EXPORT INSTABILITY WHEN INTERNATIONAL AGRICULTURAL MARKETS OPERATE UNDER OLIGOPOLY

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Abstract

This article uses a theoretical model to show that instability in international markets of agricultural commodities may increase as a consequence of power imbalance exiting in the food chain supply. This instability, in turn, may cause negative impacts on the environment. The article argues that in order to minimize this problem, informational strategies should be implemented at the farming level.

Keywords: export instability, oligopolistic international markets, farming sector

1. Introduction

The issue of export instability has been studied for more than three decades. According to some empirical works, export instability is caused mainly by fluctuations in imports and exports of commodities. For example, Adebusuyi (2004) found that cyclical change in consumers' income is one of the factors that have increased import fluctuations. A related result was found by Wong (1986). According to this researcher, variability in GDP per capita is strongly significant in explaining export instability, although this factor is not dominant. On the other hand, Jansen (2004) and Malik and Temple (2005) found that export concentration is a strongly predictor of terms of trade volatility. Finally, Prasad (2000) found that short term fluctuations in export are dominated by the supply side shock.

Different negative effects of export instability have been identified. Empirical evidence has revealed that economic growth is negatively impacted by this instability (see for example Gymah-Brempong, 1991; Lutz, 1994; Turnovsky and Chattopadhyay 2003; Jansen, 2004; and Malik and Temple, 2005). In relation to this effect, Ramey and Ramey (1991) argue that income fluctuation caused by export instability can affect firms' commitment to invest in technology reducing, in this way, economic growth. This argument was confirmed by Ramey and Ramey (1995). Another negative effect of export instability is related to farmers' welfare. According to Bourguignon et al (2004), developing countries depend strongly on agricultural export which is subject to external volatility. Nonetheless, households can smooth consumption when this instability is transitory. The problem is that farmers in these countries normally face capital restrictions and lack of credit facility making consumption smoothing difficult.

The standard policy recommendation that has been proposed to reduce export instability is export diversification. This is because the instability of portfolios composed of commodities with prices that are negatively correlated is reduced (for a discussion, see Stanley and Bunnag, 2001; Adebusuyi, 2004; and Chami Batista, 2004).

While these investigations have been useful in identifying some sources of export instability, they have neglected the existing power imbalance that is present in the food supply chain in several countries. As a consequence of this power imbalance, international markets of agricultural commodities operate now under oligopoly.

Different evidence and arguments has been used to inform about the existence of oligopolistic competition in international markets of agricultural commodities. One of them postulates that the industrialization of agricultural markets has generated larger firms that are more tightly aligned across the production chain and more concentrated due to their larger scale. According to Boehlje and Doering (2000), this concentration can be sufficient to exercise oligopolistic power. For example, it is recognized that the vertical relationship between suppliers and retailers of fresh produce in the UK is dominated by nine large retailers, Tesco being the largest of these (White, 2000; and Duffy et al., 2003). McCorriston (2002) argues that this is one of the reasons of why researchers should consider the assumption of oligopoly when studying international markets of agricultural commodities. In particular this author points out: "*Arguably, it is the high and increasing concentration in food retailing that is the most distinguishing feature of the European food chain. Taken together with the oligopolistic nature of food manufacturing in many European countries, the food chain is perhaps best described as a successive multi-stage oligopoly. In this case, an oligopolistic sector sells its output to another oligopolistic sector that distributes the final good to consumers*" (p. 354). Imperfect competition has also been identified in other contexts. For example, the State Trading Enterprises and the Australian Wheat Board manage the total amount of exports of cereals of some countries such as Canada and Australia. According to Sckokai and Soregaroli (2008), imperfect competition is likely to arise from these enterprises a fact that has been supported by empirical academic works (see for example Reimer and Stiegert 2006; and McCorrisnton and MacLaren, 2007a,b). Imperfect competition has also been identified in other markets. For example, Lloyd et al. (2006) in the UK beef chain; Saitone et al. (2008) in the U.S. corn sector in relation to the U.S. corn ethanol subsidy; and Byeong-Il and Lee (2010) found evidence of oligopoly in the Korean market of milk.

The objective of this article is to show, using a theoretical model, that the existence of oligopolistic markets of agricultural commodities may amplify export instability in the short run. Moreover, this problem may be persistent if farmers do not have reliable information to make predictions about future market conditions, a fact that may cause significant negative effects on the environment

The article is organized as follows. Section 2 presents the theoretical model. Section 3 shows key results that are obtained when solving the theoretical model. Section 4 presents evidence that is consistent with the predictions made by the theoretical model. Finally, Section 5 concludes the paper.

2. The model

In order to study the effects of oligopolistic competition on export instability, a dynamic model is proposed. Two versions of this model were adopted in this article. The first one is a simplified version that assumes a world composed of three countries. The objective of considering this simplification is to explicitly identify the dynamic process that is associated with export instability. In order to investigate how this process is influenced by available information on the strategy adopted by competitor countries, this version considers two extreme cases, namely: (i) when countries have perfect information about the strategy adopted by the competitor countries; and (ii) when countries have completely imperfect information. The second version of the model is a generalization that considers a world composed of n countries. This model also investigates the case when countries have partial information about the strategy adopted by the competitor countries.

2.1. The simplified version of the model

The model assumes a world composed of 3 countries denoted by *i, j* and *k*. Each country *i* has a rural sector that produces a homogeneous crop . Because this output is exported by an intermediary who has oligopolistic power, countries *i, j* and *k* play Cournot in each market where they compete. It is assumed that farmers face the same marginal cost *c*. In order to simplify the analysis it is assumed without losing generality that the intermediary is also the only farmer in the country. This simplification does not lose generality because what it is highlighted in this model is the existing oligopolistic structure in the food supply chain.

The inverse demand function for agricultural good in an arbitrary country *k* and in period *t* + 1 is given by:

$$p^k_{t+1} = \alpha - q^i_{t+1} - q^j_{t+1} + q^k_{t+1} \tag{1}$$

Because the agricultural output that will be harvested in period *t* + 1 is established in period *t*, the farmer in country *k* maximizes the following expected profit:

$$\max_{q^k_{t+1}} E^k_t(\pi^k_{t+1}) = \left[E^k_t(P^k_{t+1}) - c\right] q^k_{t+1} \tag{2}$$

The expected value in period *t* of the price in country *k* in period *t* + 1 is:

$$E^k_t(P^k_{t+1}) = \alpha - q^k_{t+1} - E^i_t(q^i_{t+1}) - E^i_t(q^j_{t+1}) \tag{3}$$

According to this equation, the expected value of the future price depends on the expectation that farmer *k* has on the output that will be exported by countries *i* and *j* to country *k*. It is assumed that the expectation on each of these outputs is given by:

$$E^k_t(q^i_{t+1}) = \lambda q^i_t + (1-\lambda) q^i_{t+1} \tag{4}$$

In this equation when the farmer does not have any information about the future output that will be exported by the competitor country, then *l* = 1. That is, in this case the farmer considers the current output exported by this country as a proxy of future export. In contrast, if the farmer can perfectly anticipate the future output that will be exported by this competitor, then *l* = 0. By using Equation 4 the maximization problem of the farmer in country *k* becomes:

$$\max_{q^i_{t+1}} E^i_t(\pi^i_{t+1}) = \left[\alpha - c - q^i_{t+1} - \lambda q^j_t - (1-\lambda) q^j_{t+1}\right] q^i_{t+1} \tag{5}$$

After solving this maximization problem, the following reaction functions are obtained:

$$q^i_{t+1} = \frac{\alpha - c}{2} - \frac{\lambda q^j_t}{2} - \frac{(1-\lambda) q^j_{t+1}}{2} - \frac{\lambda q^k_t}{2} - \frac{(1-\lambda) q^k_{t+1}}{2} \tag{6}$$

$$q^j_{t+1} = \frac{\alpha - c}{2} - \frac{\lambda q^i_t}{2} - \frac{(1-\lambda) q^i_{t+1}}{2} - \frac{\lambda q^k_t}{2} - \frac{(1-\lambda) q^k_{t+1}}{2} \tag{7}$$

$$q^k_{t+1} = \frac{\alpha - c}{2} - \frac{\gamma q^i_t}{2} - \frac{(1-\gamma) q^i_{t+1}}{2} - \frac{\lambda q^j_t}{2} - \frac{(1-\lambda) q^j_{t+1}}{2} \tag{8}$$

Using substitution, the following system of two dynamic equations is obtained:

$$\begin{bmatrix} \zeta_0 & -\zeta_1 \\ \varphi_0 & -\varphi_0 \end{bmatrix} \begin{bmatrix} q^j_{t+1} \\ q^i_{t+1} \end{bmatrix} = \begin{bmatrix} \zeta_2 \\ 0 \end{bmatrix} + \begin{bmatrix} \zeta_3 & \zeta_4 \\ \varphi_1 & -\varphi_1 \end{bmatrix} \begin{bmatrix} q^j_t \\ q^i_t \end{bmatrix} + \begin{bmatrix} \zeta_5 & \zeta_5 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} q^j_{t-1} \\ q^i_{t-1} \end{bmatrix} \tag{9}$$

where $\zeta_0 = 3 + 2\lambda - \lambda^2$; $\zeta_1 = \lambda^2 - 1$; $\zeta_2 = \alpha - c$; $\zeta_3 = 2\lambda - 2\lambda^2$; $\zeta_4 = -2\lambda^2$; $\zeta_5 = \lambda^2$; $\varphi_0 = 1 + \lambda$; and $\varphi_1 = \lambda$.

Note that the long run Nash equilibrium output that is obtained from this system is equal to $\frac{\alpha - 2}{4}$ and is the same for each country. This long run equilibrium is important to determine how the system evolves throughout time. This is referred to as the dynamic process around the long run Nash equilibrium. In order to analyze this process, the roots that equal to zero the following expression are needed[1]:

$$\begin{aligned} & b^3(\zeta_1\varphi_0 - \zeta_0\varphi_0) + b^2(\zeta_3\varphi_0 + \zeta_4\varphi_0 - \zeta_1\varphi_1 + \zeta_0\varphi_1) + \\ & b(\zeta_5\varphi_0 - \zeta_3\varphi_1 + \zeta_5\varphi_0 - \zeta_4\varphi_1) - \zeta_5\varphi_1 - \zeta_5\varphi_1 \end{aligned} \tag{10}$$

2.2. The general version of the model

This model is a generalization of the model described in the previous section and is based on the same general assumptions. In particular, it is assumed that farmer in country *k* considers the following expected value in period *t* of the price in *k* and in period *t* + 1:

$$E^k_t\left(P^k_{t+1}\right) = \alpha - q^k_{t+1} - E^k_t\left(\sum_{j \neq k} q^j_{t+1}\right) \tag{11}$$

Where is the output exported by county *j* to country *k*. Note that this expression is similar to Expression 3 above. The only difference is that Expression 11 considers *n* competitor countries while Expression 3 only considers three competitors. Assuming the same expectation process described in equation 4, the maximization problem faced by farmer in country *k* is given by:

$$\max_{q^i_{t+1}} E^k_t(\pi^k_{t+1}) = \begin{bmatrix} \alpha - c - q^k_{t+1} - \lambda \sum_{j \neq k} q^j_t \\ -(1-\lambda) \sum_{j \neq k} q^j_{t+1} \end{bmatrix} q^i_{t+1} \tag{12}$$

The solution of this problem gives the following reaction function of farmer in country *i*:

$$q^k_{t+1} = \frac{\alpha - c}{2} - \frac{\lambda \sum_{j \neq k} q^j_t}{2} - \frac{(1-\lambda) \sum_{j \neq k} q^j_{t+1}}{2} \tag{13}$$

The following matrix system considers the reaction function of all the countries competing in country *k* altogether:

$$Q^k_{t+1} = A + BQ^k_{t+1} + \Phi Q^k_t \tag{14}$$

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[1] Expression 10 was obtained assuming that and, where m and n are arbitrary constants.

where,

$$Q_{t+1}^{k} = \left[q_{t+1}^{j} \quad q_{t+1}^{k} \quad \cdots \quad q_{t+1}^{n} \right]^{T}$$

$$A = \left[\frac{\alpha - c}{2} \quad \frac{\alpha - c}{2} \quad \cdots \quad \frac{\alpha - c}{2} \right]^{T}$$

$$B = \begin{bmatrix} 0 & -\frac{(1-\lambda)}{2} & -\frac{(1-\lambda)}{2} & \cdots & -\frac{(1-\lambda)}{2} \\ -\frac{(1-\lambda)}{2} & 0 & -\frac{(1-\lambda)}{2} & \cdots & -\frac{(1-\lambda)}{2} \\ -\frac{(1-\lambda)}{2} & -\frac{(1-\lambda)}{2} & 0 & \cdots & -\frac{(1-\lambda)}{2} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ -\frac{(1-\lambda)}{2} & -\frac{(1-\lambda)}{2} & -\frac{(1-\lambda)}{2} & \cdots & 0 \end{bmatrix}$$

$$\Phi = \begin{bmatrix} 0 & -\frac{\lambda}{2} & -\frac{\lambda}{2} & \cdots & -\frac{\lambda}{2} \\ -\frac{\lambda}{2} & 0 & -\frac{\lambda}{2} & \cdots & -\frac{\lambda}{2} \\ -\frac{\lambda}{2} & -\frac{\lambda}{2} & 0 & \cdots & -\frac{\lambda}{2} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ -\frac{\lambda}{2} & -\frac{\lambda}{2} & -\frac{\lambda}{2} & \cdots & 0 \end{bmatrix}$$

3. Solving the model

3.1. Solution of the simplified version of the model

This section solves the simplified version of the theoretical model described in Section 2.1 assuming both completely imperfect and perfect information about the future output that will be exported by the competitor countries.

When countries are completely uncertain about the output that the competitor countries will export in period $t + 1$ (i.e. $l = 1$), Expressions 9 and 10 converge to:

$$\begin{bmatrix} 4 & 0 \\ 2 & -2 \end{bmatrix} \begin{bmatrix} q_{t+1}^{j} \\ q_{t+1}^{i} \end{bmatrix} = \begin{bmatrix} \alpha - c \\ 0 \end{bmatrix} + \begin{bmatrix} 0 & -2 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} q_{t}^{j} \\ q_{t}^{i} \end{bmatrix} + \begin{bmatrix} 1 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} q_{t-1}^{j} \\ q_{t-1}^{i} \end{bmatrix} \tag{15}$$

$$-8b^{3} + 6b - 2 = 0 \tag{16}$$

By using these expressions, the following solution of the system is obtained[2]:

$$q_{t}^{i} = \frac{1}{9}\left[q_{0}^{i} - q^{N} \right](-1)^{t} + \frac{8}{9}\left[q_{0}^{i} - q^{N} \right](0.5)^{t} + \frac{4}{3}\left[q_{0}^{i} - q^{N} \right] t\,(0.5)^{t} + q^{N} \tag{17}$$

where $q^{N} = \frac{\alpha - c}{4}$ is the long run Nash equilibrium and q_{0}^{i} is the initial condition.

2 A similar expression can be derived for countries j and k as a consequence of the symmetrical countries assumption.

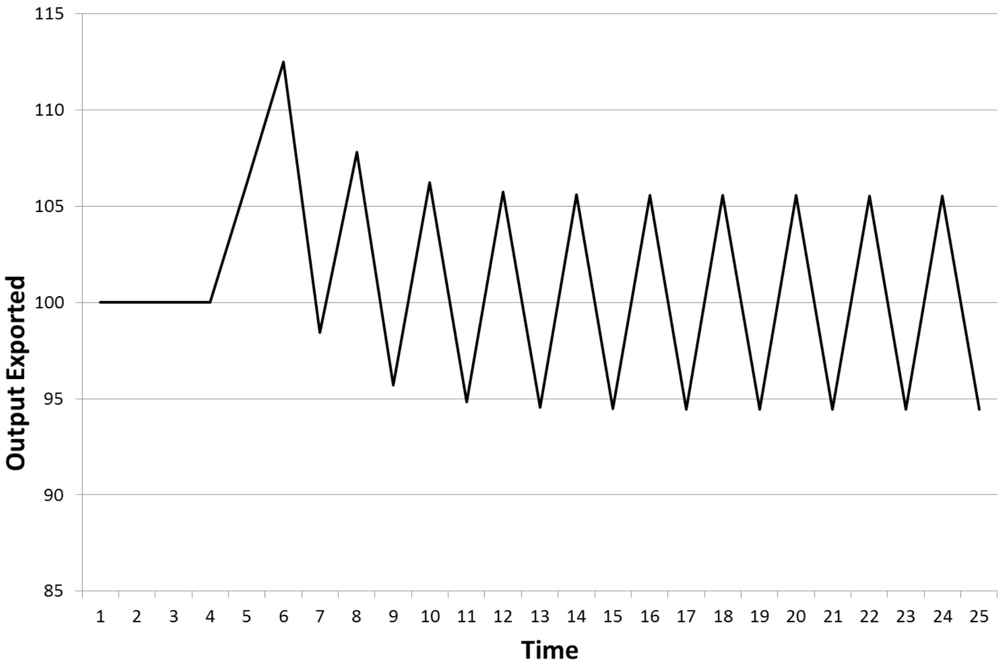

Figure 1. Export instability

- **Proposition 1:** *If farmers are completely uncertain about the output that the competitor countries will export in the next period, then export instability in each country will consist of an oscillatory and persistent change of exported output around the long run Nash Equilibrium.*
- **Proof:** Because equation 17 has a root equal to -1, it is concluded that the model oscillates around the long run Nash Equilibrium and does not converge to this equilibrium.

This is an impressive result that proves the fact that lack of reliable information in a world characterized by oligopolistic international markets of agricultural commodities may be associated with high levels of instability and uncertainty. In order to see how this instability behaves, a simulation based on Equation 17 is presented in the following figure.

In this simulation it was assumed an initial Nash equilibrium equal to 100. After an exogenous shock is introduced in period 4, the long run equilibrium is broken with persistent fluctuations around this equilibrium.

There is an important environmental implication associated with this result. That is, researchers have found that the most important factor causing natural habitat loss is agricultural expansion induced by international trade (see, for example, Angelsen and Kaimowitz, 1999; and Barbier, 2004). This is because the agricultural land that is needed to produce additional output for exportation is obtained from natural habitats. This is why researchers in this area argue that the loss of natural habitats is positively related to the output produced in the farm (Polasky et al., 2004). In terms of the result presented in Proposition 1, this means that the positive fluctuations with respect to the long run Nash equilibrium may be associated with significant loss of natural habitats in some countries. To see this, consider again the simulation present in Figure 1. Before the exogenous shock in period 4, the output produced in this country was 100 and this output was associated with a determined level of habitat destruction. After the shock, there was a huge increase in output which may be coupled with a significant increase in habitat destruction and, therefore, with biodiversity loss.

Suppose now that countries have perfect information about the output that competitor countries will export in period t + 1 (i.e. l = 0). In this case the Expressions 9 converges to:

$$\begin{bmatrix} 3 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} q^{j}_{t+1} \\ q^{i}_{t+1} \end{bmatrix} = \begin{bmatrix} \alpha - c \\ 0 \end{bmatrix} \tag{18}$$

- **Proposition 2:** *If farmers know with certainty the output that the competitor countries will export in the next period, then export instability in each country is eliminated.*
- **Proof:** This result is inferred from Expression 18. The unique result that is obtained from this expression is (a - c)/4 which corresponds to the long run Nash equilibrium.

According to this proposition, the instability problem identified in the case of imperfect information is completely eliminated when farmers can anticipate with certainty the output that will be produce by the competitor countries in the next period. This offers an interesting possibility for policymakers. That is, the design of policy programs aimed to improve the flow of relevant information in the farming sector. In theory these programs have the potential of generating positive externalities in terms of reducing export instability in international markets of agricultural commodities.

3.2. Solution of the general version of the model

Let us now solve the general version of the model. The results are presented in the following proposition:

- **Proposition 3:** *If l* £ 0.5*, then the system described in Expression 14 converges to a stable equilibrium. If this is not the case, then the stability depends on the number of firms competing in country k.*
- **Proof:** Note that Expression 14 can be represented as the following VAR(1) model:

$$Q^{k}_{t+1} = \tilde{A} + \tilde{\Phi} Q_t \tag{19}$$

where $\tilde{A} = [I - B]^{-1} A$; and $\tilde{\Phi} = [I - B]^{-1} \Phi$. The model described in Expression 19 is stable if and only if the roots of the system $[I - \tilde{\Phi} Z]$ lie outside of the unit circle. That is, if and only if $|Z| > 1$. The model has n – 1 identical roots equal to Z = 1 + 1/l > 1. The other root is equal to Z = − [2 + (1 − l)(n – 1)]/[l(n − 1)]. This expression is smaller than -1 when 1/(n – 1) > l– ½.

This condition is satisfied for all $\lambda \leq 0.5$. In contrast, if l > 0.5, then Expression 19 converges to an equilibrium only when n < (l + 0.5)/(l − 0.5). This completes the proof.

According to this model, even if farmers have partial information about the output that competitors will export in the next period, an unstable system can be originated. For example, if l = 0.4 and if the number of competitors is larger than 11, then export instability arises. Moreover, this instability is explosive meaning that in the short run lack of information can cause a significant impact on export instability. This, in turn, can have important negative impacts on the environment when agricultural production is associated with loss of natural habitats.

4. Some evidence

According to the results obtained from the theoretical model, imperfect information about the strategy adopted by competitor countries might cause high export instability when countries compete in oligopolistic markets. This result suggests that countries involved in free trade agreements may face high levels of export instability as a consequence of being participating in international oligopolistic agricultural markets with imperfect information.

The aim of this section is to show some evidence of how export instability has indeed increased after a particular country signed a number of free trade agreements. A suitable country that can inform about the effect of free trade liberalization on export instability is Chile. This country is one of the most opened countries in the world and is currently involved in 19 agreements. These agreements and the dates of their implementation are presented in the following table.

This table shows that Chile signed two agreements between 1995 and 2000; seven agreements between 2001 and 2005; and eight agreements between 2006-2010. In order to determine whether these agreements have increased export instability, the standard deviation of the output of some selected agricultural goods exported by this country is analysed. Because Chile is an important exporter of fresh fruits, the following goods are considered: apples; apricots; cranberries; grapes; lemons and limes; oranges; peaches and nectarines; raspberries; and strawberries. Information of the change of standard deviation in different periods of time is presented in Appendix A.

According to the figures presented in this appendix, export instability increased after Chile started signing free trade agreements in 1997. After that, export instability has remained high for all the goods considered in the appendix. In some cases export instability decreased in the period between 2006 and 2010 which may reflect the fact that farmers have learned to some extent the

Table 1. Free Trade Agreements signed by Chile

Free Trade Agreements	Date of Implementation
Chile-Canada	05-Jul-1997
Chile-Mexico	01-Aug-1999
Chile-Costa Rica (Central America)	15-Feb-2002
Chile-Guatemala (Central America)	23-Mar-2002
Chile-El Salvador (Central America)	01-Jun-2002
Chile-European Union	18-Nov-2002
Chile-United States	01-Jan-2004
Chile-Republic of Korea	01-Apr-2004
Chile-EFTA	01-Dec-2004
Chile-New Zealand-Singapore	28-May-2006
Chile-China	10-Oct-2006
Chile-Japan	03-Sep-2007
Chile-Panama	07-Mar-2008
Chile-Honduras (Central America)	19-Jul-2008
Chile-Peru	01-Mar-2009
Chile-Australia	06-Mar-2009
Chile-Colombia	08-May-2009
Chile-Turkey	01-Mar-2011
Chile-Malaysia	25-Feb-2012

Source: World Trade Organization, 2013

strategy adopted by partners. However, the level of instability in this period is higher than before the country was involved in free trade supporting the results obtained from the theoretical model proposed in this article.

5. Conclusions

This article uses a theoretical approach to show that export instability can be amplified when international markets of agricultural commodities operate under oligopoly and when farmers have imperfect information about the output that will be exported by competitor countries. This instability consists of persistent fluctuations of exported output around the long run Nash equilibrium. This result suggests that countries involved in free trade agreements may face high levels of export instability as a consequence of being participating in oligopolistic markets with imperfect information. Partial evidence obtained from Chile seems to support this prediction.

This problem may be solved by means of policy programs that favor the flow of relevant information in the farming system. The way in which this strategy might be implemented is left for future research.

6. References

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Appendix A

Standard deviation of export quantity of selected agricultural goods exported by Chile (information obtained from FAO statistics)

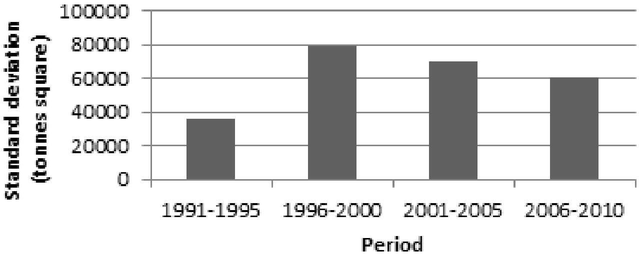

Figure A1. Standard deviation of export quantity of apples

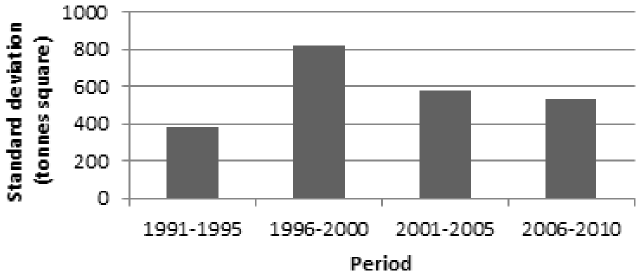

Figure A2. Standard deviation of export quantity of apricots

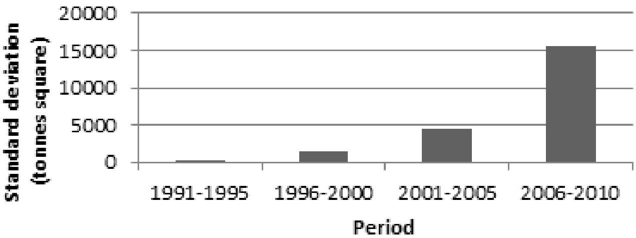

Figure A3. Standard deviation of export quantity of cranberries

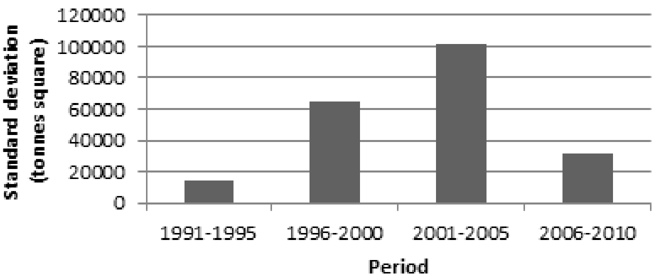

Figure A4. Standard deviation of export quantity of grapes

Figure A5. Standard deviation of export quantity of lemons and limes

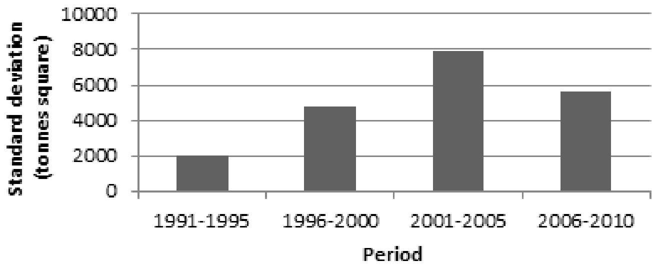

Figure A6. Standard deviation of export quantity of oranges

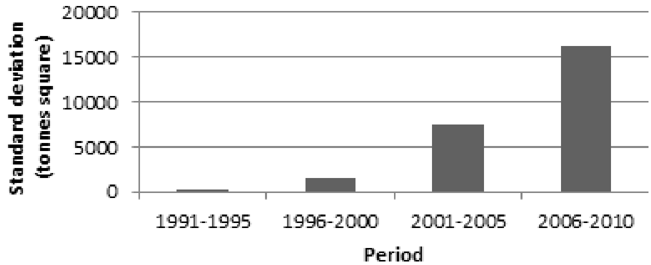

Figure A7. Standard deviation of export quantity of peaches and nectarines

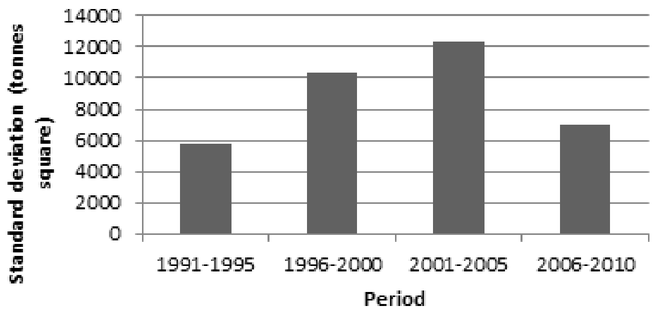

Figure A8. Standard deviation of export quantity of raspberries

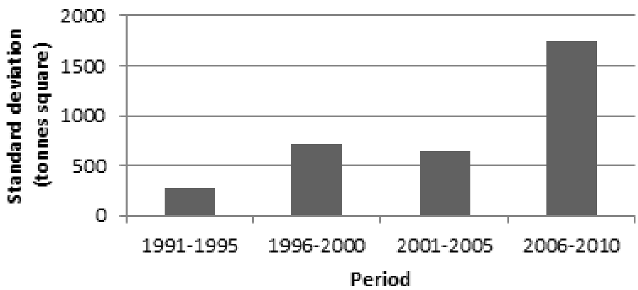

Figure A9. Standard deviation of export quantity of stawberries