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The Interactions of Eco-Labeling, Environment, and International Trade

Yi Qian

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ABSTRACT

A simple graphical model has been developed to examine the relationship between eco-labelling, international trade and environment. This paper analyses that labelling can possibly have adverse effect on environment when the supply of environment-friendly good is greater than the demand of the friendly good pre-labelling (fig.2). In a dynamic setting, however, this situation could be reversed by shifts of demand and supply curves of environment-friendly products (fig.3).

The theoretical model predicts change of product prices, which in turn can alter international trade. In bilateral trade, the interaction with country 2 will result in an improvement in the environmental situation in country 1 only if there is offsetting demand for the environment-friendly good from that country. The environmental situation in country 1 would worsen under international trade only if there is offsetting excess supply of the environment-friendly products from abroad.

An empirical case of US tuna export is studied and “dolphin-safe” labelling is found to have a negative coefficient with tuna export volume from US to Canada.

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ABSTRACT

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I. INTRODUCTION

As concerns with the environment grows among the public, both in developed and developing countries, environmental issues are beginning to take more of a center stage in economic and trade policies. One manifestation of this is the desire to inform consumers more fully about the products they purchase, not only with regard to those characteristics that affect their well-being directly, such as quality and nutrition, but also with regard to the environmental impacts of the production processes in general, for example, whether tuna was caught through "dolphin-free" methods. "The practice of supplying information on the environmental characteristics of a commodity to the general public may be called Eco-labelling" (Markandya 1997, P1). There are Eco-labelling schemes in operation (or about to come into operation) in 17 countries.

Environmentally concerned consumers and producers applaud the eco-labelling policies. As for the economic impacts, firms may view certain eco-labelling as a way to acquire product differentiation and comparative advantage. On the other hand, a labelling scheme could be perceived as a voluntary tax born by a section of environmentally conscious consumers to subsidize a section of the producers who produce environmental friendly goods. Such a scheme could lead to a negative demand shock for the other section of producers, who do not or cannot produce goods deemed to be environment-friendly. Thus, the conditions of acquiring the label and entering into the environment-friendly segment of the market assume crucial trade and environmental significance. There are also other important factors that influence the trade and environmental effects of eco-labelling. For example, how many consumers are concerned about the environment-friendliness? To what extent are they concerned and are willing to pay labelling premiums? And what are the trade and environmental consequences?

The main body of this paper consists of two parts: theoretical background (section II) and a case study (section III). Section II presents graphical models based on Mattoo and Singh and discusses environmental effects of labelling both in closed and open economies. Section III provides an empirical case study of US-Canada tuna trade. The relationship between "dolphin-safe" labelling and US tuna export volumes was explored. Section IV includes critiques on the models, suggestions of further research and some policy implications.

II. LITERATURE REVIEW

Around 1990, trade and environment sprung with little warning to the forefront of the public policy debate. Denmark incensed Germany with its bottle law, Mexico outraged US citizens with its challenge to one of America's most revered environmental laws – the U.S. Marine Mammal Protection Act[1], and Germany upset almost every other nation with its packaging laws. WTO and OECD both organized intense discussions on this hot issue. Their main findings and conclusions are published in a series of workshop papers. OECD's working papers range from general overview of the environment and trade issues, to discussions of more specific areas within the environment and trade paradigm (OECD 1994).

On the theoretical approach side, a two-sector model is first developed known as the North-South trade model (Copeland and Taylor, 1994), and referred to in many later literatures. This model shows that the higher income country chooses stronger environmental protection and specializes in relatively clean goods, and that free trade increases world pollution. It also shows that increase in rich North's production possibilities increases pollution, while similar growth in poor South lowers pollution, and that unilateral transfers from North to South reduce worldwide pollution.

More policy oriented papers come from OECD and Worldwatch Institute. Different cases were presented, and conclusions were drawn that the growing mobility of capital through trade can undermine environmental standards by allowing polluting industries to escape enforcement rather than clean up their act (Hilary French, 1993). This seems to echo part of Copeland and Taylor's arguments.

Empirical researches on the topic of environment and trade were carried out by many, but seldom with concrete results. Because it is very hard to pin down exactly whether it is environmental regulation or some other factors that affected trade, and if so, by how much environment and trade correlate with each other. One empirical study finds that the introduction of environmental control measures has not altered countries' comparative advantages and their trade patterns (James Tobey, 1990). The author, however, also discussed possible criticisms on the model his study was based on.

[1] The public became concerned with dolphin killing rates, and Congress responded by passing the Marine Mammal Protection Act in 1972. This act was intended to reduce the dolphin kills "to levels approaching zero" by legally requiring U.S. tuna fishermen to incorporate these techniques. Furthermore, the act established a permit system, setting a fixed ceiling for dolphin kills and limiting the taking rate for species that were endangered. To ensure that these regulations were abided by, the MMPA also required U.S. vessels to carry federal observers. The MMPA greatly reduced the number of dolphins killed by U.S. vessels. However, the composition of ships also changed (meaning foreign killing increased), and the total number of dolphin kills did not decline. (Stanford University PS142K, International Law: the online casebook; http://www.stanford.edu/class/ps142k/casebook/tunacase.htm)

More recently, new environmental measures had been developed, and discussions of how such measures relate to trade are also brought about. The Process and Production Methods(PPM) and Life Cycle Assessment(LCA) are considered to be effective environment regulatory actions (OECD, 1997). Eco-labelling is in turn introduced with the applications of PPM and LCA. Its effects on trade and environment are not robust, and specific effects are discussed for each specific case (Zarrilli et al. 1997). A simple graphical model was developed to illustrate the possible effects of eco-labelling on the environment (Mattoo and Singh, 1994). It gives a theoretical prediction that eco-labelling is only environmentally beneficial when there is an initial excess demand for the environment-friendly product. The graphical model serves as a theoretical base for this paper. It will be discussed and extended, and its dimension will be expanded to include discussions of trade issues. An empirical study on US tuna exports will be carried out to test certain discussions based on the model. The inspiration of choosing the tuna case for this paper partly comes from Mattoo and Singh's suggestion of possible empirical tests.

III. THEORETICAL BACKGROUND

In section A, a simple model is presented to show when Eco-labelling (henceforth "labelling") would have desirable consequences for the environment. Section B discusses the possible effects of eco-labelling on international trade. Section C furthers the discussion of environmental effects of eco-labelling by adding the international trade element.

A. A graphical model for the Environmental Effects of Eco-labelling

The labelling of products indicates whether or not they have been produced by methods friendly to the environment. It is expected that labels will enable consumers to discriminate between products, leading to reduced demand and hence reduced output of products produced by methods detrimental to the environment. This section shows that in certain cases, Eco-labelling could also lead to an adverse effect on the environment.

Based on the model by Mattoo and Singh (later abbreviated as M&S) (1994), the following assumptions are made:

1. A product can be produced through environment-friendly method, or environmental-unfriendly methods. Besides the fact that products can come out of different methods, all the products are the same in all other aspects. So before labelling, the product was not differentiated. Eco-labelling differentiates products into environmentally friendly product/process (F) and environmentally unfriendly ones (U); (This assumption can be made clear by consider the tuna case. Tuna can be caught in two ways: either in a way that is harmless to dolphin, or that is harmful to dolphin. Before labelling, consumers did not know how a tuna is caught. Only after the "dolphin-safe" labelling is implemented, can consumers differentiate tuna according to different methods tuna are caught.)
2. The market consists of consumers who are concerned about environmental problems and others who are not. Concerned consumers only purchase F and unconcerned consumers purchase products with lower price;
3. The numbers of concerned and unconcerned consumers are assumed to be fixed, while the quantities of F and/or U products they demand may change over time due to change in production costs;
4. The market structure is perfect competition, hence prices of both F and U are determined by their corresponding quantities of demand and supply;

5. "Df(p, 0) ≤ Df(p, E), i.e., the concerned consumer is willing to pay slightly more for a product that is known to be environment-friendly product than for an undifferentiated product"(M&S, 1994);
6. "All the conditions necessary for the existence, uniqueness and stability of equilibrium in each of the following situations are satisfied"(M&S, 1994);
7. labelling does not add extra costs to F production, hence post-labelling price is mainly adjusted in response to demand; and
8. In this section we only consider a closed economy case, where no trade is involved; trade element will be added in section II.C.

M&S model predicts that labelling has a positive effect on environment when the potential demand of environment-friendly product (later abbreviated as F) exceeds supply of F in pre-labelling market. Labelling has adverse environmental effects when the supply of F exceeds potential demand for F pre-labelling. Following M&S, a simple numerical example is used here to illustrate the intuition behind these two outcomes of the model. The market of yellowfin tuna was in equilibrium at a certain price P with 100 units being supplied and demanded. Each category of consumers (concerned vs. unconcerned) demands 50 units. Before labelling, though both F and U products exist in market (tuna were caught by both "dolphin-safe" methods and unsafe methods), the two products were not differentiated because consumers were not able to distinguish F from U. As soon as labelling differentiates products into F and U, environmentally concerned consumers will withdraw from U and only purchase F. If the quantity produced of F products at price P was less than 50 (fig 1), then there is excess demand for the F products immediately after labelling differentiates products. Hence the price of such products would increase relative to P. At the same time, the price of U products would fall because it loses concerned consumers. Higher price of F will attract more producers to switch away from U and produce F. In this case, labelling would achieve its objective of discouraging production by environment-unfriendly methods.

However, consider the situation that the quantity produced of F at price P was greater than 50 (fig 2). Then if only concerned consumers buy F, there will be excess supply and create the tendency for the price of F to fall relative to P. But as soon as price of F falls relative to price of U, unconcerned consumers would also go for F and bring up total demand of F products, i.e., perform arbitrage until a uniform price is established for both F and U. Now say concerned consumers are willing to pay even slightly more for the certainty of purchasing a product produced by an environment-friendly method than they were for the undifferentiated product. This is to say that for the same price level, the quantity of F demanded by these concerned consumers increases after labelling. Then aggregate demand in the post-labelling situation will be greater than that in the pre-labelling situation. M&S argues that this will cause the uniform price post-labelling to be higher than P, which implies that the productions of both F and U are likely to increase.

It is worth pointing out that assumption 7, which the above analysis is based on, is arguable, because in reality labelling usually adds a premium to the environment-friendly product. Such premium costs can include two parts: the costs of adopting environment-friendly methods that conform to labelling standards, and the bureaucratic costs of obtaining the label. The first part of costs is in fact included in M&S model, because these costs would be the same for F products pre and post labelling. It is the second part that is overlooked. This could influence the dynamic setting in the M&S model. Because labelling increased the costs of F products, the immediate response from the production side may be a decrease in supply (an upward shift of the Sf curve). At the same time, concerned consumers' willingness to pay the labelling premium increases demand of F products (outward shift of Df curve). In fig.1, this will widen the initial excess demand and bidding the post-labelling price of F even higher. So the environment-friendly production method will be more attractive and more producers will gradually switch to F production. The result is especially significant in situation 2. Fig.3 illustrates another possible scenario. When the Sf and Df shifts are large enough so that Df > Sf, and the Du and Su curve shift in the reverse direction, leading to Du< Su. The situation now rather resembles fig1, which favors environment. The occurrence of this particular case certainly will depend on how flexible and fast supply can adjust, how strongly environmental concerns affect the demand of concerned consumers, and how such concerns can influence other consumers and drive down the demand of U products.

In short, M&S model predicts that labelling is favorable for the environment when the economy starts with excess demand of F products, and unfavorable otherwise. They did not consider shifts of demand and supply curves, but only movements along these curves. In a dynamic setting, it is possible that situation 2 would change into situation 1, and labelling could still be favorable (fig.3). The quantities of F and U products depend on both the slopes and shifts of Df and Sf curves.

B. Effects of Labelling on International Trade

Now let's move from domestic market to bilateral trading market. Consider a situation where two countries, country 1 and country 2, are trading with each other, and each could have both concerned and unconcerned consumers as well as friendly and unfriendly production. The pre-labelling equilibrium price is P, and at this price, country 1 could be either a net exporter or net importer of the product. The graphic model introduced in section A still applies here for each country's domestic market. Assumption 8 is now relaxed (i.e. trade is allowed). The introduction of eco-labelling in country 1 could result in either an excess demand in F in country 1 at price P, or an excess supply in F in country 1 at price P. This can in turn lead to a change in trade.

To take a simple bilateral trade example[2], consider a highly environmentally conscious country 1, which, prior to labelling, was a net importer of an undifferentiated good, but also had significant domestic production by environment-unfriendly methods. The introduction of eco-labelling in the country differentiates the good market into F and U segments. Country 1 is environmentally conscious means that it has a high domestic demand for F products. If it is not economically feasible for domestic producers to opt for environment-friendly methods, then import of F products will increase. Since Df is greater than Sf in country 1, country 1's situation is similar to the case in fig1. As discussed in the previous section, the price of U product will be lower than F product in equilibrium. Suppose that the consumers in country 2 are not as concerned as those in country 1, then their demand of country 1's U product will increase due to the lowering price. Hence country 1's export in U product will increase. After trading, the total demand will equal to total supply in both F and U segments (Fig.5). The bilateral trade pattern changes: Country 1 changes from a net importer of the undifferentiated product to an importer in F, and exporter in U.

C. Effects of Eco-labelling and Trade Together on Environment[3]

In section A, we discussed the effects of eco-labelling itself on environment in a closed economy, and in section B, we discussed the effects of labelling on trade. How will trade add on to the labelling vs. environment equation? How do labelling and trade interact together to affect environment? Several typical situations will be specifically discussed, relating back to the graphical models of section A. Consider the situation when in country 1 there is greater domestic supply of F than domestic demand for that product at the pre-labelling price (described by fig.2). Section A showed that adverse environmental consequences are possible in this situation. However, if there is more demand for country 1's F product in its trading partner country 2, then the total demand of F can possibly outweigh country 1's total supply of F. This brings the situation to that of fig.1, where eco-labelling has a positive effect on environment.

[2] This example is first suggested by M&S (1997), and the analysis is furthered here.
[3] This section is based on M&S (1997)'s analysis.

Consider again the situation described by fig.1, when country 1's domestic demand is greater than domestic supply for F at the pre-labelling price. If its trading partner country 2 has more demand for country 1's F product, then the total demand Df will be even greater. According to the discussions in section A, eco-labelling will improve environment by making producers move toward environment-friendly methods and products. However, if there is excess supply of the F good from country 2, then trading could result in the situation that total supply of F product outweighs total demand. This will be the case outlined in fig.2, and eco-label ends with an adverse effect on environment.

Hence, the interaction with country 2 will result in an improvement in the environmental situation in country 1 only if there is enough offsetting demand for the environment-friendly good from that country. The environmental situation in country 1 would worsen under international trade only if there is offsetting excess supply of the environment-friendly products from abroad.

IV. CASE STUDY

In this section, the US to Canada tuna export case will be studied to examine the effects of eco-labelling on trade volumes. After the background information in section A, section B introduces a model developed to summarize the relationship between the implementation of "dolphin-safe" labelling and US to Canada Tuna export volumes, controlling other variables such as seasonal fluctuations and exchange rate. A monthly data set from 1989 to 1999 was used to test the model in section C. Section D then discusses the empirical results.

A. Background Information and Data Selection

There has been a long history of dolphins being killed in the Eastern Tropical Pacific (ETP). It became significant in the 1950s when tuna fishermen began to exploit the unique relationship that existed between the tuna and the dolphin. In this zone, the tuna schools swam below the surface swimming dolphin. The fishermen took advantage of this by developing the purse-seine net fishing method. They also used the dolphins to track, chase, and encircle the tuna.

Since 1991, tuna imported into the United States market can be labeled "dolphin-safe" only if it fulfills certain conditions. Methods perceived to be dolphin-unfriendly could be used for harvesting tuna, either on the high seas by vessel engaged in drift-net fishing, or in the eastern tropical Pacific Ocean by a vessel using purse seine nets.

During 1990/1991, the U.S. enacted the embargo against any country that violated the MMPA (Marine Mammal Protection Act)[4]. The embargoed countries include Mexico, Venezuela, Equador, Panama and Vanatu[5]. Canada, however, did not incur the US tuna embargo. Canada also did not follow such tuna embargo against other countries. Therefore the exports of tuna from US to Canada will be examined.

The tuna trade data used here are from the Fisheries Statistics & Economics Division of the National Marine Fisheries Service (NMFS)[6]. The exchange rate data is from the International Financial Statistics (IFS) CDROM, which gives monthly averaged exchange rate (in market rate) between US and

[4] The embargo was imposed under the MMPA of 1972, as subsequently amended. See US Government [1992]. The MMPA is a US domestic law to protect marine mammals. An international level tuna protection law – International Convention for the Conservation of Atlantic Tunas(ICCAT)—was passed in Rio de Janeriro on 14 May, 1966 (Green Globe Yearbook 1996, p158).
[5] Stanford University http://www.stanford.edu/class/ps142k/casebook/tunacase.htm
[6] The Fishery commission has developed a series of programs that can be used to summarize U.S. foreign trade in fishery products for the years 1975 to present. The kilos and dollar value by your choice of years, products, countries, and the type of trade can be summarized.

Canada from 1950s to January 1999. The case study focuses on the monthly report of US tuna export to Canada from January 1989 up to February 1999[7]. Yellowfin tuna is specifically tested, because it is said to be most sensitive and relevant for the "dolphin-safe" labelling[8]. It is assumed here that other trading conditions, such as transportation costs and custom charges, experiences no significant or unexpected changes over the testing period. This assumption is reliable because the tuna trade between U.S. and Canada has been reasonably stable. Gradual changes in transportation costs would have been incorporated statistically into the regression against previous months' exports.

B. Model

a. Descriptive statistics and model specification

The data was organized and a set of variables are generated: xt(export volume in month t), xt1(export volume of month t-1), xt2(export volume of month t-2), xt3(export volume of month t-3), xt4(export volume of month t-4), x5 (export volume of month t-5), x6(export volume of month t-6), x12(export volume of month t-12), x13(export volume of month t-13), ext(exchange rate of month t), ext1(exchange rate of month t-1), ext2(exchange rate of month t-2), eco(dummy variable for eco-labelling policy), inter (interaction of eco-labelling and exchange rate of month t), id(numerical index of the 106 rows of observations). All export volumes are in kilograms. Exchange rates refer to the averaging market exchange rate (US$/C$) over the month. "eco" stands for eco-labelling, "dolphin-safe" labelling in this case, with 0 values for the years before February 1991, and 1 thereafter.

As we begin to develop models using time series analysis, we want to know whether the underlying stochastic process that generated the series can be assumed to be invariant with respect to time. "If the characteristics of the stochastic process change over time, then the process is nonstationary"(Pindyck, P443). It is often difficult to represent the time series over past and future intervals of time by a simple algebraic model. If the stochastic process is fixed in time, then it is stationary, and one can model the process via an equation with fixed coefficients that can be estimated from past data.

"Any stationary process may be approximated by either an autoregressive (AR) or an moving average (MA) process of sufficiently high order"(Kendall, p66). In both moving average and autoregressive model, the random disturbances are assumed to be independently distributed over time. In the MA

[7] The US-Mexico tuna trade is most typical and interesting, but not very feasible to test because the embargo against Mexico enacted in 1991 will blur with the Eco-labelling policy. It will hence not be feasible to draw any valid conclusion on the effects of Eco-labelling on the trade.

[8] Stanford University http://www.stanford.edu/class/ps142k/casebook/tunacase.htm

process of order q each observation Yt is generated by a weighted average of random disturbances going back q periods. $Yt = \mu+\varepsilon_t - \theta 1\ \varepsilon_{t-1} - \theta 2\ \varepsilon_{t-2} - \ldots - \theta q\ \varepsilon_{t-q}$ where the parameters $\theta 1,\ldots, \theta q$ may be positive or negative. In the AR process of order p the current observation Yt is generated by a weighted average of past observations going back p periods, together with a random disturbance in the current period. $Yt = \phi 1\ Y_{t-1} + \phi 2\ Y_{t-2} + \ldots + \phi p Y_{t-p} + \delta + \varepsilon_t$, where δ is a constant term which relates to the mean of the stochastic process.

How do we decide whether MA or AR model will be most suitable for each time series data then? The autocorrelation function is usually the best check. The autocorrelation function(ACF) tells how much correlation there is(and by implication how much interdependency there is) between neighboring data points in the series Yt. The ACF for AR(1) is particularly simple – it begins at $\rho 0 = 1$ and then declines geometrically. Note that this process has an infinite memory. “The current value of the process depends on all past values, although the magnitude of this dependence declines with time”(Pindyck, P 473). ACF for autoregressive processes of order greater than 1 are typically of damped exponential form, “with a steady or oscillatory pattern depending on the signs of the roots”(Kendall, p60). The ACF of MA process of order q contains “spikes at lag1 through q, then cut off”(Nelson, p89). For first-order seasonal AR and MA processes, correlation at the seasonal lags persists indefinitely, although with declining intensity in the AR case, but it cuts off after one seasonal period in the MA case. On the other hand, the processes are similar in that for both the series of Jan observations is a time series which is independent of the series of February observations, and so forth (Nelson, p172).

As preliminary checks, time series plots and autocorrelation function plot were carried out to verify the nature of the data, and to decide the appropriate regression model to use. The time series plot of xt against id shows a cyclical seasonal pattern (Fig.7). The plot shows rough stationarity as well. Differencing the data once was sufficient to ensure stationarity (Fig.8). The autocorrelation function is exponentially decaying, with some seasonal variations at lag 12(Fig.9). The sample autocorrelation function begins declining immediately at lag k=1 and sees a relatively high point again at lag k=12, which shows that the export volume of month t is relatively highly correlated with that of moth t-12 (the same month previous year). Then it exponentially declines again after k=12. This ACF pattern shows that the seasonal effect is of a 12-month period. The first regression of xt against xt1 results in a 0.6434795 coefficient (<1). All these results show that the data is stationary and autoregressive model can be applied.

Hence the model is first tentatively set up as *xt = b0 + b1* xt1 + b2* xt2 + b3*xt3+ b4*Xt4+b5*xt5+b6*xt6+…+b12*xt12+b13*xt13+b14*ext+b15*ext1+b16*ext2+b17*inter+b18*eco* b0 is the constant term and b1 through b18 are the corresponding coefficients for the predictor variables.

b. Model estimation

A series of regression tests were carried out to test which combination of predictor variables is most reasonable to be included in the model. There are mainly three criteria for deciding which variables to include as predictor variables:

1. R^2 measures the proportion of the variation in Y which is "explained" by the multiple regression equation. "R^2 is often informally used as a goodness-of-fit statistic and to compare the validity of regression results under alternative specifications of the independent variables in the model"(Pindyck, P77). With other conditions being the same, the bigger R^2 is, the better the regression model is. In practice, the adjusted R^2 value is used as a better indicator of goodness of fit than R^2. The adjusted R^2 is defined as 1-(MSE / MST), where MSE refers to mean squared error, and MST refers to mean square of the total;
2. The p-value of t-test for each variable indicates how significant each corresponding variable is in relation to the response variable xt. In normal circumstances, if p-value is less than 0.05, then the variable is considered to be significantly correlated with the response variable, and will be included in the model;
3. Another criterion to evaluate the importance of a variable is to see how much the different coefficients will change upon adding or omitting the variable into regression. If the coefficients change a lot without the variable as opposed to having the variable in, then the variable should be included in regression.

Bearing these three criteria in mind, the final regression model is estimated through the following procedures.

The first regression was carried out including all the variables xt1 through xt13, ext, ext1, ext2, inter and eco. The very high p-value for ext1 keeps this variable out of the second round of regression. After taking ext1 away, the p-values of most of the remaining variables became less (improved the significance of these variables). For instance, the p-value of xt2 was 0.014 in the first regression and 0.007 in the second. The coefficients of the predictor variables in the second regression only changed a little – approximately 0.01 points difference. The value of adjusted R^2 rose from 0.4679 to 0.4883. These results show that the model achieves more efficiency by dropping the several insignificant variables.

By the same procedure and comparison, the regression model is narrowed down to include xt1, xt2, xt12, ext, inter and eco as predictor variables (the regression table is included in appendix). Notice the p-values for most variables are very low, except xt12 (which is 0.093). Another regression was hence undertaken without xt12. However, the later regression did not seem to be better, mainly because the adjusted R^2 value dropped from 0.4848 to 0.4752. There are also some other disadvantages of the later model. It raised p-values for several variables. For example, the p-value of ext rose from 0.022 to 0.026. The coefficients of the predictor variables also changed. Among them, the coefficients of ext, inter, constant term and eco changed most. For the above reasons, the later regression was rejected, and xt12 was kept as a predictor variable.

Several other regressions of more simplicity were also tried out, with the predictor variable combinations: xt, xt1, xt12, ext, inter, eco; xt, xt1, ext, eco; xt, et1, ext; etc. But they were all rejected for similar reasons as explained in the previous paragraph. So the final regression model is decided to be:

$$xt=0.3783843*xt1+0.3107966*xt2+0.1471963*xt12-512875*ext+510458.5*inter-442918.6*eco+445958.9$$

(All the coefficients are read off from the regression table, as attached in appendix, Table 2.)

c. Diagnostic check

There are mainly two sets of diagnostic checks necessary to test the validity of the regression: i. Check residual plots, and ii. Check autocorrelation of errors.

i. Use residual plots to test the assumptions of the multiple regression model:

a. the error term has 0 expected value and constant variance for all observations.

b. errors corresponding to different observations are independent and therefore uncorrelated.

c. the error variable is normally distributed.

d. the conditional mean is linear in predictor variables.

The qnorm(Fig.9) and histogram(Fig.10) plots of residual e1 show that the errors are approximately normally distributed. e1 were plotted against id (Fig.11) and predicted value y1(Fig.12) respectively. In both Fig 11&12, the number of observations are scattered evenly on both sides of the y=0 line, and exhibit no special pattern, which shows that errors corresponding to different observations are independent. The number of observations on both sides of the y=0 line are approximately equal, and different observations on both sides of the line are of similar total distances to the line. So the error terms tend to have 0 expected value and constant variance. The predicted and observed xt values are also plotted against predictor(independent) variables to test criterion d. Taking the plot of y1, xt, xt1 as an example, Fig.13 shows a positive correlation between y1 and xt1, xt and xt1, which shows that the conditional mean is linear in predictor variable xt1.

ii. Use Durbin-Watson regression to test autocorrelation of errors. When the error terms in the regression model are positively autocorrelated, the use of ordinary least squares procedures has a number of important consequences(refer to Neter, p497):

1. The estimated regression coefficients are still unbiased, but they no longer have the minimum variance property and may be quite inefficient.
2. MSE may seriously underestimate the variance of the error terms;
3. Standard deviations calculated according to the ordinary least squares procedures may seriously underestimate the true standard deviation of the estimated regression coefficient;
4. Confidence intervals and tests using the t and F distributions are no longer strictly applicable.

To illustrate the problems of autocorrelation, we assume that the error terms ε_t are positively autocorrelated as $\varepsilon_t = \varepsilon_{t-1} + Ut$, where Ut, called disturbances, are independent normal random variables, with mean 0 and variance 1. Since all the errors are correlated, different initial ε_0 value and different disturbances would lead to sharply different fitted regression lines. This variation from sample to sample in the fitted regression lines due to the positively autocorrelated error terms may be so substantial as to lead to large variances of the estimated regression coefficients when OLS methods are used.

In view of the seriousness of the problems created by autocorrelated errors, it is important that their presence is detected. Durbin-Watson test is widely applied for such detection. "The D-W test for autocorrelation assumes the first-order autoregressive error models with the values of the predictor variable(s) fixed"(Neter, p504). The test consists of determining whether or not the autocorrelation parameter ρ is zero. If $\rho=0$, then $\varepsilon_t = Ut$. Since the disturbance terms Ut are independent, the error terms are independent as well. The D-W test statistic D is obtained by using OLS to fit the regression function, calculating the ordinary residuals et= Yt –Yt hat, and then calculating the statistic :

$D=\Sigma^n_{t=2} (e_t-e_{t-1})^2 / (\sum^n_{t=1} e_t^2)$, where n is the number of cases. Exact critical values are difficult to obtain, but Durbin and Watson have obtained lower and upper bounds dL and du such that a value of D outside these bounds leads to a definite decision. If D>du, conclude that $\rho=0$, if D<dL, then conclude $\rho>0$, and if $dL \le D \le du$, the test is inconclusive. These results are intuitive because the "adjacent error terms tend to be of the same magnitude when they are positively autocorrelated"(Neter, p505). Hence, the differences in the residuals, e_t-e_{t-1}, would tend to be small when $\rho>0$, leading to a small test statistic D.

The two principal remedial measures when autocorrelated error terms are present are to add one or more predictor variables to the regression model or to use transformed variables. One typical example of addition of predictor variable is the use of indicator variables for seasonal effects. This can eliminate or reduce the autocorrelation in the error terms when the response variable is subject to seasonal effects. The regression model in this paper had such seasonal control by including xt1, xt2 and xt12 as predictor variables. In order to be able to use the transformed model, one generally needs to estimate the autocorrelation parameter ρ since its value is usually unknown. There are three methods to achieve the transformation: the Cochrane-Orcutt Procedure, the Hildreth-Lu Procedure, and the first differences procedure. They differ in how the estimation of ρ is done. Often, however, the results obtained with the three methods are quite similar.

A Durbin-Watson test was run to test the tuna regression model developed in this paper (Table 3). The Durbin-Watson Statistic D = 2.014514 (please refer to the regdw table in appendix). Consulting the D-W critical value table (Pindyck, p568), we obtain dL=1.57 and du=1.78 for 100 observations and 5 predictor variables. This regression involves 106 observations, and 6 variables (including 1 dummy variable). So the critical values should still apply here. Since D = 2.014514 >du, we conclude that there is no autocorrelation among the error terms. As a double check, a Cochrane-Orcutt regression is also carried out here (Table 4). The estimated autocorrelation coefficient appears at the bottom of the regression table. This model incorporates a relation between successive errors: $\varepsilon_t = -0.0557\varepsilon_{t-1} + Ut$. Again indicating the absence of autocorrelation here, the estimated coefficient (rho=-0.0557) is not significantly different from zero. Its 95% confidence interval is $-0.2505 < \rho < 0.1390$.

Both the residual plots and autocorrelation tests proved the validity of the regression model. Hence the model is confirmed.

C. Intuitions For The Results

a. General results

The extremely small p-values of the regression coefficients of xt1 (0.000) and xt2 (0.002) show that the export volume of month t is highly correlated with the export volumes of previous two months. This is practical because trade exhibits consistency in usual cases, when there is no drastic shocks. The seasonal effects are also non-negligible, as removing xt12 variable changed the coefficients and p-values of all predictor variables as described in section III. Empirically, seasonal effects are especially important for tuna catch, and hence important for trade volume.

The relationship between export volume and exchange rates can not be predicted fully, because exports depend on real not nominal exchange rate. When the real exchange rate rises, the dollar is depreciated, which makes US exports relatively cheaper. According to international trade theory, the export volume should increase if other things being constant. Yet only nominal exchange rate data was available for this study. If the price of the US tuna increases more than exchange rate, which implies an actual depreciation of dollar, With other things being constant, the negative coefficient here could be resolved. Unfortunately, the prices of yellowfin tuna over the examined period were not found. This postulation could not be verified directly. However, the "eco" variable could account for the price influence.

Since labelling requires environment-friendly methods, which is more costly. We would have expected a higher price of yellowfin tuna in the post-labelling equilibrium than that of pre-labelling equilibrium, given that concerned consumers were willing to pay more for tuna which was clearly dolphin-friendly than they had been willing to pay for undifferentiated tuna. The fact that Canada did not have "dolphin-safe" labelling may demonstrate an assumption that Canadians are not as concerned as Americans are in this matter. It is then not surprising to see that US tuna exports were discouraged by the increase in price. This can be the intuition for the negative correlation between "dolphin-safe" labelling and US to Canada export volume. It may first seem striking to see such a big coefficient of eco-labelling. Does this necessarily mean that the existence of eco-labelling will cause a decrease of 442918.6 kilograms in export volumes? The answer is negative after noting the big variance of this coefficient, which amounts to 190430.

Labelling will possibly influence the product competitiveness in international market, and hence may influence exchange rates. This explains the significance of the variable "inter" as shown up in regression. For instance, the higher cost of catching dolphin-safe tuna in US may undermine its tuna industry's competitiveness in international market, especially if consumers abroad are not as concerned as US consumers, and hence less willing to pay for the premium incurred from labelling. This could lead to a depreciation of US dollars to bring up the export. Such effects will show up as a positive correlation between interaction and xt.

b. Possible Explanations for the Negative Correlation of Eco-labelling and Tuna Export – Relating to the M&S model

"Crude estimates suggested that before the labelling requirement was introduced, tuna caught by methods which qualified as 'dolphin-friendly' was over 80% of the total tuna supplied to the United States market. On the other hand, market surveys suggest that the percentage of demand originating from concerned consumers was significantly smaller"(M&S 1994). Thus it would seem that the tuna market conformed to the situation described in fig2 or fig 3. That is, before labelling was introduced, demand originating from environmentally concerned consumers was smaller than the supply from dolphin-friendly methods. On that basis, we would have expected a higher price of yellowfin tuna in the post-labelling equilibrium than that of pre-labelling equilibrium, if concerned consumers were willing to pay more for tuna which was clearly dolphin-friendly than they had been willing to pay for undifferentiated tuna. The fact that Canada did not have "dolphin-safe" labelling may demonstrate an assumption that Canadians are not as concerned as Americans are in this matter. It is then not surprising to see that US tuna exports were discouraged by the increase in price. This can be the intuition for the negative correlation between "dolphin-safe" labelling and US to Canada export volume.

V. DISCUSSION

In this section, both critiques of research and policy implications are included. Section A addresses discussions of further improvements. Section B addresses policy issues. I will comment upon each section of the theoretical background part (Section II, A through C), and provide suggestions on both theoretical modeling (Section IIA in particular) and empirical testing (Section III).

A. Potential Improvements in Models and Methods

The graphical model presented in this paper (II.A) helps to predict effects of eco-labelling under different circumstances. The key assumption (Assumption 6) is empirically plausible. Opinion polls throughout the OECD area demonstrated that at least some consumers are willing to pay a premium for environmental friendly goods. For example, in a survey of the United States, consumers were found to be willing to pay over 6% more certain green products than for the regular brands: while a small part (approximately 10%) of the population was willing to pay as much as 20% more for green products, a third of the population would not pay any more for them than for regular brands (M&S, 1994).

However, the model is by no means perfect. Its assumptions are simplified and may not fully account for other important factors in reality. From the consumption side, the assumption that concerned consumers only purchase environment-friendly products are somewhat rigid. In reality, concerned consumers are more likely to be willing to pay up to a maximum premium for the labeled product, and "the number of consumers who are willing to pay for labelling premium is usually smaller than that of environmental conscious consumers"[9]. In equilibrium, the price difference between the labeled and the unlabelled product will be equal to the premium that the marginal concerned consumer in the labeled segment is willing to pay.

From the production side, there are two types of labelling schemes: a. labels are simply given to the existing F products; b. there was no F products in the pre-labelling market. In post-labelling market, companies will change their production process in order to attain the label that might enable them to acquire comparative advantages. These two labelling schemes can lead to different results. The graphical model in section IIA only accounted for scenario a. A different model[10] could be developed to illustrate scenario b (fig.6). Suppose that a market consists of only U production pre-labelling. The labelling policy stimulates a sector of environmental conscious producers to adopt environmental friendly methods. Now

9. These points are suggested by Barbara Becker.
10 This model is first set up by Yu-chin Chen, and elaborated by Yi Qian.

the market differentiates to Sf and Su, with market weighted average supply Sd. Due to information-spread time lag, consumers are still not aware of the importance of F versus U, and the market still maintains its pre-labelling uniform price P. At this short run equilibrium stage, the productions (which equals consumption) of F and U are at levels Qf1 and Qu1 respectively. In the long run, when product differentiation are fully known to public and when concerned consumers who are willing to pay labelling premiums withdraw from U, the price of F will be bid up by the increase of its demand, and price of U will drop. The new equilibrium arrives with (Qf2, Pf2) and (Qu2, Pu2). Notice that Qf2>Qf1, and Qu2<Qu1. In the very long run, when more and more consumers are willing to switch to F, the slope of the demand curve can change (D -> D'). As reflected in graph, more F product will be purchased at a higher price, and the reverse works for U. Labelling will hence achieve its purpose of encouraging F production.

The predictions of labelling effects on international trade (section II.B) and predictions about how labelling and trade together influence environment (section II.C) are not precise and subject to discussions for each individual case, because there are many variables involved. Such variables can include : the relative size of concerned consumer populations in the trading countries, the production of environment-friendly and unfriendly products in the trading countries, the different feasibility and flexibility of switching to environment-friendly technologies in the trading countries, and the extent to which labelling influences consumer behavior in each country, etc.

It is worth noting that the two cases presented in section II.C are again simplified. There are more dimensions in reality. Firstly, the extent that Eco-labelling influences consumer and producer behavior differs from country to country. The feasibility and flexibility for the producers to switch toward environment-friendly technologies also differ. Secondly, there is likely conflict between fulfilling the objective of reducing production of environmentally unfriendly products and the objective of increasing income levels of some of the countries involved. For example, even when labelling in country 1 results in an improvement in the environment situation, it could also result in a lower income level because of possible declines in terms of trade. The decline in income may impede the attainment of the environmental objective. Lastly, other issues, such as whether the labelling is mutually recognized or unilaterally imposed, can all complicate the trade and environmental scenario.

In terms of the empirical case study (section III), the dataset used in the empirical study is big enough to illustrate trends and responsible results. However, the shortcoming of the dataset first comes from the fact that no data is available before year 1989. Fortunately the monthly nature of the data makes up the above deficiency. The second data constraint is the lack of price index. Because there is no price data, the deduction that the price of tuna increased after labelling in section III.D cannot be verified here.

In analysis, tuna caught by "dolphin-friendly" methods was over 80% of the total US tuna market pre-labelling (M&S 1994). With such a high product market share of F products, consumers in some areas could have no other choice but environment-friendly products[11] even if they are not environment conscious. Labelling could have improved consumers' "dolphin-safe" awareness, and increased the number of consumers who are truly willing to buy F. Yet this positive effect of labelling would have been overlooked from data alone.

Besides the above data deficiencies, the predictions of the case study are also limited because of other possible predictor variables that could also influence the export volume, but that relevant data were not found.   There are several options to further improve the study:

1. It will be more appropriate if domestic and foreign consumers' preferences could be measured and entered into regression as control variables. Then the result will be more accurate and persuasive in terms of predicting the effects of eco-labelling on trade.
2. Regressions could also be carried out using the export values instead of volumes.
3. The exports of different categorized tuna products could be compared to test how environment-friendly production and environment-unfriendly production change relative to each other before and after labelling.
4. If prices of the different categorized tuna products can be observed, hence the prices of environmentally friendly and unfriendly tuna before and after labelling are observed, then the predictions of price changes in fig.1 and 2 can be tested also.
5. Labelling of other products, such as timber and textile, can also be examined. Due to time constraint, interesting datasets on these industries were not found.

This section discusses the shortcomings of theoretical background and empirical study presented in this paper. It is found that the graphical model has simplified assumptions for both consumption and production sides. The theoretical predictions in section II.B and C are not concrete, because there are many variables involved in the issue. Suggestions of further improvement of the empirical studies are listed in this section.

B. Policy Implications

Tuna case study shows that eco-labelling can have a negative effect on trade, i.e. it reduces tuna export from US to Canada. As discussed before in section II, the adverse effect on the environment arose when there is excess supply of F pre-labelling. In effect, policy makers should ensure the criteria that the total supply of F before labelling is less than the demand of F. In some cases, labelling policy has already reflected this criteria. For instance, in the case of the German program, the *product market share*[12] is also examined and products already holding a dominant market share are not included in the program (OECD 1991, P45).

Certain dynamic effects of policy were first examined by M&S(1994); the analysis is furthered here. Consider first the effect of policies that are designed to enhance environmental consciousness among consumers. This could be either due to "unconcerned" consumers becoming environmentally conscious, i.e. they become willing to pay a premium for the labeled products; or due to the existing environmentally conscious consumers willing to pay a larger premium. If the result of these efforts were "widened" awareness, meaning more consumers became concerned, then the demand of environment-friendly products will increase, and the likelihood of the adverse situation of fig2 would diminish. However, if the result were only "deepened" awareness, meaning the already concerned consumers were willing to pay even higher premium, and we were in situation 2, then the adverse consequence could be worsened. One solution though, is to bring about fast increase in supply of environment-friendly products. This could be achieved by providing more direct incentives for the use of environment-friendly production methods, such as direct governmental subsidy to the environment-friendly technologies and productions.

Therefore, in general, unless policy makers are well informed about the underlying demand and supply, the consequences of indirect measures like labelling are not predictable. Rather, directly encouraging the move of producers from the unlabelled to the labeled segment of the market would have a much more immediate effect on mitigating "environmental unfriendliness".

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[11] This point was raised by my tutorial leader Barbara Becker

[12] It is worth noting that "Product Market Share" is different from "firm market share". Product market share simply refers to the percentage a certain type of product enjoys in the whole market.

VI. CONCLUSION

This paper first starts with theoretical discussions on how eco-labelling can influence environment differently in different cases. M&S's graphical model was introduced and elaborated. It has been shown that Eco-labelling will possibly have adverse effects on environment when the proportion of total quantity supplied which qualified as environment-friendly was greater than the proportion of demand originating from potential concerned consumers (Fig.2). In a dynamic setting (Fig.3), it is also possible that the demand and supply of F and U products would shift so that the situation reverses to the case that the proportion of total quantity supplied which qualified as environment-friendly is less than that of environment-conscious demand (Fig.1). Then labelling performs a positive effect on environment.

The relationship between labelling, trade and environment are then further explored. A summary table is developed in Appendix1. In general, the introduction of labelling can change the trade volumes of F and U products (section II.B). In the case that domestic demand outweigh supply of environment-friendly product, environmental situation in the country will worsen under international trade only if there is offsetting excess supply of the environment-friendly good from abroad. And in the case that domestic demand is less than supply of environment-friendly product, the adverse effect of labelling on environmental could be ameliorated if the trading partner is a country where consumers have high environmental concern. However, the issue is far more complicated, and the exact consequences shall be discussed and decided from case to case.

An empirical study of the tuna eco-labelling case was carried out to exam whether and how empirical evidence echoes theoretical discussion. The results of tuna export study supported the theoretical prediction. The tuna industry falls into the second situation (fig.2). Following the theoretical analysis, the introduction of "dolphin-safe" labelling would raise the tuna price, and hurt export. This result indeed shows up in empirical data analysis. After controlling seasonal fluctuations of tuna trade, the labelling has a negative coefficient with export volume. The coefficient is not as startling as it appears from the very high numerical value, because the variance of the coefficient value is very high as well.

As an ending note, it is very hard to generalize the effects of eco-labelling on international trade and environment. There are many possible influences as discussed in section IV. For instance, the proportions of concerned consumers in trading countries; the production of environment-friendly and unfriendly products in the trading countries; the different feasibility and flexibility of switching to environment-friendly technologies in the trading countries; and whether demand of environment-friendly product outweigh the supply of such product in each country. The policy makers will have to balance the labelling, trade and environment equation from case to case.

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APPENDIX 1 – GRAPHS[13]

FIG. 1: Df > Sf pre-labelling (situation 1)

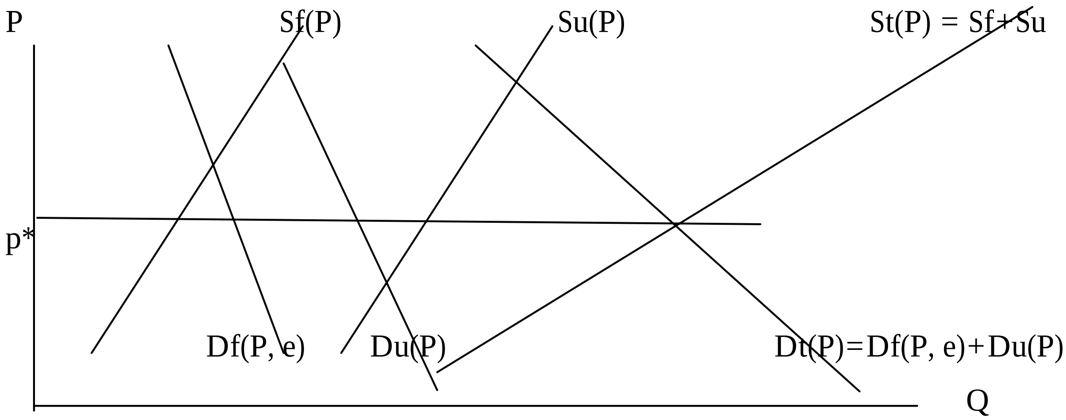


FIG. 2: Df < Sf pre-labelling (situation 2)

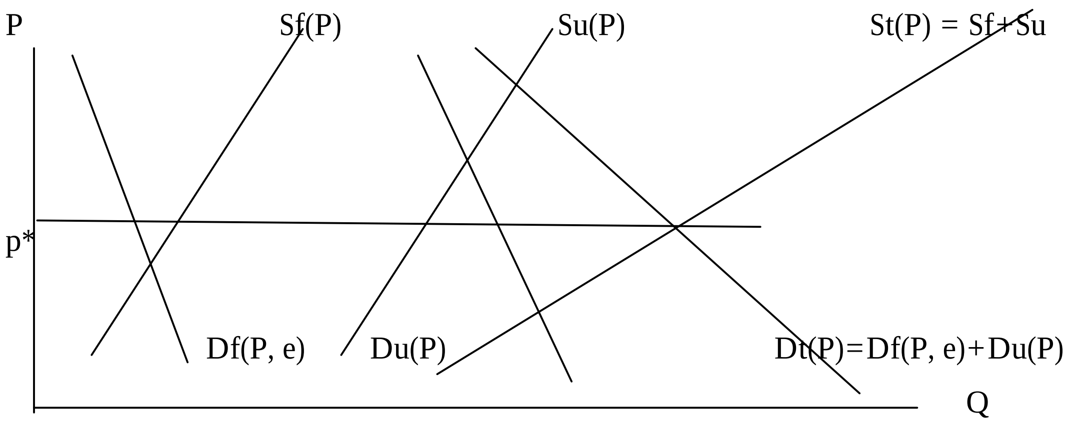
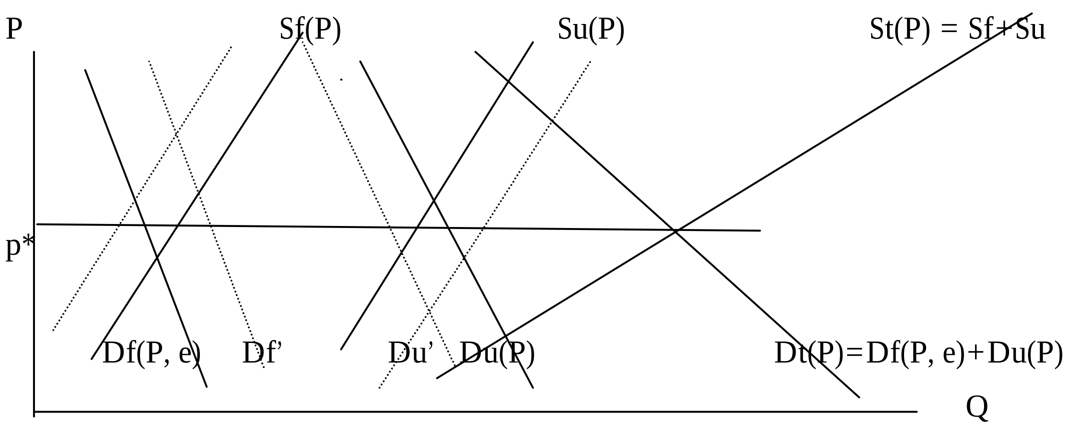


FIG. 3: Df < Sf, but with dynamic changes in supply and demand (situation 3)



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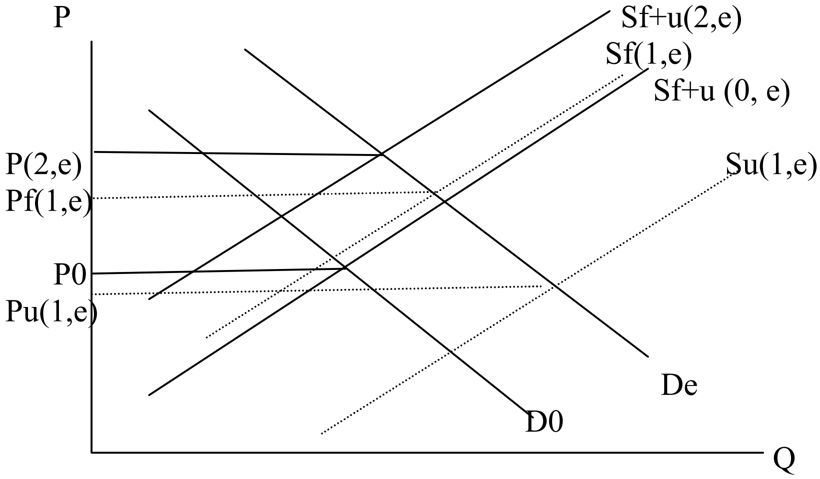
[13] Fig.1 and 2 are directly from P56 of Mattoo and Singh(1994). Fig.3 is Yi Qian's improvision.

Fig.4 : Comparing the price levels before and after labelling

-- A different presentation for Situation 1 and 2 together



e -- Eco-labelling implemented; P0 – uniform price before labelling;

Pf(1,e) – price of environment-friendly product after labelling in situation 1;

Pu(1,e) – price of environmental-unfriendly product after labelling in situation1;

P(2,e) – uniform price of both sectors of product after labelling in situation 2;

Sf+u – total supply of the product, including environment-friendly and environmental-unfriendly sectors;

Su(1,e) – supply of environmental-unfriendly product after labelling in situation 1;

D0 – total demand before labelling; De – total demand after labelling;

FIG. 5: Effects of labelling on trade (section II.B)

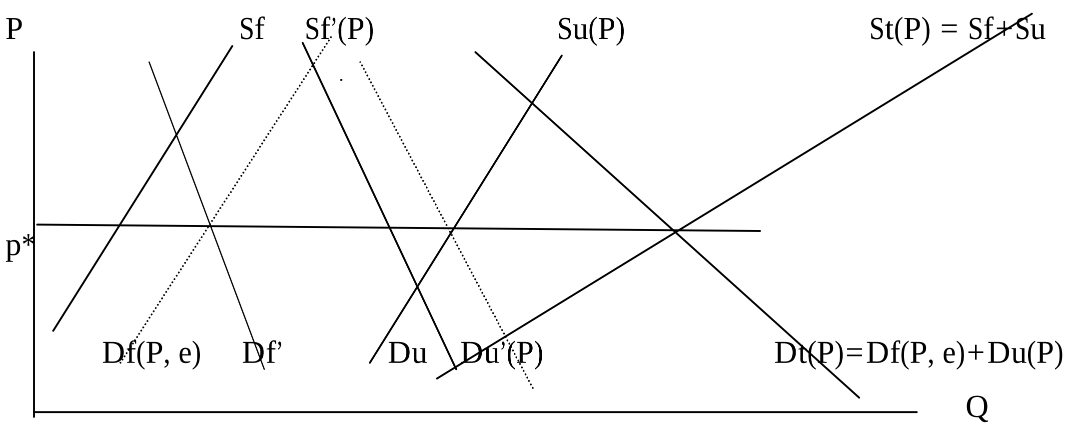


Fig. 6. Labelling effects on environment in the case that no F pre-labelling, and labelling initiates F production.

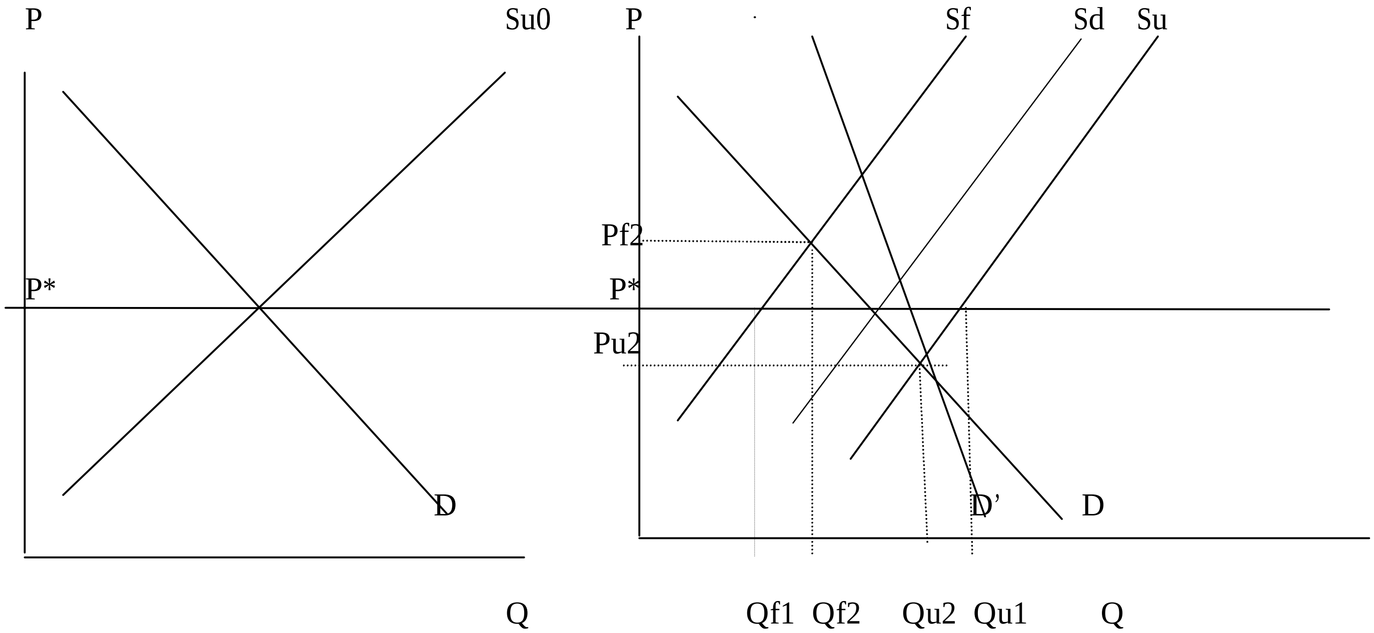


Table 1: Summary Table of Labelling, Trade and Environment Scenario:

	DOMESTIC MARKET	INTERNATIONAL TRADE
Df > Sf	Price of environment-friendly products rises relative to that of environmental-unfriendly products.	Import is possible to rise; Environment will be undermined only if there is offsetting excess supply of the environment-friendly products from abroad
Sf > Df	a. static case: price of both F and U products will rise and a uniform price will be reached after labelling, which is higher than original P*; b. dynamic case: possible shifts in demand and supplies, driving situation back to Df > Sf case.	Export falls; Environment will be ameliorated if there is offsetting demand for the environment-friendly good from the trading partner country.

APPENDIX 2 – STATA OUTPUT

Table 2. The Formal Regression Model

```
. regress xt xt1 xt2 xt12 ext inter eco

  Source |       SS       df       MS              Number of obs =     106
---------+------------------------------           F(  6,    99) =   17.47
   Model |  1.8848e+09     6   314134576           Prob > F      =  0.0000
Residual |  1.7805e+09    99  17984730.2           R-squared     =  0.5142
---------+------------------------------           Adj R-squared =  0.4848
   Total |  3.6653e+09   105  34907578.5           Root MSE      =  4240.8
------------------------------------------------------------------------------
      xt |      Coef.   Std. Err.       t     P>|t|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
     xt1 |   .3783843   .0957631      3.951   0.000       .1883695    .5683991
     xt2 |   .3107966   .0992395      3.132   0.002       .1138838    .5077094
    xt12 |   .1471963    .086893      1.694   0.093      -.0252183    .3196109
     ext |    -512875   221079.9     -2.320   0.022      -951545.5   -74204.47
   inter |   510458.5   220962.9      2.310   0.023       72020.27    948896.8
     eco |  -442918.6     190430     -2.326   0.022        -820773   -65064.18
   _cons |   445958.9   190496.8      2.341   0.021       67971.96    823945.8
```

Interpretation of variables:

xt – volume of US tuna exports of month t;

xt1 – volume of US tuna export of month t-1;

xt2 – volume of US tuna export of month t-2;

xt12 – volume of US tuna export of month t-12 (which is the same month previous year);

ext – the U.S.-Canada exchange rate of month t;

eco – dummy variable for eco-labelling, which takes on value 1 if eco-labelling is implemented, and 0 otherwise;

inter – interaction variable of ext (exchange rate) and eco (existence of eco-labelling).

Table 3. The Durbin-Watson Regression

```
. regdw xt xt1 xt2 xt12 ext inter eco, t(id)

  Source |       SS       df       MS              Number of obs =     106
---------+------------------------------           F(  6,    99) =   17.47
   Model |  1.8848e+09     6   314134576           Prob > F      =  0.0000
Residual |  1.7805e+09    99  17984730.2           R-squared     =  0.5142
---------+------------------------------           Adj R-squared =  0.4848
   Total |  3.6653e+09   105  34907578.5           Root MSE      =  4240.8
------------------------------------------------------------------------------
      xt |      Coef.   Std. Err.       t     P>|t|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
     xt1 |   .3783843   .0957631      3.951   0.000       .1883695    .5683991
     xt2 |   .3107966   .0992395      3.132   0.002       .1138838    .5077094
    xt12 |   .1471963    .086893      1.694   0.093      -.0252183    .3196109
     ext |    -512875   221079.9     -2.320   0.022      -951545.5   -74204.47
   inter |   510458.5   220962.9      2.310   0.023       72020.27    948896.8
     eco |  -442918.6     190430     -2.326   0.022        -820773   -65064.18
   _cons |   445958.9   190496.8      2.341   0.021       67971.96    823945.8
------------------------------------------------------------------------------
Durbin-Watson Statistic =  2.014514
```

Table 4. The Corchrane-Orcutt Regression

```
. corc xt xt1 xt2 xt12 ext inter eco, t(id)
Iteration 0:  rho = 0.0000
Iteration 1:  rho = -0.0111
Iteration 2:  rho = -0.0200
Iteration 3:  rho = -0.0271
Iteration 4:  rho = -0.0329
Iteration 5:  rho = -0.0376
Iteration 6:  rho = -0.0415
Iteration 7:  rho = -0.0447
Iteration 8:  rho = -0.0473
Iteration 9:  rho = -0.0494
```

```
Iteration 10:  rho = -0.0512
Iteration 11:  rho = -0.0527
Iteration 12:  rho = -0.0539
Iteration 13:  rho = -0.0549

(Cochrane-Orcutt regression)

  Source |       SS       df       MS              Number of obs =     105
---------+------------------------------           F(  6,    98) =   19.81
   Model |  2.1541e+09     6   359017871           Prob > F      =  0.0000
Residual |  1.7765e+09    98  18127193.6           R-squared     =  0.5480
---------+------------------------------           Adj R-squared =  0.5204
   Total |  3.9306e+09   104  37793963.4           Root MSE      =  4257.6

------------------------------------------------------------------------------
      xt |      Coef.   Std. Err.       t     P>|t|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
     xt1 |   .4243882   .0972107      4.366   0.000       .2314768    .6172995
     xt2 |   .2817145   .1011747      2.784   0.006       .0809366    .4824925
    xt12 |   .1423971   .0850092      1.675   0.097      -.0263008     .311095
     ext |  -518753.3   219019.8     -2.369   0.020        -953391   -84115.52
   inter |   516225.3   218926.9      2.358   0.020        81772.1    950678.5
     eco |  -447915.2   188722.8     -2.373   0.020      -822429.5      -73401
  _inter |   450947.4   188777.9      2.389   0.019       76323.82      825571
------------------------------------------------------------------------------
     rho |    -0.0557     0.0982     -0.567   0.572        -0.2505      0.1390
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    2.014514
Durbin-Watson statistic (transformed) 1.888026
```

Fig.7 Time series plot of xt

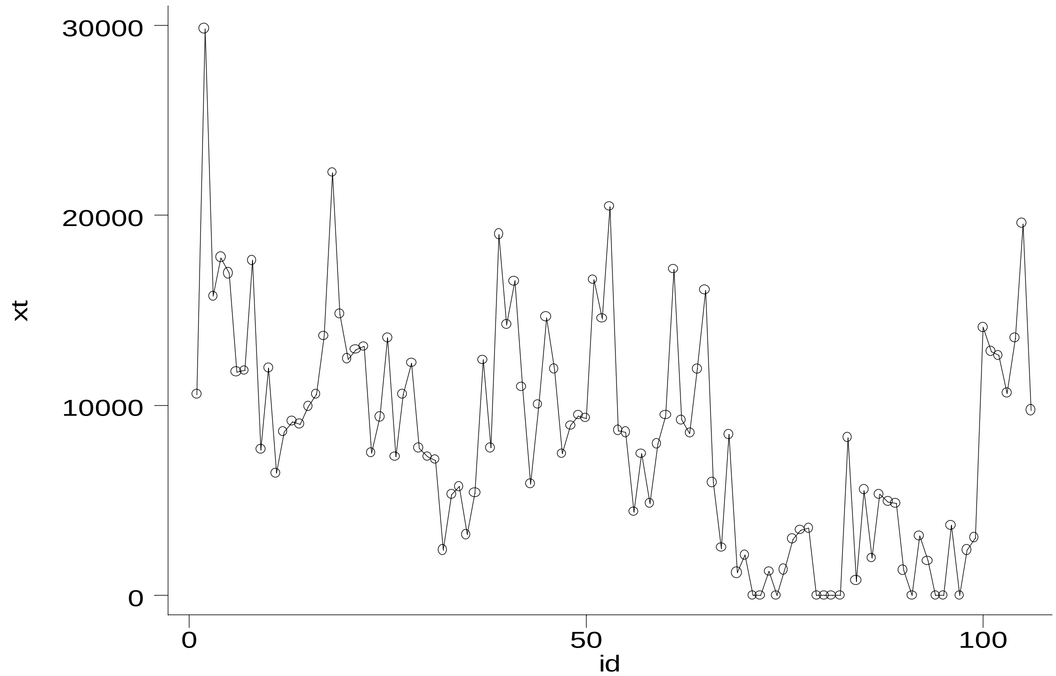


Fig.8 first differencing of xt

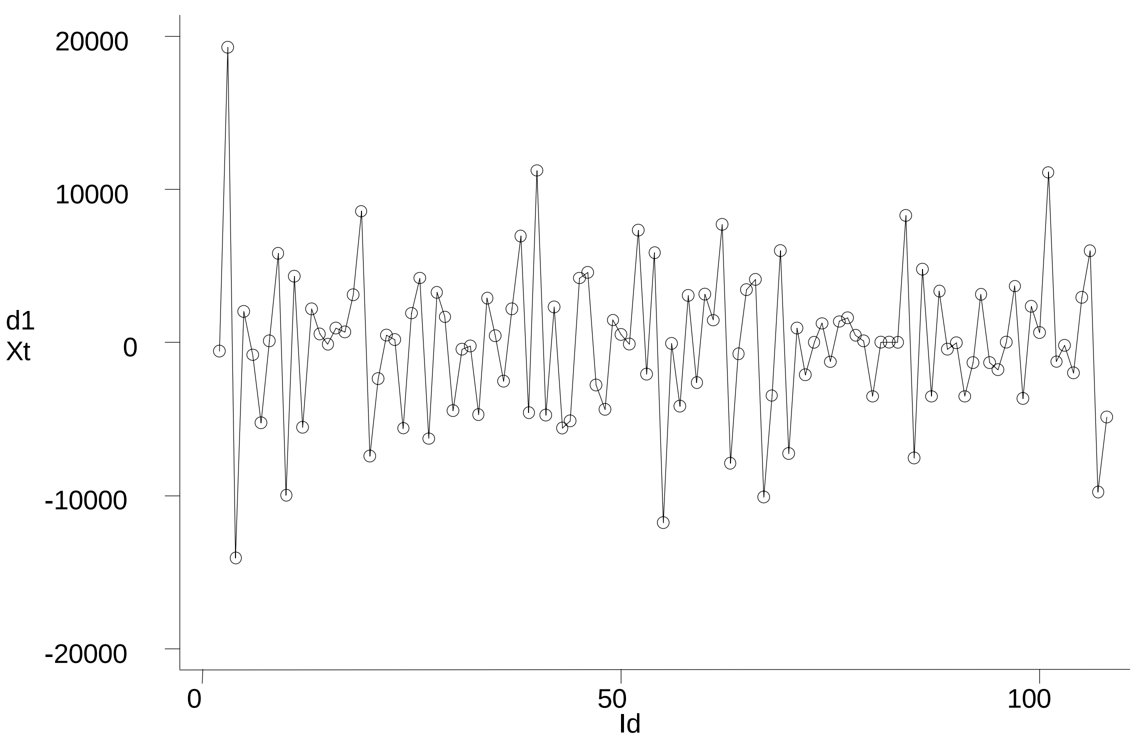


Fig. 9. Q-norm plot of residuals

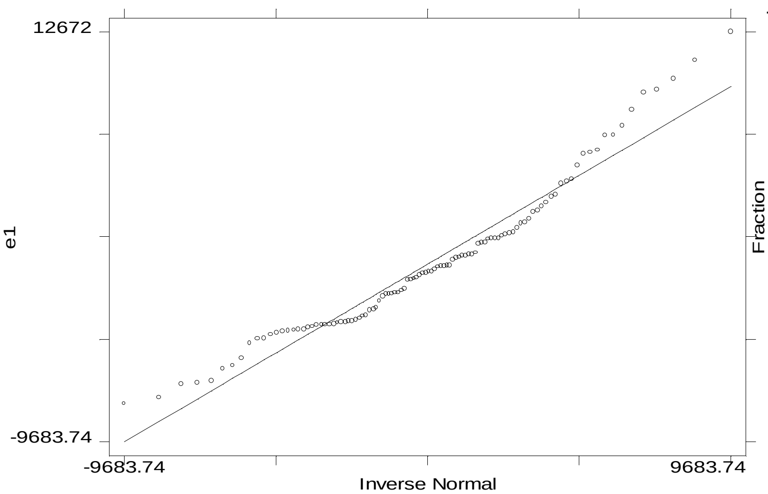


Fig.10. Histogram of Residuals

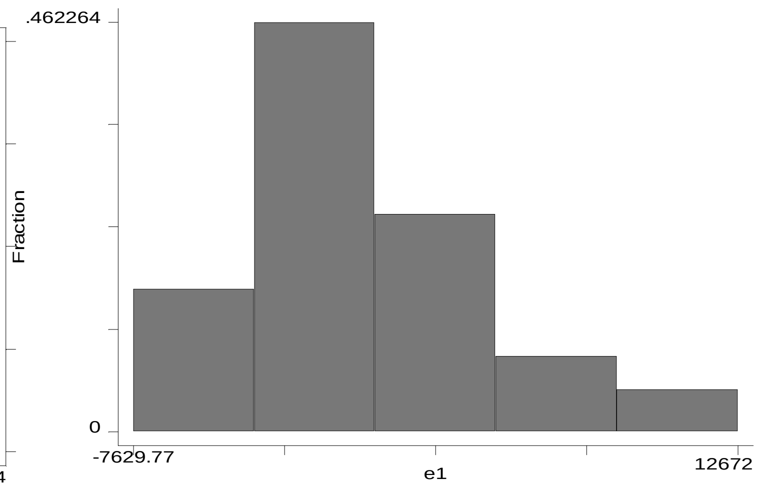


Fig.11. Residual plot against id.

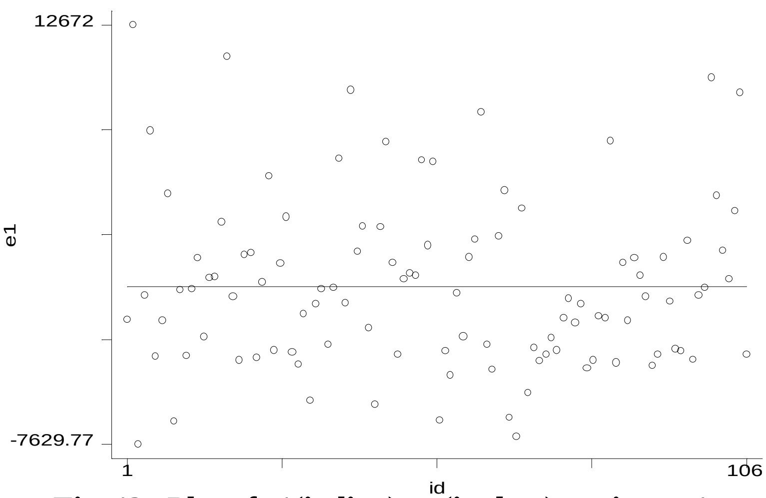


Fig.12. Residual plot against

Predicted

Response variable y1

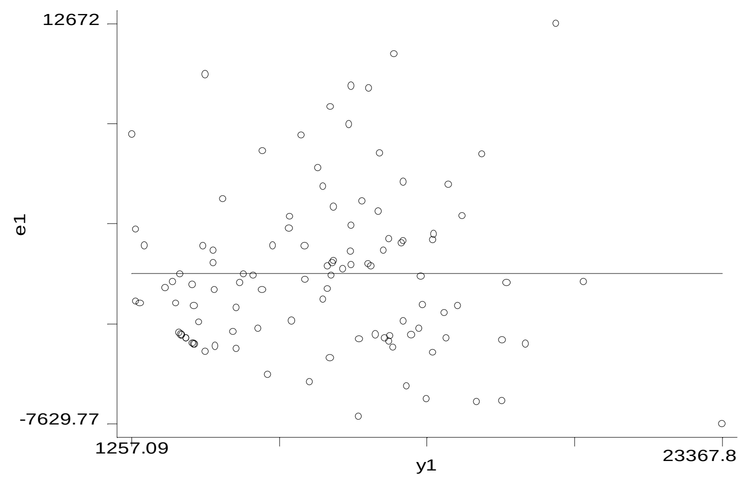


Fig. 13. Plot of y1(in line), xt(in dots) against xt1