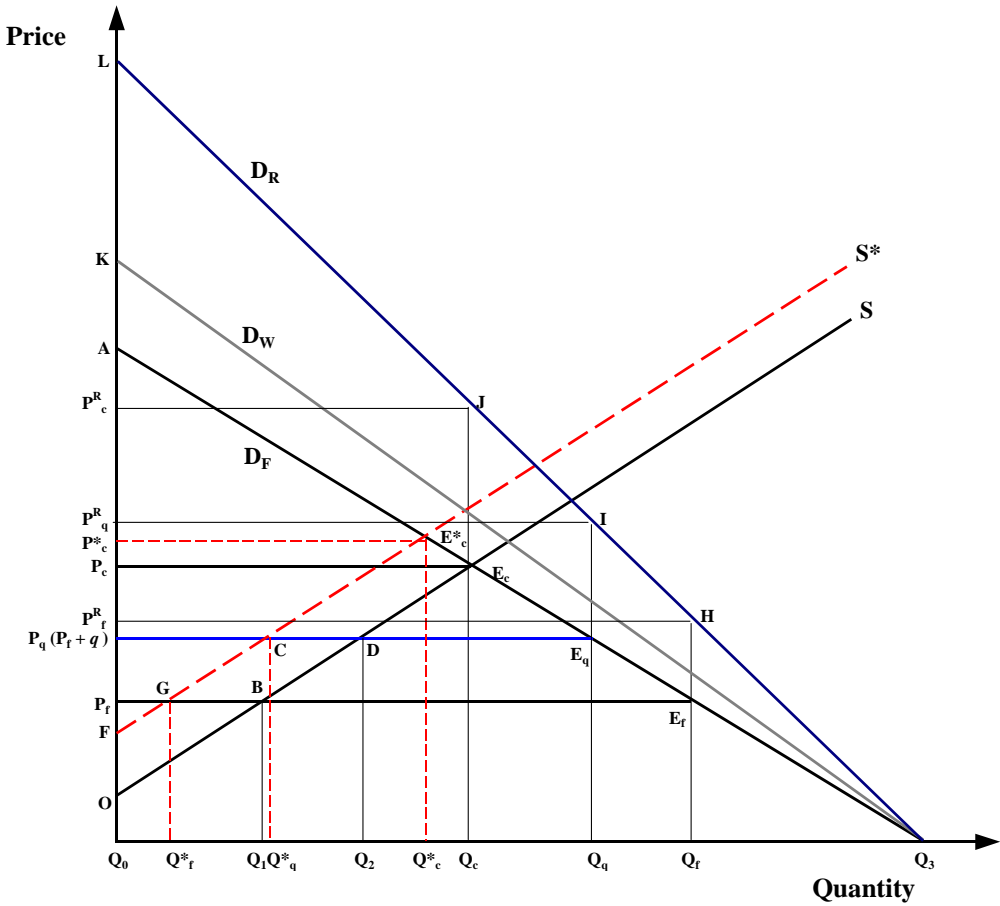
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[4] See Hinchy and Fisher (1991).
[5] While this approach may seem simplistic, Fraser (2000) asserts that the impact of risk in determining the net effect of quarantine policies on an industry is relatively minor.
[6] Presented in full in Cook (2000).
[7] There are around 23 Perth market agents in WA (PMA, pers comm, 23/11/99).

Figure 1: *Interstate Import Clearance & Social Welfare Loss*

price is P_c and the quantity supplied is Q_c, the corresponding retail price is P^R_c. Therefore, although PS remains constant, CS with marketing margins in place becomes P^R_cJL. If the market is now opened up for unrestricted trade with other states, WA suppliers will be thrown into direct competition with imported product. Instead of dictating terms in the market, WA producers will become price-takers assuming the prevailing state producer price (P_c) exceeds the national producer price (P_f) (CIE, 1988). At P_f domestic suppliers are willing to supply Q_1, while demand is Q_f. Hence, Q_f-Q_1 is made up by imported fruit. As it has been drawn in the diagram, CS increases by the area P^R_cJHP^R_f (i.e. from P^R_cJL to P^R_fHL) as the economy is opened up to free trade, and PS decreases by the area P_fBE$_c$P$_c$ (i.e. from OE$_c$P$_c$ to OBP$_f$). With this information it is possible to calculate the net gains by subtracting the loss in PS from the gain in CS. In the case of the economy moving from a state of autarchy to one of free trade net gains can be calculated as (P^R_cJHP^R_f – P_fBE$_c$P$_c$).

The presence of pests in the eastern states of Australia which are exotic to WA means that a free trade regime maximises the risk that one or more of these pests will gain entry to the state via interstate trade (there being Q_f-Q_1 imports entering WA free of screening mechanisms). It is for this reason that the Western Australian Quarantine and Inspection Service (WAQIS) imposes restrictions on imported commodities (such as heat and chemical treatment, fruit sampling, and the like) designed to reduce the probability of importing exotic pests. Suppose then a quarantine restriction on imported *x* is introduced in an effort to decrease the likelihood of pest entry. The cost to external (i.e. to WA) producers of complying with the specified protocols, *q*, is passed on to consumers as higher prices. Hence, with the quarantine restriction in place the market faces

the producer price P_q and retail price P^R_q. At this price, consumers remain better off than under the closed economy scenario, but worse off than under a free trade regime. Their CS is now $P^R_q IL$, an increase of $P^R_c JIP^R_q$ relative to autarchy. The opposite is true of producers, being worse off than under autarchy and better off than under free trade. The PS is now ODP_q, a decrease of $P_q DE_c P_c$ relative to the no trade situation. Therefore, the net gains of quarantine restricted trade as opposed to a closed economy can be calculated as $P^R_c JIP^R_q - P_q DE_c P_c$.

Using this framework, the impact of quarantine restrictions on CS and PS are clearly seen. Consider what happens when there is an incursion of an exotic pest which is highly host-specific. Once it has entered and been detected, certain measures will be taken to manage the spread of the pest according to its biological characteristics, the existence of nationally co-ordinated management strategies, the size and structure of the affected market, and so forth. For now, assume the impact of these management strategies is to raise the domestic cost of x production. In the absence of any demand shocks domestic supply will contract from S to S* while the volume of x imported increases[8]. Under the quarantine restricted price P_q domestic supply will be Q^*_q, and imports Q_q-Q^*_q. Domestic CS will remain constant at $P^R_q IL$, and PS will contract to FCP_q. Therefore, the net loss to the WA economy of importing the pest becomes the area ODCF.

An estimate of the potential economic benefits and costs of adopting any one strategy (either a free trade policy or quarantine restricted trade) can now be calculated by comparing the net gains from trade with the potential loss of domestic PS should a pest enter. For instance, the potential net benefits to a free trade policy (PB_{ft}) relative to a closed economy situation are given by:

$$PB_{ft} = (P^R_c JHP^R_f - P_f BE_c P_c) - (p \times OBGF) \quad (1)$$

where;

$$p = \text{probability of pest entry under free trade}$$

$$P^R_f HJP^R_c - P_f BE_c P_c = \text{net gains from trade under a free trade regime}$$

$$OBGF = \text{potential loss of PS under free trade}$$

With unrestricted trade, p is expected to be relatively high when compared to a restricted environment assuming quarantine only affects the probability of a disease outbreak, and has no impact on the severity. The potential net benefits to a quarantine restricted trade policy (PB_{qt}) with respect to a closed economy situation is calculated as:

$$PB_{qt} = (P^R_c JIP^R_q - P_q DE_c P_c) - (p^* \times ODCF) \quad (2)$$

where;

$$p^* = \text{probability of pest entry under quarantine restriced trade (i.e. } p^* < p)$$

$$P^R_c JIP^R_q - P_q DE_c P_c = \text{net gains from trade under a quarantine policy}$$

$$ODCF = \text{potential losses to PS brought about by a pest incursion.}$$

If expected losses under a free trade regime are sufficiently low when compared to those expected under a quarantine policy, then it is very difficult to justify this protection. On the other hand, if the pests which could potentially enter WA through imported x are capable of inflicting severe damage, it may be that free trade is not worth the risk. By simply subtracting (2) from (1), an expression is derived indicating the potential benefit of quarantine policies relative to free trade ($PB_{qt/ft}$):

$$PB_{qt/ft} = [(P^R_c JIP^R_q - P_q DE_c P_c) - (p^* \times ODCF)] - [(P^R_c JHP^R_f - P_f BE_c P_c) - (p \times OBGF)] \quad (3)$$

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[8] It is conceivable that consumers will switch to rival goods if the pest has a negative impact on "product image". However, the model ignores this possibility, recalling assumption (3) above.

Estimating ($p^* \times$ ODCF) and ($p \times$ OBGF), the expected losses to PS from pest incursions under quarantine and free trade respectively, involves a high degree of subjectivity. An alternative is to calculate ($P^R_c JIP^R_q$ - $P_q DE_c P_c$) - ($P^R_c JHP^R_f$ – $P_f BE_c P_c$), the total net welfare loss to society resulting from choosing quarantine restrictions over free trade, and assume the policy will break even (i.e. total net gain = total notional PS loss):

$$(P^R_c JIP^R_q - P_q DE_c P_c) - (P^R_c JHP^R_f - P_f BE_c P_c) = (p^* \times \text{ODCF}) - (p \times \text{OBGF}) \qquad (4)$$

or

$$(P_f BDP_q - P^R_q IHP^R_f) = (p^* \times \text{ODCF}) - (p \times \text{OBGF}) \qquad (5)$$

In doing so, it is possible to estimate the minimum value of the right hand side of (4) necessary for the policy to be justified on economic grounds. Comparing the figure on the right to an estimate of total PS in WA "post-quarantine restriction" allows the expected damage to the domestic x industry which is avoided by trade restrictions to be placed in perspective[9].

Efforts to keep part A simple still result in there being a considerable demand for accurate information, much of which is not available at a state level. However, extensive sensitivity analysis has revealed the model's relative insensitivity to all but a select few input variables[10]. While the model does not appear to be overly sensitive to changes in the elasticity of demand or the elasticity of supply, changes in the price under autarky (P_c) cause slightly more than proportional changes in net welfare loss of the same sign. This suggests a mild sensitivity to P_c. However, the areas of highest sensitivity are associated with the free trade price (P_f) and post-quarantine price (P_q). The former displays a negative relationship with the net welfare loss, and the latter a positive relationship. Relatively small changes in these values have a large impact on the net welfare loss, which is easily explained in terms of Figure 1. Sensitivity analysis alters the vertical distance between P_f and P_q, thus affecting the size of the areas $P^R_q IHP^R_f$ (the opportunity cost of maintaining quarantine protocols) and $P_f BDP_q$ (the gain in PS). It follows that raising the value of P_f diminishes the loss in CS and gain in PS, whilst the opposite effect is had by increasing P_q.

3.3 The Spatial Estimation Technique

In a state as large as WA the technical conditions of production are seldom equivalent across all producers and production regions. Where conditions vary between different growing areas, the Marginal Cost (MC) and Average Variable Cost (AVC) curves (and the Total Cost (TC) curves from which they are derived) also vary. For example, x may present a viable option in several different growing areas despite certain regions being more suited to its production than others. Where this is the case, separate assessments may be made of PS accruing in different areas facing different AVCs. Assumption (1) stated that growers within specific regions face equivalent technical production conditions, whilst those in other regions will vary according to the growing environment. So, by aggregating growers from each region, the impact of varying degrees of competition (i.e. closed economy, quarantine-restricted trade and free trade) on each can be determined.

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[9] Although this methodology has proved to be applicable in quantitative evaluations (e.g. James and Anderson (1998)), it contains several shortcomings which are important to note. These include: a). PS losses are calculated on the assumption of zero opportunity cost, as a result of which producer losses may be overstated (Sinner, 1999); b). the analysis is industry specific, and does not allow for cross-industry impact analysis; and c). concise information on marketing margins, particularly at the retail level, is difficult to come by.

[10] See Cook (2000).

Figure 2: *The Regional Impact of Quarantine Protocols*
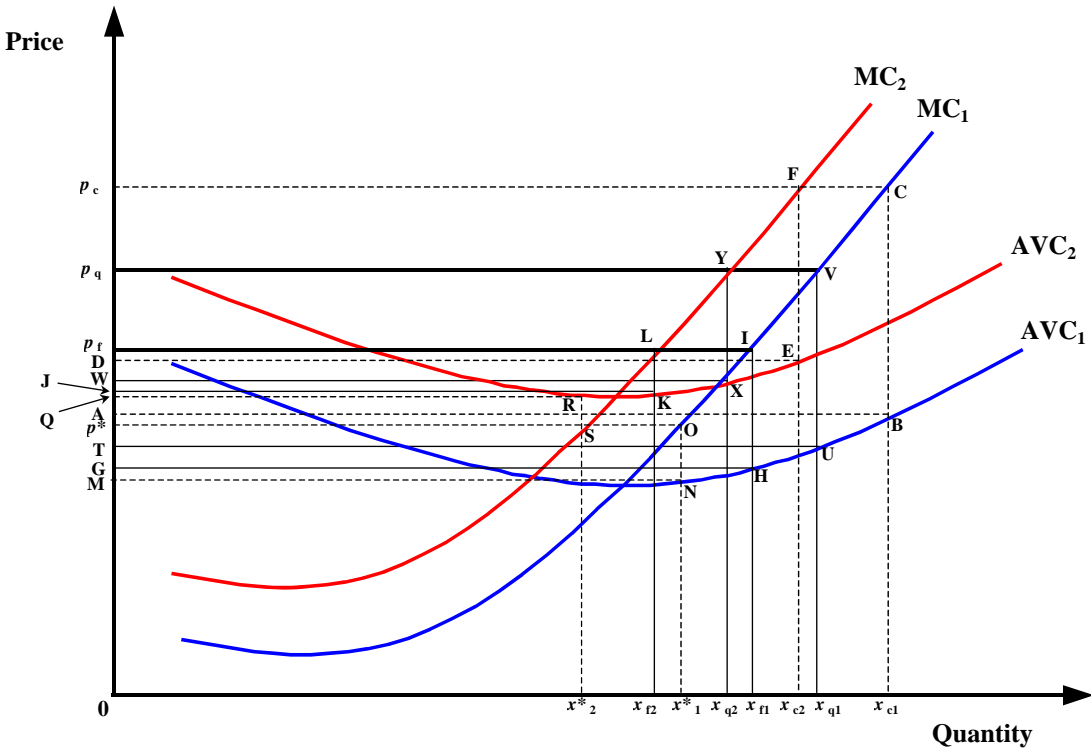
Assume, for instance, that there are two x producing regions within WA, call them regions 1 and 2. Let region 1 be characterised by a relatively low cost of production and region 2 by a relatively high cost of production. If the technical conditions of producing x in each area are such that the TC function is characterised by increasing returns to factor inputs up to some high-output capacity, after which decreasing returns set in, the AVC curve will be as depicted in Figure 2. This diagram illustrates the impact of price changes on regional industry profits by plotting the MC and AVC curves for both, and the demand (or price) curve faced under different quarantine regimes.

Consider firstly a closed economy situation where competition from rival producers in other States and Territories within Australia is completely restricted, and domestic producers face a price p_c for x. Region 1 will maximise profits by producing a level of output x_{c1} (i.e. $p_c = MC_1$), where profit is indicated by the area $ABCp_c$ (i.e. $(p_c - AVC_1) \times x_{c1}$). Region 2 will behave in exactly the same manner, producing x_{c2} to maximise its profit at $DEFp_c$ (i.e. $(p_c - AVC_2) \times x_{c2}$). Since it faces a higher cost of production, it is impossible for region 2 to enjoy the same profit margin as region 1, but so long as the price paid for its output remains above the minimum value of AVC_1 short-run profits will be positive.

Now assume that the ban on interstate produce is lifted, and goods are permitted to move across state borders into WA unimpeded. Suddenly the priced faced by domestic producers will fall to the national, or free trade level p_f. Region 1 will adjust its output in response, choosing to produce the lower quantity x_{f1}, where profit is maximised at $GHIp_f$. Region 2 will also adjust its output to a new lower level x_{f2} where its profit falls to the area $JKLp_f$. Hence, both experience a significant loss of profit under the increased competition from growers elsewhere in Australia, but both remain profitable since p_f exceeds the minimum value of AVC_1 and AVC_2. The extent of this loss relative to the closed economy situation for region 1 is represented by ($ABCp_c$-$GHIp_f$), and for region 2 by ($DEFp_c$-$JKLp_f$).

Had the free trade price been lower however, say p^* for instance, the situation would be quite different. At this price, region 1 must reduce output even further (to x^*_1) to maximise its

profit, which declines to the area MNOp^*. If region 2 were to follow suit and produce x^*_2, it would make a loss of QRSp^* since AVC$_2$ exceeds p^*. Producers in the region would be better served producing zero output in order to minimise short-run losses, so they do not demonstrate the same capacity to absorb the impact of competition when compared to the lower cost region 1. In effect, region 2 will pay the price for its inefficiency by being squeezed out of the market entirely while efficient producers remain. It can be argued that herein lies one of the principal benefits of increased competition, but there are a host of other factors which need to be considered - not the least of which are adjustment costs for secondary domestic industries in the value chain for *x* and socio-economic impacts associated with the loss of income to communities in region 2.

Since free trade maximises the risk of importing exotic pests from other States and Territories of Australia, assume quarantine protocols are employed in the market for *x* such that consignments moving into WA must undergo specified treatments before they can be sold on the Perth wholesale market. If the cost of these treatments inflate the market price from p_f to p_q region 1 will choose to expand its output to x_{q1} to maximise profit at TUVp_q. Region 2 will do likewise and produce x_{q2} to earn a profit of WXYp_q. Hence, the former's decrease in profit relative to the closed economy situation is represented by (ABCp_c-TUVp_q), and the latter's by (DEFp_c- WXYp_q).

The extent of changes to profit in each region brought about by different quarantine strategies can not be fully appreciated in an aggregated model. Whilst it requires a more detailed knowledge of the cost curves faced by different producing regions, the spatial approach demonstrated above has the advantage of supplying the policy-maker with an indication of where the highest losses or gains will be felt under different quarantine circumstances. This raises certain problems from an analytical point of view in the sense that it is not clear when an aggregated model with a relatively low demand for input variables is appropriate, and when a more detailed, spatial assessment is necessary. It is this dilemma which is to be explored the following sections through the use of two case studies involving mangoes and tomatoes.

4. Case Study 1 – Mangoes

4.1 Western Australian Production

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*), and a pilot eradication programme is currently underway in the Broome region to provide information for future feasibility studies of more extensive campaigns.

4.2 Import Protocols for Mangoes

Although mango trees are relatively hardy, there are several pests which pose a significant threat to their health and productivity. Because of WA's freedom from many major pests, quarantine plays a vital role for the domestic industry (Strickland, 1992). 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 if outbreaks (if and when they occur) are not detected and treated early, and/or to add significantly to the marginal costs of production if they were to 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.

Protocols to prevent the introduction of Fruit Flies to the state are very specific. In the case of Q-fly, they require product from all states and Territories to be certified as having been immersed in a dip containing 400mg/L of dimethoate or fenthion for 1 minute; or having been flooded as part of a single layer of produce with 400mg/L of dimethoate or fenthion at ambient temperature in a high volume application of at least $16L/m^2$ per minute for at least 10 seconds and as having remained wet for at least 1 minute before drying; or having been fumigated with methyl bromide at rates between 24 g/m^3 (at 26° - 31.9°C) and 48 g/m^3 (at 10° - 14.9°C) for 2 hours. at one of the following rates (WAQIS, 1999). Dipping or flood spraying must be the last treatment before packing (Scott, 1998).

Detection of MSW requires the fruit to be dissected and inspected for evidence of larvae in the seed, as the name would suggest, rendering it unfit for sale. A property wishing to export to WA must undergo sampling for two years prior to the first consignment being permitted across the border to demonstrate *property freedom.* This involves up to 4,000 fruit being inspected at the commencement of each season. If approval is given by the Western Australian Quarantine and Inspection Service (WAQIS) and export takes place, a market sample of 600 fruit will be taken either prior to or immediately upon arrival. Maintenance of property freedom is accepted on the basis of there being no MSW infestation within 50km of the property, and no detection in annual fruit sampling or consignment sampling (WAQIS, 1999; Manbulloo Mangoes Australia, pers comm, 26/8/99).

4.3 Variables

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

Marginal Cost (MC) - In a competitive environment the MC curve for a particular growing region represents its supply curve. Since MC is assumed to become infinitely elastic at prices below the minimum AVC of the region (as the cost minimising decision for producers becomes zero output), the portion of the curve above AVC is of primary interest. The model assumes that the own-price elasticity of this supply curve can be approximated by that of the industry supply curve. However, 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". Certainly from a state perspective, it would appear that the situation has changed very little. Nevertheless, 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[11].

Average Variable Cost (AVC) - production costs for each growing region are provided in White (1997). No other source for this information in WA has been found, making it impossible to cross reference the "best bet" values. On this basis AVC for the Central statistical division are specified as **$1,440/tonne** post-quarantine and **$1,470/tonne** under a closed economy, and as **$1,460/tonne** and **$1,490/tonne** under a closed economy for the Kimberley statistical division.

Post-Quarantine Quantity Supplied (Q_q) - 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 (P_q) - 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 (P_c) - 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 (P_f) - 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

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[11] The significance of this assumption, and hence the importance of the subjectiveness surrounding the best bet value is explored in Cook (2000). With relatively small price changes, the sensitivity of net welfare change resulting from the quarantine policy to the elasticity of supply is very low.

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 - These are of most importance to the aggregate model. The size of the marketing margins applied at the 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.

4.4 Results

Modelling the effect of quarantine protocols on the domestic market for mangoes using best bet values produces the following results. These have been grouped into two parts, one presenting results of the aggregated modelling approach, and the other presenting the results of the spatial estimation technique.

Table 1: Results (Aggregate): *Quarantine Protocols for Mangoes*

	Free Trade	Post-Quarantine Restriction
Price (Farm Gate)	$ 1,750	$ 1,800
Change in CS	$ 492,898	$ 357,436
Change in PS	$ (304,870)	$ (225,124)
Net Economic Welfare Gain	$ 188,028	$ 132,312
Change in Economic Welfare	$ (55,716)	
Approximate PS Under Quarantine Restricted Trade	$ 588,945	
Break Even Probability of Incursion	9.5%	

<u>Note</u> *- brackets indicate negative values*

Here the base case is a closed economy, so the changes in CS and PS indicated in Table 1 reflect changes relative to autarchy. It is therefore to be expected that both the quarantine restricted trade and free trade scenarios will produce benefits for consumers at the expense of producers. The total change in economic welfare for the WA economy associated with each scenario respectively is calculated by summing the change in CS and PS. Using these calculations, the overall change in economic welfare resulting from the inflationary effects of quarantine protocols

above a free trade level is then estimated as the difference between net welfare gain under both scenarios.

The estimated PS under quarantine restricted trade is derived in a simplistic way. It relies on the assumption of a linear demand curve, the slope of which is estimated using the point elasticity from which the free trade quantity supplied was calculated[12]. Using this estimate, a break even probability can be formed which merely determines the probability of losing the entire PS necessary for the policy to break even. To put this another way, Table 1 suggests that the expected benefits for producers of reducing the probability of pest entry and establishment through quarantine protocols for mangoes must constitute around 9.5 per cent of the total PS (under quarantine restricted trade) in order to justify the loss in total economic welfare.

<u>**Table 2: Results (Spatial):** *Quarantine Protocols for Mangoes*</u>

Cost Curve & Quantity Information:

	Kimberley (Kununurra)	Central (Carnarvon)
Average Variable Costs Under Closed Economy ($/T)	$ 1,468	$ 1,493
Average Variable Costs Post Quarantine ($/T)	$ 1,437	$ 1,462
Quantity Supplied Under Closed Economy (T)	661	860
Quantity Supplied Post-Quarantine (T)	608	791

Price Information:

	Farm Gate	Wholesale	Retail
Closed Economy Price ($/T)	$ 1,946	$ 2,189	$ 2,919
Post-Quarantine Price ($/T)	$ 1,800	$ 2,025	$ 2,700

Short-Run Profit:

	Central	Swan Coastal Plain	INDUSTRY TOTAL
Profit Under Closed Economy	$ 319,289	$ 393,987	$ 916,159
Profit Post-Quarantine	$ 220,747	$ 267,476	$ 588,945

Table 2 includes profit figures for both of the significant growing regions in WA. Production figures from the Australian Bureau of Statistics (ABS) used in this analysis group centres by statistical division. As a consequence, and in the absence of accurate information on the sources of mangoes passing through the Perth market over time, production from Carnarvon and Geraldton have been combined in the Central statistical division. Collectively, the regions modelled account for over 90 per cent of total mango production in WA (ABS, 1998; White, 1997). Recall that the sum of profits from each region given any one scenario (i.e. closed economy, free trade or quarantine restricted trade) equates with the total profit estimates in the aggregate model.

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[12] Given the quarantine restricted trade price and quantity information from PMA time-series data, and the free trade price derived from eastern states grower costs and freight to the Perth market, the quantity supplied by WA growers under free trade can be estimated using a point elasticity. Due to the lack of more comprehensive information concerning the nature of the demand curve for mangoes, assume the elasticity between these two price and quantity combinations can be approximated by the national own-price elasticity of demand put forward in Kane (1989).

5. Case Study 2 – Tomatoes

5.1 Western Australian Production

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).

5.2 Import Protocols for Tomatoes

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 several other species of quarantine significance are mentioned below.

Protocols to prevent the introduction of Fruit Flies to the state are the same as those outlined in section 4.2. A closely related species to Q-fly is *Bactrocera neohumeralis*, which is also exotic to WA and a quarantine concern. The two are so similar that they have been shown to mate and produce fertile offspring under laboratory conditions, although in the wild they are prevented from doing so due to different mating times (Gibbs, 1967). Also of quarantine significance is Cucumber Fly (*B. cucumis*), which is essentially a tropical species restricted mainly to a relatively narrow fringe on the east coast of Queensland and the northern extremes of the Northern Territory (HPC, 1991). To prevent the entry of these species (collectively) from Queensland, New South Wales and the Australian Capital Territory, imported tomatoes must be certified as having come from properties demonstrating area freedom. This status can only be reached if the property concerned and the area within a 50km radius of it have been free from *B. neohumeralis* and Cucumber Fly for the twelve months preceding export to WA (WAQIS, 1999).

To guard against the introduction of ERM from Victoria, Tasmania, Queensland, South Australia, the Australian Capital Territory and New South Wales tomatoes must originate from an approved property or certified as examined and found to be free of European Red Mite, and grown and packed at least 50km from a known outbreak of European Red Mite. Alternatively, they must be fumigated with methyl bromide at rates between 56 g/m^3 (at 5.0° - 10.0°C) and 16 g/m^3 (at 31°C and above) for 2 hours. These conditions do not apply to produce from the Northern Territory where ERM is exotic (WAQIS, 1999).

Measures to reduce the likelihood of importing Melon Thrips with interstate tomato imports are very similar. This pest can be found in Queensland, the extreme north east of New South Wales and the Northern Territory. For these States, produce from any area within 100km

of an outbreak of Melon Thrips is prohibited unless it undergoes the same methyl bromide fumigation process required for ERM.

Spiralling Whitefy, exists only in limited abundance. It only affects Queensland, and outbreaks have been discovered in the extreme north of the state, around the Cairnes area, and most recently in the Townsville area (WAQIS, 1999). Produce from these regions moving into WA are prohibited .

5.3 Variables

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

Marginal Cost (MC) – Quantitative studies offering estimates of supply elasticities for tomatoes and tomato products in WA are not available at the present time. In fact, very few examples of any such studies performed anywhere in the world are to be found. Comparative static estimates are not available, but examples of dynamic estimation techniques being used to estimate tomato supply functions can be used as 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 best bet elasticity of supply closer to the upper bound, say **0.80**, is specified.

Average Variable Cost (AVC) - production costs for the Swan Coastal Plain are provided in Gartrell (1997) from which a best bet value of **$660/tonne** post quarantine is taken (and $710/tonne under a closed economy inferred). Production costs for the South West Region are specified as approximating those for the Manjimup district, the details of which are contained in Gartrell (1997). Using these figures, a value of **$540/tonne** post-quarantine was reached ($590/tonne under a closed economy). Finally, production costs for the Central statistical division are specified to approximate those of the Carnarvon district, which are detailed in White (1998). A best bet value of **$880/tonne** was used ($590/tonne under a closed economy). The primary cause of this high production cost is the price of water. There are variations in water prices throughout the state, and in some rural areas there may be no controls at all. On the Swan Coastal Plain, the Water and Rivers Commission may grant a private water allocation to a block of land if there are sufficient underground water reserves[13]. In contrast, there is a fixed quota throughout the year in the Carnarvon district, which is dependent on the flow of the Gascoyne River, and properties are carefully metered. In the case of mangoes grown in this area, this is offset by more intensive growing techniques and

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[13] This will be allocated in terms of total land area based on a general water requirement of 15,000 kiloliters per hectare for vegetable crops like tomatoes. Properties are not metered, but may be inspected for area of cropping at any time (Burt and Gartrell, 1998).

higher yield per hectare[14], but where tomatoes are concerned growing techniques are (in general) more uniform between regions (Burt and Gartrell, 1998).

Post-Quarantine Quantity Supplied (Q_q) - 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 (P_q) - 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 (P_c) - Reliable cost estimates for products undergoing the quarantine treatments listed in section 5.2 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[15]. 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 best bet value for P_q is assumed as **$1,080/tonne**.

Free Trade, or National Price (P_f) – 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, 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.

5.3 Results

Modelling the domestic tomato industry using "best bet" values produces the following profit figures for each of the growing regions included. Collectively, these account for over 90 per cent of total industry production (PMA, 2000). So, the sum of profits from each region given any one

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[14] Most recent plantings in Carnarvon are high density plantings of 400 to 600 trees per hectare, as opposed to traditional management styles where trees are planted at around 200 per hectare and thinned to 100 trees per hectare after 12 years (to avoid overcrowding and subsequent yield loss). Under a high density management style, mangoes are pruned and shaped manually in the initial stages and later hedged by a machine to restrict tree size (Hawkins, 1994).

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

scenario (i.e. closed economy, free trade or quarantine restricted trade) would be expected to equate with the total PS estimates of the aggregate model given the factors outlined above.

Table 3: Results (Aggregated): *Quarantine Protocols for Tomatoes*

	Free Trade	Post-Quarantine Restriction
Price (Farm Gate)	$ 950	$ 1,000
Change in CS	$ 4,725,344	$ 2,844,413
Change in PS	$ (2,871,811)	$ (1,775,550)
Net Economic Welfare Gain	$ 1,853,534	$ 1,068,863
Change in Economic Welfare	$ (784,670)	
Approximate PS Under Quarantine Restricted Trade	$ 6,123,358	
Break Even Probability of Incursion	12.8%	

Note - brackets indicate negative values

As was the case in the first example, the base case is a closed economy, so the changes in CS and PS indicated in Table 3 show changes in relation to a closed economy situation. Hence, both the quarantine restricted trade and free trade scenarios will have a positive impact on the consumer side whilst exerting negative pressure on the producer side through competition. It is estimated that the net change in economic welfare resulting from the inflationary effects of quarantine protocols above a free trade level is around $785,000 per annum. Using the approximate value of PS, this welfare loss constitutes around 12.8 per cent of total PS. So, in order to break even, quarantine protocols for tomatoes need to be expected to prevent an equivalent level of domestic production loss by lowering the probability of exotic pest incursion.

Table 4: Results (Spatial): *Quarantine Protocols for Tomatoes*

Cost Curve & Quantity Information:

	Central	Swan Coastal Plain	South West
Average Variable Costs Under Closed Economy ($/T)	$ 927	$ 707	$ 587
Average Variable Costs Post Quarantine ($/T)	$ 880	$ 660	$ 540
Quantity Supplied Under Closed Economy (T)	12,176	9,789	1,446
Quantity Supplied Post-Quarantine (T)	11,295	9,081	1,341

Price Information:

	Farm Gate	Wholesale	Retail
Closed Economy Price ($/T)	$ 1,080	$ 1,242	$ 1,656
Post-Quarantine Price ($/T)	$ 1,000	$ 1,150	$ 1,533

Short-Run Profit:

	Central	Swan Coastal Plain	South West	INDUSTRY TOTAL
Profit Under Closed Economy	$ 2,149,353	$ 3,881,540	$ 746,684	$ 8,654,362
Profit Post-Quarantine	$ 1,355,368	$ 3,087,383	$ 616,854	$ 6,123,358

Table 4 includes profit figures for both of the significant growing regions in WA. As mentioned in section 4.4, production figures used in this analysis group centres by statistical division, and production from Carnarvon and Geraldton have been combined in the Central statistical division. Collectively, the tomato-growing regions modelled account for over 90 per cent of total production in WA (ABS, 1998; White, 1998).

6. Interpretation

While it is recognised that the case studies used here are only two of a large number of commodities traded across state borders and subject to interstate quarantine restrictions, the results for mangoes and tomatoes represent some interesting findings. At the very least, they provide an indication of the usefulness of different analytical techniques when dealing with different commodities.

Focusing on the results of the aggregate model to begin with, does the relative size of a particular industry have a major bearing on the viability of quarantine policies, or the ease with which they can be justified using a static, partial equilibrium trade model? The results of this study would suggest that the expected gain in PS produced through the restriction of pests required to equate benefits and costs increases with industry size.

Consider the tomato example. When compared to an industry like mangoes, the increased price of tomatoes in WA is amplified by the sheer volume flowing through the Perth market. It should also be noted that the relative price increase of tomatoes induced by quarantine measures in relation to the closed economy price is slightly higher than that of mangoes, as Table 5 would indicate. However, the consumer side of the ledger carries a good deal more weight. The proportion of the WA food consumer's budget affected by quarantine-induced price inflation is more substantial in the case of tomatoes, and therefore the level of damage prevented by these policies must be higher to bring benefits and costs into balance.

Table 5: Relative Price Increases Induced by Interstate Quarantine Measures

	Mangoes	Tomatoes
Price increase resulting from quarantine procedures (%)	7%	8%
Proportion of total WA fruit (incl. Tomatoes) GVAP[*]	3%	6%
Break even probability of incursion	9%	13%

[*] ABS (1998)

Such a finding may be of some concern to domestic tomato growers. After all, it could be argued that relaxing interstate quarantine protocols in the interests of consumers could spell disaster for their business if a pest were to gain entry as a result. Indeed it could, and this is precisely why an economic assessment of this nature must be used in conjunction with a scientific risk assessment so that the *break even probability of incursion* can be viewed in context. It may be that the nature and number of endemic pest species in the east of Australia would pose too great a risk to domestic industry under a free trade or relaxed quarantine scenario. Perhaps the expected damage would be greater than $785,000, or 13 per cent of PS. However, this is largely a scientific question rather than an economic one.

Turning now to spatial results, what can be said with regard to the second question posed at the beginning of the paper? The results appear to lend support to the idea that an aggregated, industry-wide approach to modelling the effects of quarantine measures may not be appropriate where there is significant variation in AVC between growing centres. The ability of different regions to absorb competition-induced price decreases (below a closed economy level) will vary according to the commodities in question, and so too the impact of quarantine. If these differences are minor, as in the case of mangoes grown in the Central and Kimberley districts, an aggregated model will provide an accurate indication of the effects of interstate quarantine regulations. On the other hand, when dealing with commodities like tomatoes with sizeable differences in growing costs between each of the main growing regions, the impact of import

protocols will vary across the industry. This is perhaps best illustrated by expressing the change in regional profit with the move from a closed economy in percentage terms. Table 6 shows the percentage decline in profit (relative to post-quarantine profit) estimated under both modelling approaches.

Table 6: *Percentage Decline in PS - Closed Economy to Quarantine-Restricted Trade*

Mangoes			Tomatoes			
Central	**Kimberley**	**Aggregate**	**Central**	**Swan Coastal Plain**	**South West**	**Aggregate**
-31%	-32%	-36%	-37%	-20%	-17%	-29%

In the case of mangoes the percentage decline in aggregate profit following a move from closed economy to post-quarantine is similar to that of each component region, reflecting their similarity in terms of AVCs. However in the case of tomatoes, the impact for each region is very different from that represented by the weighted average in the aggregate result, reflecting differing levels of AVC.

An alternative way of presenting this finding is contained in Table 7, which expresses spatial profit under each trade scenario in percentage terms to illustrate the effects on individual regions more closely.

Table 7: *Regional Profit as a Percentage of Modelled Growing Centres*

	Mangoes		Tomatoes		
Scenario	**Central**	**Kimberley**	**Central**	**Swan Coastal Plain**	**South West**
Closed Economy	45%	55%	30%	57%	11%
Post Quarantine	45%	55%	22%	65%	13%
Free Trade	45%	55%	27%	61%	12%

Clearly, the relative contribution of each mango growing region remains constant as the economy moves from a state of autarchy to one of quarantine restricted trade and free trade.[16] In contrast, the contribution of each tomato growing region changes quite markedly. Downward pressure on prices exerted by increased levels of competition will see a shift in production significance towards lower cost areas like the Swan Coastal Plain and the South West, and away from high cost areas like the Central statistical division.

These results are not captured by an aggregated approach. Cost differences are simply embedded in weighted averages used to describe the industry concerned. While this may not be a direct concern in terms of satisfying the requirements of the SPS agreement, they are certainly important for domestic policy-makers wishing to maintain office. While aggregation may be warranted in the case of some commodities with similar cost characteristics across production regions, for others it would be to the detriment of the decision-maker's ability to encompass domestic producer effects. In this sense, the implications of such a finding for economists are highly significant.

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[16] Percentages shown represent the relative contribution of each growing region in terms of all of the regions modelled rather than aggregate PS.

7. Conclusions

Both the aggregated and the spatial techniques described above can provide large amounts of information about the likely benefits and costs imposed by interstate quarantine strategies by exploring their effects on producer and consumer welfare. However, circumstances have been identified under which one technique can be recommended above another. The two case studies presented here indicate that an aggregated trade modelling approach is warranted when the industries concerned are characterised by uniform production costs across all growing regions, as is the case for mangoes. When this is the case, aggregation does not diminish the power of the model to demonstrate the welfare implications of various levels of competition induced by quarantine strategies. If, on the other hand, industries are characterised by significant cost variations between growing regions, a spatial technique can be used to make these differences explicit and hence determine the capacity of each to absorb the pressures imposed by competition.

In addition to spatial characteristics, it would also appear that the size of an industry has a significant bearing on the economic viability of quarantine restrictions. Generally, the larger the industry, the greater the consumer welfare implications of restricting interstate competition. In the case of tomatoes, small price changes are effectively amplified by the sheer volume of product demanded by consumers, and consequently the effects on consumer welfare of any price rise (such as from a free trade price to a quarantine restricted price) will tend to weigh heavily on the decision to place restrictions on competition. In a small industry like mangoes, the producer welfare implications are generally larger, and interstate import restrictions become somewhat easier to justify on economic grounds.

It would appear then that the analytical techniques to be recommended for quarantine policy analysis will largely depend on the industries concerned. Where the production cost characteristics are similar across growing regions, an aggregated approach is justified under which the size of the industry and the potential consumer welfare implications can be expected to exert an influence on the result. Where there are significant production cost variations between individual growing regions within an industry, a spatial approach is more appropriate which will also be influenced by industry size. Certainly, the nature of the markets each of these techniques is applied to may require the use of a range of other decision criteria to complement consumer and producer welfare information (i.e. relating to flow on effects to secondary industries and possible socio-economic and environmental concerns). These issues and their empirical implications are yet to be fully explored.

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