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THE IMPACT OF DOMESTIC POLICIES ON INTERNATIONAL COMPETITIVENESS

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ABSTRACT OF DISSERTATION

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Agriculture at the University of Kentucky

By

Md. Ashfaqul Islam Babool

Lexington, Kentucky

Director: Dr. Michael R. Reed, Professor of Agricultural Economics

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ABSTRACT OF DISSERTATION

THE IMPACT OF DOMESTIC POLICIES ON INTERNATIONAL COMPETITIVENESS

The impact of domestic policy regulations and standards on trade has been at the forefront of global policy during the past decade. Every country develops their own policies and standards that differ from country to country. These differences create problems for manufacturing industries, especially in major exporting countries. This study overviews the policy context driving standards in the manufacturing industries. The study consists of three different articles that attempt to examine the role of technical regulations and standards and their relationship with trade using different econometric models

In the first article, the standard factor endowment approach is employed to explain the effects of environmental regulatory policy on net exports in different manufacturing industries. The study hypothesizes that a country's comparative advantage depends on its factor abundance. The regulatory policy increases production costs and, thus, reduces the output level of an industry. The results indicate that each industry is unique in the factors determining net exports and in many instances environmental regulations are important.

In the second article, we investigate the impact of competition policy on a country's production and export competitiveness. Since the impact of competition regulation depends upon the particular circumstances of the industry to which the policy is applied, we examine how competition policy impacts production and exports of a specific sector, in particular the agri-food processing sector. The results suggest that competition policy enhances competition by reducing entry barriers, and causes firms to produce more output with lower prices. Exports for both total and food manufacturing in the post-competition policy period are higher than exports in the pre-competition period.

In the third article, we estimate regressions based on an extended gravity model to determine the possible influence of food safety standards on export flows of six Asia-Pacific countries to ten importing countries. We examine the relationship between bilateral exports and importers' imposition of food safety standards. The results show that the value of exports in food and food products is negatively affected by food safety standards: the greater the aflatoxin standards, the lower its restrictiveness, and higher the bilateral export flows.

KEYWORDS: Export competitiveness, factor endowment, environmental regulations, competition policy, food safety standards.

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THE IMPACT OF DOMESTIC POLICIES ON INTERNATIONAL COMPETITIVENESS

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I wish to dedicate all these works to my beloved wife.

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TABLE OF CONTENTS

ACKNOWLEDGMENTS iii
LIST OF TABLES vii
LIST OF FIGURES ix

CHAPTER I: Overview 1

CHAPTER II: **The Impact of Environmental Regulatory Policy on International Competitiveness of Manufacturing Industries: An Empirical Analysis**

Introduction 5
Research Objectives 8
Review of Literature 8
Model Description 13
Heckscher-Ohlin model and environmental regulations 13
Empirical Model 21
Category 1: Pollution intensive industries 24
Category 2: Non-Pollution intensive industries 24
Category 3: Industries either pollution- or non-pollution intensive 24
Data Sources and Description 24
Empirical Results 27
Summary and Conclusion 37

CHAPTER III: **The Impact of Competition Policy on Production and Export Competitiveness: A Perspective from Agri-food Processing**

Introduction 41
Research Objectives 43
Competition Policy and Trade 43
Review of Literature 44
Theoretical Model 47
Fixed effects model 49

Random effects model 49
Empirical Model 50
For manufacturing production 51
For manufacturing exports 52
Data Sources and Description 52
Empirical Results 56
Conclusion 62

CHAPTER IV: **Food Safety Standards and Export competitiveness in the Food and Processed Food Industries in Asia-Pacific Countries**

Introduction 64
Research Objectives 66
Producers' Constraints to Export Processed Food 66
Indonesia 67
Sri Lanka 69
Fiji 71
Nepal 72
China 74
Vietnam 75
Review of Literature 77
The Gravity Model 78
Standards and Technical Regulations in the Gravity Model 79
Model Specification 84
Data Sources and Description 88
Bilateral trade 88
GDP 88
Food safety standards 89
Distances 90
Population 91
Price indices 91
Empirical Results 91

Conclusion 96

CHAPTER V: Summary and Conclusion 97

APPENDICES 102
Appendix A 102
Appendix B 108
Appendix C 112
Appendix D 113
Appendix E 118

REFERENCES 120

VITA 127

LIST OF TABLES

Chapter II

Table II.1: Industry's product-based classification including pollution intensity 7
Table II.2: Description of Environmental Sustainability Indicators, 2002 and 2005 26
Table II.3: Regression results of net export in pollution intensive industries, 1987-2003 .. 30
Table II.4: Regression results of net export in non-pollution intensive industries, 1987-2003 33
Table II. 5: Regression results of net export in industries either pollution intensive or non-pollution intensive, 1987-2003 36

Chapter III

Table III.1: Data sources and description 52
Table III.2: Adoption of competition policy 55
Table III.3: Regression results of total manufacturing production in OECD countries, 1980-2003 58
Table III.4: Regression results of total manufacturing exports in OECD countries, 1980-2003 59
Table III.5: Regression results of food manufacturing production in OECD countries, 1980-2003 60
Table III.6: Regression results of food manufacturing exports in OECD countries 61

Chapter IV

Table IV.1: Maximum tolerated levels of aflatoxin in food and food products 89
Table IV.2: Regression results of bilateral exports in the food and food product sector 93
Table IV.3: Regression results of bilateral exports in the food and food product sector 95

Appendices

Table A.1a: Descriptive statistics of the variables for the period, 1987-2003 102
Table A.1b: Descriptive statistics of the variables- continued 103
Table A.1c: Descriptive statistics of the variables- continued.. 104
Table A.2a: Regression results of net export in different industries................................. 105
Table A.2b: Regression results of net export- continued.. 106
Table A.2c: Regression results of net export- continued.. 107
Table C.1: Descriptive statistics of the variables for the period 1980-2003...................... 112
Table D.1: Importance of Agricultural Exports in Selected Asia-Pacific Countries 117
Table D.2: Export of Food Products in 2002 in Asia-Pacific Countries:
By HS Chapter (% total food export) 118
Table D.3: Distances between important seaports in nautical miles 119
Table D.4: Descriptive statistics of the variables used for food and food product
exports.. 120
Table D.5: Partial derivatives of the variables used as quadratic forms in Equation
(IV.13).. 121

LIST OF FIGURES

Chapter II

Figure II.1: Heckscher-Ohlin theorem 14
Figure II.2: Effects of factor-intensity and production 16
Figure II.3: Effects of environmental policy 19
Figure II.4: Trade and environmental policy 21

Chapter III

Figure III.1: Trade and competition policy 44
Figure III.2: Production and exports in total manufacturing industries 54
Figure III.3: Production and exports in food manufacturing industries 54

Chapter IV

Figure IV.1: Exports of Indonesia 68
Figure IV.2: Exports of Sri Lanka 70
Figure IV.3: Exports of Fiji 72
Figure IV.4: Exports of Nepal, 1994-2003 73
Figure IV.5: Exports of China 74
Figure IV.6: Exports of Vietnam 76
Figure IV.6: Distances between important seaports of exporting and importing countries in nautical miles 90

Chapter II

Figure B.1: Rybczynski theorem 111

Chapter I

Overview

The impact of domestic policy regulations and standards on trade has been an important global policy issue during the past decade. Regulations and standards, in principle, are designed to facilitate production, guarantee quality of products, reduce transaction costs and enhance contestability in the market. For example, pollution standards can contribute to a clean environment, health and sanitary requirements can improve the health status in an economy, and competition policy can enhance market contestability. However, standards and technical regulations can produce serious distortions in commercial markets: domestic regulatory systems may deter trade and limit market entry through environmental, health or safety standards (Maskus et al.).

A country's technical regulations and standards, which are often considered non-tariff barriers, are of particular concern in a development context. Every country establishes their own policies and standards to deal with needs of the national industry. In this context, developing countries fall behind developed country in establishing effectual standards and regulations that take international best practices into consideration. Developing countries find it difficult to develop standards that are straightforwardly acceptable by the developed nations, and they have a hard time in meeting standards and regulations set by developed countries (Prasad, Jayasuriya). Every country develops their own policies and standards for a specific product and they differ from country to country. These differences create problems for manufacturing industries, especially for major exporting countries.

A large literature has focused on how technical regulations and standards impact productivity growth and trade competitiveness in both manufacturing goods and agricultural products. With respect to regulations and standards, many policy-makers suggested that a domestic policy influences a country's decision what to produce, whether to export, and where to export. However, empirical analyses of the impact of policy regulations and standards on exporting firms in developing countries are relatively sparse. On the other hand, compliance costs stemming from technical regulations and standards vary across industries, and depend on firm size, firm characteristics and market structure. So it is imperative to examine the impact of domestic policy on product-based industries including manufacturing and food processing industries. This study begins with a review of the policy context driving a demand for empirical analysis of standards involving trade in the manufacturing sector. In this study, we review methodological approaches that have been used to analyze standards and regulatory policy. The study consists of three different articles that attempt to overview the role of technical regulations and standards and their relationship to trade using different econometric models.

The first article, presented in Chapter II, analyzes whether stringent environmental policies impact export competitiveness in manufacturing industries for OECD countries. This study follows the standard Heckscher-Ohlin (H-O) model to explain the effects of environmental regulations on export competitiveness.

The study hypothesizes that a country's comparative advantage depends on its factor abundance: if a country has an abundance of labor, then capital is more expensive than labor and the marginal productivity of capital in the industry is higher. As a result, there is a substitution of labor for capital, and the country has a comparative advantage to produce labor-intensive goods, and is better off exporting such goods to countries where labor is an expensive factor input (Takayama). The regulatory policy increases production costs and, thus, reduces the output level of an industry. Large bodies of literature empirically examine this issue, most of which provide no strong evidence to support the contention that environmental standards lead to loss of international competitiveness. According to Jaffe et al., relatively high environmental standards have no significant impacts on international competitiveness. As reflected in their results, the environmental compliance cost associated with firm production is too small to influence competitiveness. Metcalfe found evidence that environmental regulations influence competitiveness. He reported that European Union pork exports were significantly influenced by their stringent environmental regulations. The work by Mulatu et al. is notable: he investigated the responsiveness of international export flows to the environmental policy using a factor endowment model and found that tougher environmental regulations worsened the net exports of the dirty industry. This work motivated the present study that decomposes total trade by product-based industry on the basis of pollution intensity. This study analyzes the factor endowments theorem and examines whether stringent environmental policies impact trade competitiveness in industries for OECD countries.

The purpose of the second article, presented in Chapter III, is to develop a better understanding of competition policy and its impact on a country's production and international trade flows: testing the hypothesis that competition policy positively impacts a firm's production as well as export competitiveness in the manufacturing of food and food products.

Competition policy plays an important role to ensure market competition: when a market exhibits some form of imperfection or monopolistic competition, governments establish competition laws to regulate economic activities in order to ensure that markets operate in the public interest. A number of empirical studies focused on competition and competition policy issues. But the literature is still largely silent regarding its empirical evidence on competition policy's impact on food and processed food products both at the domestic and international levels. Kahyarara investigated the impact of competition policy on trade flows in the manufacturing sectors. He concluded that competition policy enhances a firm's economic performance, and increases productivity, investment and exports. In our study, we attempt to assess how global agricultural markets could be better regulated in respect of competition policy. In particular, we examine whether competition policy will promote the best environment for the contestability of markets in the agri-food processing sector.

In the third article, presented in Chapter IV, we overview the export performance in six different Asia-Pacific countries and the challenges exporters in these countries face. While the growth in demand for ready to eat food creates exciting opportunities for food processing industries in Asia and the Pacific, developed countries' technical regulations and safety requirements act as important non-tariff barriers in outward trade flows in the region. The region's producers face several constraints. Among them is increasingly more stringent food safety standards imposed by developed countries. Differing standards across markets are other constraint (Alimi, Jayasuriya, Prasad). The food safety concern is not without merit. A wide range of chemical substances including pesticides, additives etc., are commonly used in food production and processing, and thus, residues of these chemicals may remain in the end products. These residues are harmful for humans, animals, and plants, and the environment where they live. So consumers in developed countries have exhibited a high level of food safety concern related to their processed food supply. However, the economic nature of the food safety issue in developing countries, including Asia and the Pacific, is somewhat different from developed countries. Their concern is about food safety regulations enforced by developed countries that act as important non-tariff barriers: these standards increase compliance costs of suppliers and thus reduce their export competitiveness (Gunawardena, Jayasuriya).

Despite the concern of the term "Food safety" in both national and global forums, little attention has been paid to examine its empirical relationship with international competitiveness. A number of papers/ studies exist on different dimensions of food safety and international trade. Among them, the work of Jayasuriya et al. is one who discussed food safety issues and challenges facing Indian food industries in exporting food products to developed countries. From their investigation, they found that Indian food exporters received significant losses from the stringent food safety regulations set by developed countries and the variations in such standards across countries. Lacovone's work is also noteworthy: he used an aflatoxin standard as a direct measure of food safety standards and their impact on food exports. He found that the aflatoxin standard adversely impacts trade flows. In our study, we aim at reviewing challenges Asia-Pacific food exporters are facing in developed countries, developing a better understanding of food safety regulations, and examining the impact of food safety standards on exports from Asia-Pacific countries.

Chapter II

The Impact of Environmental Regulatory Policy on International Competitiveness of Manufacturing Industries: An Empirical Analysis[1]

Introduction:

There has been growing concern from both analysts and policy makers about the linkage between environmental policy and international competitiveness: whether a country's imposition of stiffer environmental regulations impacts its international competitiveness. From a theoretical point of view, stringent regulations, in the form of required abatement costs imposed on manufacturing, raises production costs of a domestic firm. These higher costs shift the firm's supply curve to the left and result in a new equilibrium where the firm produces fewer goods at higher prices. As a result, a country's export competitiveness declines (Jenkins). A country could relax strict controls over environmental degradation to protect domestic firms as well as to increase trade flows in the world market. An inflexible environmental policy will encourage industries facing high stringent environmental regulations to move to countries with lower standards.

There is a large body of literature that empirically examines this issue, most of which provide no strong evidence to support the contention that environmental standards lead to loss of international competitiveness. According to Jaffe et al., relatively high environmental standards have no significant impacts on international competitiveness. As reflected in their results, the environmental compliance cost associated with firm production is too small to influence competitiveness. Using a gravity model, Harris et al. investigated the relationship between environmental regulations and international competitiveness and they found no significant impact between these two variables. Ratnayake used the Heckscher-Ohlin-Venek model to examine the impact of environmental regulations on New Zealand's trade, and the results did not support the

[1] This part of research was presented at the American Agricultural Economics Association Annual Meeting, July 22- July 27, 2005, Providence, Rhode Island, 2005.

hypothesis that stringent environmental regulations harmed international trade. In examining the same proposition, Larson et al. and Xu found mixed results.

Some studies have found evidence that environmental regulations influence competitiveness; Metcalfe for one. He reported that European Union pork exports were significantly influenced by their stringent environmental regulations whereas regulations imposed by the U.S. and Canada had minimal impact on their competitiveness. Kalt's findings are consistent with the theoretical expectation that imposition of environmental regulations lowers U.S. manufacturing good exports. Han supported this result in his dissertation. Mulatu et al. investigated the responsiveness of international export flows to the environmental policy using a factor endowment model and found that tougher environmental regulations worsened the net exports of the dirty industry. These findings are supported by Busse who argued that stringent regulations only affect the competitiveness of iron and steel sectors.

Two different models, the gravity model and standard Heckscher-Ohlin factor endowment (H-O) model, are often used in empirical analysis. However, they produce mixed results based on time period, countries/ industries modeled, etc. so the debate about the linkage between environmental regulations and competitiveness continues. Empirical findings are questioned because the studies lack adequate and reliable data on environmental regulations (Busse, Jaffe et al.). Previous studies use either environmental regulation indices or data collected by survey. Busse used a unique and comprehensive dataset for environmental indicators in terms of environmental regulations and treaties. Since we are interested in examining the relationship between environmental regulations and international competitiveness, we choose the environmental governance indicator that is compiled from a number of variables (Table II.2) related to environmental regulatory policy. This study uses the same data source but recent and large dataset in the model.

This study follows the H-O model in that a country's export competitiveness is explained by factor intensities and environmental regulations imposed on its manufacturing industries. It decomposes total trade by product-based industry based on an OECD database, and categorizes industries into three subgroups on the basis of pollution intensity (pollution intensive, non-pollution intensive, and industries either pollution intensive or non-pollution intensive) as reflected in Low and Yeats (Table II.1).

Table II.1: Industry's product-based classification including pollution intensity

ISIC Number (Rev. 3)	Industry [A]	Abbreviation (used in the study)	Pollution intensive (Y)/ non-pollution-intensive (N)[B]
29	Machinery and equipment nec	McNEC	Y
36	Manufacturing nec	ManfN	N
27	Basic metals	Bmet	Y
26	Other non-metallic mineral products	Nmet	Y/N
29-33	Machinery and equipment	Mach	Y
271 +2731	Iron and steel	Iron	Y
15-16	Food products, beverages and tobacco	Food	N
28	Fabricated metal products, except machinery and equipment	Fmet	Y/ N
20	Wood and products of wood and cork	Wood	N
17-19	Textiles, textile products, leather and footwear	Textiles	N
21-22	Pulp, paper, paper products, printing and publishing	Papers	Y
272 + 2732	Non-ferrous metals	Nfer	Y
24	Chemicals and chemical products	Chem	Y/ N

Notes: [A] The industry's classification is based on OECD database, [B] This is categorized on the basis of classification in Low and Yeats, and Mani and Wheeler.

The study analyzes the factor endowments theorem: a country's comparative advantage depends on its factor abundance: if a country has an abundance of labor, then capital is more expensive than labor and the marginal productivity of capital in the industry is higher. As a result, there is a substitution of labor for capital, and the country has a comparative advantage to produce labor-intensive goods, and is better off exporting such goods to countries where labor is an expensive factor input. The regulatory policy increases production costs and, thus, reduces the output level of an industry. This study follows the H-O model to explain the effects of environmental regulations on export competitiveness in the manufacturing industries for OECD countries.

Research Objectives:

The aim of this study is to test the hypothesis that environmental stringency adversely affects the international competitiveness (net exports) in manufacturing sectors. The specific objectives of this research include:

a. To identify factors that influence international competitiveness;
b. To develop a valid framework based on the H-O model to estimate changes in net exports as influenced by factor endowments along with environmental regulations; and
c. To compare the impact of regulations for different product-based industries.

Review of Literature:

A debate over environmental regulations and international competitiveness," Do environmental regulations really matter to decline export flows?" still exists, though a large body of literature has empirically examined this issue for a long time. A common trade-off between environmental regulations and international trade is that environmental regulations increase production costs that reduce productivity growth. This may cause export flows to decline. However, most empirical studies provide no strong evidence to support the hypothesis that environmental standards lead to loss of international competitiveness. We distinguish two groups of studies in the literature: one group argued on the positive or no significant impact of environmental regulations (Porter and Van der Linde, Jaffe et al.) and another group argued on negative impact of regulations (Harris et al., Xu, Ratnayake, Larson et al., Busse, Mulatu et al., Han, and Metcalfe). Another observation is that some studies follow the gravity model and some use the H-O factor endowment model to examine the impact of environmental regulations on trade flows. We review all these empirical studies in this chapter.

According to Jaffe et al., relatively high environmental standards have no significant impacts on international competitiveness. As reflected in their results, the environmental compliance cost associated with firm production is too small to influence the competitiveness. However, they pointed out some limitations, inadequate data was the most crucial amongst them, which limit their ability to measure the relative stringency of environmental regulations on trade.

Using a gravity model, Harris et al. investigated the relationship between environmental regulations and international competitiveness and they found no significant impact of regression on competition. They used the following form of the gravity equation[2]:

$$\begin{aligned}\ln IMP_{ij,t} = {} & \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} \\ & + \beta_5 \ln DIST_{ij} + \beta_6 ADJ_{ij} + \beta_7 \ln EEC_{ijt} + \beta_8 \ln EFTA_{ijt} \\ & + \beta_9 \ln NAFTA_{ijt} + \beta_{10} \ln LAND_i + \beta_{11} \ln LAND_j \\ & + \beta_{12} \ln SC_{it} + \beta_{13} \ln SC_{jt} + u_{ijt}\end{aligned}$$

where, *ln* represents natural logarithm; *i* denotes an importing country, and *j* is an exporting county; *t* is time (year); *IPM* represents imports of a country; *GDP* is a country's GDPs, and *POP* is the population of a country; *DIST* is the distance between importing and exporting country; *ADJ* represents a dummy variable, equal to 1 if importing country and exporting country are adjacent, and zero otherwise; *EEC* is a dummy variable, equal to 1 if importing country and exporting country are members of European Economic Council (EEC), and zero otherwise; *EFTA* is a dummy variable, equal to 1 if importing country and exporting country are members of European Free Trade Association (EFTA), and zero otherwise; *NAFTA* is a dummy variable, equal to 1 if importing country and exporting country are members of North American Free Trade Agreement (NAFTA), and zero otherwise; *LAND* is the land areas of a country; *SC* is the score indicating relative stringency of environmental regulations in a country; and *u* denotes error terms. In this study Harris et al. examined the effect of environmental stringency by six different indicators, which are based on energy consumption or energy supply. But the effect of these variables on imports was not statistically significant.

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[2] This model shows the same notation as in Harris et al.

Xu developed the following extended gravity model[3] to investigate the impact of environmental regulation on international trade:

$$\ln(X_{ij}) = \alpha_0 + \beta_1 \ln(Y_i) + \beta_2 \ln(N_i) + \beta_3 \ln(Y_j) + \beta_4 \ln(N_j) + \beta_5 \ln(D_{ij}) \\ + \beta_6 \ln(ENV_i) + \beta_7 \ln(ENV_j) + \beta_8 \ln(DT_i) + \beta_9 \ln(DT_j) + \varepsilon_{ij}$$

where, X_i is the exports from country *i* to country *j*; Y_i, and Y_j, are the GDPs of country *i* and *j*, respectively; N_i, and N_j are the population of country *i* and *j*, respectively; D_{ij} is the geographic distance between country *i* and *j*; ENV_i, and ENV_j, are environmental stringency indices of country *i* and *j*, respectively; and α is the constant and ε is error terms. In this study, Xu used the environmental stringency indices developed by World Bank. He did not find any significant evidence to support the proposition that environmental regulations reduce a country's exports.

Ratnayake used the Heckscher-Ohlin-Venek (H-O) model including environmental regulation as a variable, as follows[4]:

$$T_{ij} = \lambda + \alpha W_{ij} + \beta X_{ij} + \gamma Y_{ij} + \delta Z_{ij} + U_{ij}$$

In this equation, *i* represents an importing country, and *j* represents an exporting country; *T* is exports from country *i* to *j*; *W* is the factor of production derived from the traditional H-O theory; *X* is the factor of production derived from modified H-O theorem; *Y* is imperfect competition; *Z* denotes environmental regulations; and λ is the constant and *U* is error terms. To examine the impact of environmental regulations on New Zealand's trade, their results did not support the hypothesis that stringent environmental regulations harmed international trade.

In examining the same proposition, Larson et al. concluded that environmental policy changes have small impacts on production and exports. To estimate the impact of environmental regulations on exports from different industries in the non-EU Mediterranean regions, they performed six different case studies based on an empirically tractable modeling approach. They found, in some cases, that environmental standards had a little impact on exports, while in other cases the impact was substantially larger.

[3] This model shows the same notation as in Xu.
[4] This model shows the same notation as in Ratnayake.

Metcalfe is the one who found in his investigation that environmental regulations positively impact international competitiveness using an equilibrium displacement model. He reported that the European Union pork exports were significantly influenced by their stringent environmental regulations whereas imposition of U.S. and Canadian regulation had impact minimal on their competitiveness.

Using the H-O model, Busse attempted to evaluate the impact of environmental regulations on net exports in five pollution-intensive industries. In his model, capital and labor endowments are used in the relative form: capital endowments (representing *CAP_AREA*: capital divided by total land area) are expected to positively and labor endowments (representing *LAB_AREA*: labor force divided by total land area) negatively impact export flows. Two other control variables (CROP: total crop land, and FOREST: total forest land) are used in their model. A set of six dummies for mineral resources (*COAL*, *COPPER*, *IRON*, *LEAD*, *OIL*, and *ZINK*) and a set of seven dummy variables representing *REGIONAL DUMMIES* are also added to their regression equation. They used two environmental sustainable indicators (*ENV*) representing *ENV_REG*: the measure of the stringency of environmental regulations across countries, and *ENV_CONV*: the measure countries participation in international cooperative efforts dealing with environmental problems across countries. Including all these variables that explain net exports of all five industries, their model has the following form[5]:

$$\begin{aligned} NETEXPORTS = \alpha_0 + \alpha_1 CAP\_AREA + \alpha_2 LAB\_AREA + \alpha_3 CROP \\ + \alpha_4 FOREST + \alpha_5 COAL + \alpha_6 COPPER + \alpha_7 IRON \\ + \alpha_8 LEAD + \alpha_9 OIL + \alpha_{10} ZINC + \alpha_{11} ENV \\ + \alpha_{12} REGIONAL \quad DUMMIES + e \end{aligned}$$

Busse found that stringent regulations lower exports in the iron and steel industries. He concluded that higher compliance with international treaties and conventions and more stringent regulations cause net exports in the dirty industries to decline. This result is consistent with Kalt, in which imposition of environmental stringency has a negative influence on U.S. manufacturing exports.

[5] This model shows the same notation as in Busse.

Mulatu et al. developed a general equilibrium model of trade and pollution to examine how environmental standards impact exports in the dirty industries. Their model has the following form[6]:

$$NX_{it}^{c} = f\left(YEAR_t, MK_{it}^{c}, SL_{it}^{c}, UL_{it}^{c}, RD_{it}^{c}, TARIFF_{it}^{c}, PACE_{it}^{c}\right) + \varepsilon_{it}^{c}$$

In their model, they include factor endowments and environmental stringency differentials: *MK* is gross fixed capital formation that proxies the flow of capital services; *SL* and *UL* denote the flow of the skilled and unskilled labor services, respectively. They also include *RD* as expenditures for research and development; *TARIFF* as *ad valorem* tariffs that is measured as the ratio of duties paid to the custom value of imports; *PACE* as the capital expenditures for pollution abatement that is control as a share of gross fixed capital formation; *YEAR* as year from 1977 to 1992. In the model, *NX* represents net exports; *i* represents an industry; *c* is a country; *t* is time; and ε denotes an error term. They selected industries of dirty commodities in three different countries, Germany, the Netherlands and the US, and they only found a negative effect of stiffer environmental regulations for US dirty commodity exports.

Han proposed an H-O factor endowments model that includes an environmental policy variable in term of abatement costs as a production factor, and examined if the environmental policy impairs exports of US manufacturing. Han suggested that the environmental variable as production factor is a nice fit for his model. He argued that environmental regulations cause environmental factor supply to fall, and as a result, production and exports to rise in the manufacturing sector with lower environmental standards.

Based on the regression framework stated below, Han used both a fixed effects and random effects panel data approach for their analysis[7]:

$$NX_{it} = \beta_0 + \beta_1 K_{it} + \beta_2 RD_{it} + \beta_3 H_{it} + \beta_4 UL_{it} + \beta_5 AB_{it} + \beta_6 AB_{it}.t + \varepsilon_{it}$$

where *i* indicates industry and *t* is time (year); *NX* represents net exports of the manufacturing industry; *K* is capital services; *RD* is the flow of research and

[6] This model shows the same notation as in Mulatu et al.
[7] This model shows the same notation as in Han.

development; *H* is human capital service; *UL* is low skilled labor services; *AB* is pollution abatement costs of each industry; and ε denotes error terms. The empirical results of this study supported the hypothesis that the environmental regulations in terms of pollution abatement expenditures impair export competitiveness in the US manufacturing.

Unlike the hypothesis of adverse impact of strict environmental standards on international trade, Porter and Van der Linde argued that environmental regulations have a positive effect on export competitiveness. According to their argument, improved environmental quality resulting from strict environmental policy in the environmentally sensitive industries might offset their short-run losses in the long run.

Model Description:

Heckscher-Ohlin model and environmental regulations:

Eli Heckscher and Bertil Ohlin first developed the factor endowment model, simply called the Heckscher-Ohlin (H-O) model, as an improvement on the Ricardian Model. The Ricardian model assumes that labor is the only factor of production which impacts international trade flows. But the factor endowment model added capital to labor in the production process and it predicts the trade pattern in goods between two countries based on differences in relative factor endowments. It assumes that the factor inputs cause trade flows: a capital abundant country exports capital intensive goods and a labor abundant country exports labor intensive goods (Suranovic).

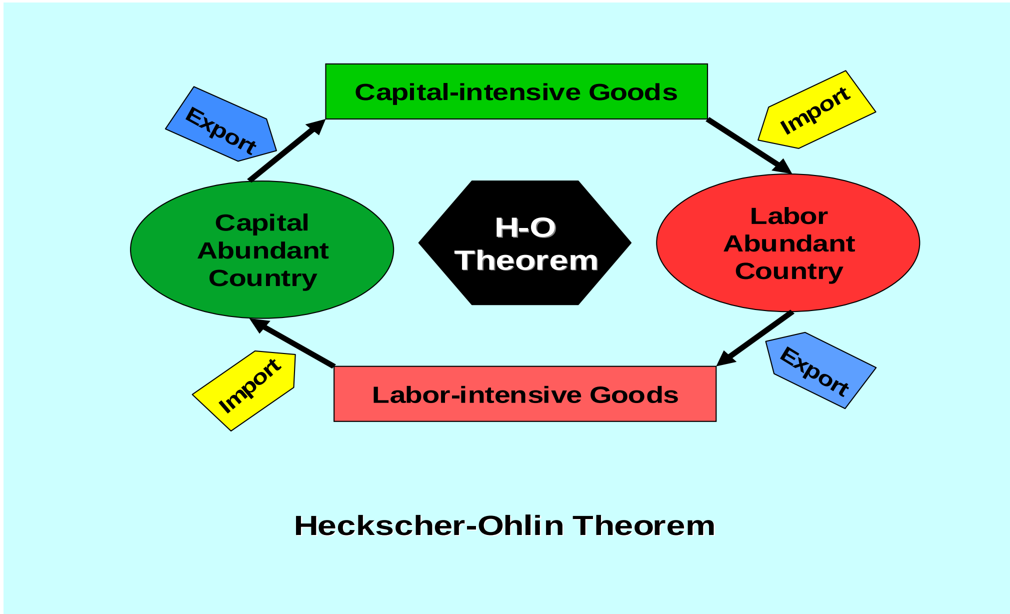

Figure II.1: Heckscher- Ohlin theorem

As shown in Figure II.1, the H-O theorem says that exports of a capital-abundant country come from capital-intensive industries, and labor-abundant countries imports such goods, exporting labor-intensive goods in return (Takayama). Thus, the H-O model has been used to explain international trade patterns in economics since its initiation. However, Samuelson develops a mathematical equation from the Heckscher-Ohlin two countries, two goods, two factors model, and demonstrates how changes in output prices affect the price of factors, with an argument that free trade equalizes factor prices. Rybczynski is one who demonstrates how changes in an endowment affect the out of goods. Vanek extends this model into multiple goods and factors.

According to the H-O model, assume two trading countries (say, a home country and a foreign country) have the same technology in production, and the production function is:

$$Q^s = f^s(N^s, K^s) \qquad \text{(II.1)}$$

where Q denotes the output of sector s, N represents the quantity of labor that the sector chooses to employ and K represents the capital that the sector employs. The marginal products of factor N and K are positive but declining as inputs increase. It is assumed that markets are perfectly competitive; there are no transportation costs; tastes and preferences are identical for both countries; and the production function exhibits constant return to scale:

($f^s(mN^s, mK^s) = mf^s(N^s, K^s) = mQ^s$ where *m* is a positive constant).

According to the H-O model, a country exports the good that makes intensive use of its relatively abundant factor. A country (for example, a home country (*h*)) is said to be capital-abundant if it has a higher ratio of capital to labor than another country (a foreign country (*f*)):

$\frac{K_h}{N_h} > \frac{K_f}{N_f}$ where $\frac{K_i}{N_i}$ is called the country's (*i*= *h*, *f*) factor intensity or capital labor ratio. Similarly, the home country is labor intensive if $\frac{K_h}{N_h} < \frac{K_f}{N_f}$ where capital becomes more expensive than labor.

Let us suppose both the home and foreign countries are identical, and their relative supply curves are at the market equilibrium point at the price level, P^* (Figure II.2). If the home country is capital abundant, this abundant supply of capital pushes its supply curve out to the right, and thus, the price of the capital-intensive good declines from P^* to P_h associated with the increasing relative quantity of goods produced (from Q^* to Q_h).

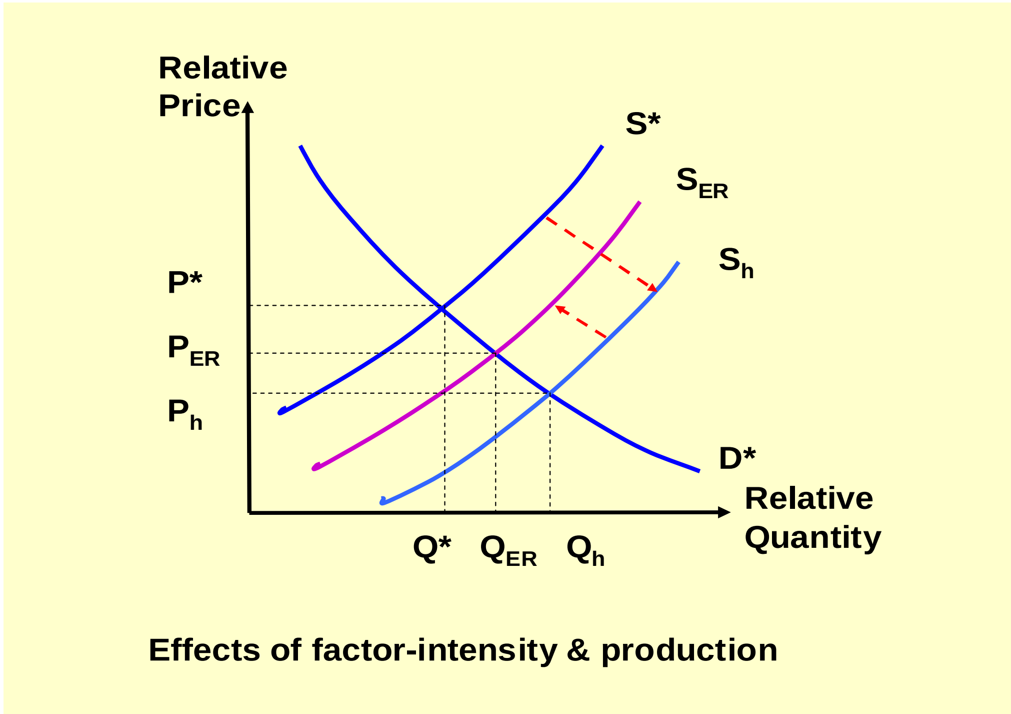

Figure II.2[8]: Effects of factor-intensity and production

Accordingly, the home country's production possibility frontier (PPF) will reflect an ability to produce higher quantities of capital-intensive goods than labor-intensive goods, and the home country will export the goods that use its abundant factor intensively, hence capital-intensive goods.

Within the context of the H-O model, McGuire developed a model incorporating an environmental regulation variable that, along with capital and labor variables, explain the country's PPF. The intuitive explanation of incorporation of the environmental regulation variable is that it will assess the impact of environmental policy regulation on production, and guide firms to reduce the pollution level of highly polluting industries (Han). Production of goods, in principle, causes pollution to rise, and if the physical presence of pollution exceeds its optimal level[9], it should be reduced. To keep pollution at the optimal level, it needs to impose regulatory policy, and governments impose environmental regulations. But regulatory policy leads to higher production costs that

[8] The figure is derived from the figure 5 in Copeland and Taylor.
[9] The optimal level is where marginal net private benefit from pollution equals its marginal external costs (Pearce and Turner).

cause the firm's production to decline. In particular, referring to Figure 2, the government imposes environmental policy, that pushes the relative supply curve (S_h) back to the optimal level of the pollution emission (S_{ER}). This theoretical idea is critically important, and it is imperative to assess how environmental regulations impact production as well as other economic activities. Therefore, inclusion of an environmental variable as a production factor in the H-O model is quite reasonable. This study follows McGuire's and Han's approach in that three production factors, *N* and *K* and an environmental policy variable, *R* are used to produce output *Q* in an industry. In our model, the output of an industry has the following form:

$$Q^s = f^s\left(N^s, K^s, R^s\right) \tag{II.2}$$

where *s* represents industries. The explanatory variables used in the above equation have a direct relationship to the firm's production, and the production function exhibits positive but decreasing returns to each production factor. We express this relationship by the following equations:

$$\frac{\partial f^s}{\partial N^s} = f_N^s\left(N^s, K^s, R^s\right) > 0\,;\ \frac{\partial^2 f^s}{\partial {N^s}^2} < 0 \tag{II.3}$$

$$\frac{\partial f^s}{\partial K^s} = f_K^s\left(N^s, K^s, R^s\right) > 0\,;\ \frac{\partial^2 f^s}{\partial {K^s}^2} < 0 \tag{II.4}$$

$$\frac{\partial f^s}{\partial R^s} = f_R^s\left(N^s, K^s, R^s\right) > 0\,;\ \frac{\partial^2 f^s}{\partial {R^s}^2} < 0 \tag{II.5}$$

According to the H-O theorem, the marginal productivity of capital (labor) in each industry increases if capital (labor) becomes more expensive than labor (capital). That is, capital and labor endowments are used in relative forms: one impacts production with respect of other. In the context of the H-O model, the Rybczynski theorem[10] demonstrates the effects of changes in factor endowments on production of two goods. According to the Rybczynski's theorem,

> *"If the supply of one factor increases with the supply of the other factor constant, the absolute output of the good which uses the increased factor relatively less "intensively" should diminish in order to keep the relative price of the goods constant."*(Takayama, p57).

[10] The Rybczynski's theorem is detailed in Appendix B.

Mathematically, let us suppose that good one (X) is capital intensive and good two (Y) is labor intensive. Assume the output prices of both goods remain the same. If labor endowment rises, then

$$\frac{\partial f^X}{\partial N} < 0 \text{, and } \frac{\partial f^Y}{\partial N} > 0 \tag{II.6}$$

Under the same assumption, if capital endowment rises, then

$$\frac{\partial f^X}{\partial K} > 0 \text{, and } \frac{\partial f^Y}{\partial K} < 0 \tag{II.7}$$

Conversely, if good one (X) is labor intensive and good two (Y) is capital intensive, then the signs of all of the above derivatives will be reversed.

Since the environmental regulation variable is assumed to be a production factor, its marginal product equals its price or its marginal cost at the profit- maximization condition (McGuire, Han). Mathematically it is:

$$\frac{\partial f^s}{\partial R^s} = f_R^s\left(N^s, K^s, R^s\right) = MC_R = \gamma \tag{II.8}$$

where γ is the marginal cost (MC) of the environmental variable in terms of abatement cost. The marginal productivity of the environmental variable for each industry increases if a country's imposition of environmental regulation becomes more expensive in terms of production.

Equation (II.8) has an implicit form:

$$R^s = \psi^s\left(N^s, K^s, \gamma\right) \tag{II.9}$$

where ψ is the marginal impact on the environment and $\psi_\gamma < 0$.

Substituting Equation (II.9) into (II.2), we can get a mixed profit / production function:

$$Q^s = f\left\{N^s, K^s, \psi^s\left(N^s, K^s, \gamma\right)\right\} = f\left(N^s, K^s; \gamma\right) \tag{II.10}$$

where various combinations of N and K are used to produce a given amount of Q, and R is automatically adjusted for each combination of N and K to bring $f_R = \gamma$. When the marginal product of R (abatement costs) equals zero, i.e., $f_R = \gamma^0 = 0$, the country's environmental policy is non-binding, But when the marginal product of R is positive, i.e.,

$f_R = \gamma^* > 0$, the regulatory policy is binding. Thus, the mixed profit-production function becomes:

$$Q^s = f\{N^s, K^s, \psi^s(N^s, K^s, \gamma^*)\} = f(N^s, K^s; \gamma^*) = f^*(N^s, K^s) \quad \text{(II.11)}$$

In this case, the level of capital and labor needs to be increased to maintain the same level of output because costs are higher due to regulatory policy, which shifts the *N*-*K* isoquant map outward. Therefore, with each *N*-*K* combination, the output produced under the condition when regulations are non-binding (γ^0) is higher than the output produced under the condition when the regulatory policy is binding (γ^*). Specifically, suppose both the home and foreign countries have different environmental regulatory policies, though they are initially identical: hold the same relative supply curve (S^{**}) with the same relative price (P^{**}) (Figure II.3).

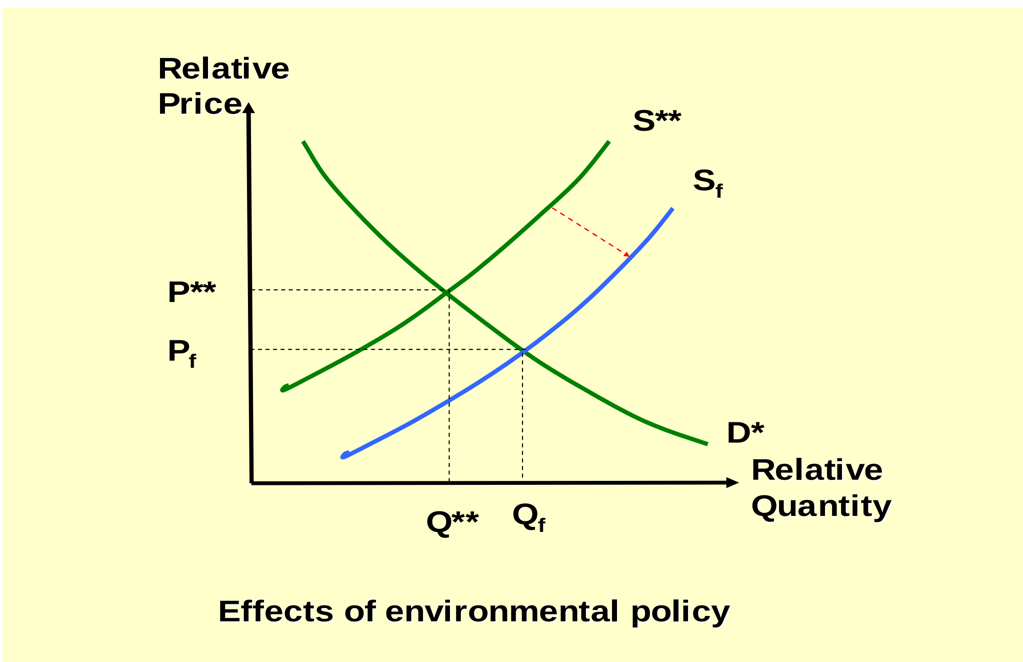

Figure II.3[11]: Effects of environmental policy

As shown in the figure, the relative production (Q_f) with each combination of *N* and *K* is higher in the foreign country if its environmental regulatory policy is less stringent than in the home country. Since regulatory policy in the home country is strict,

[11] The figure is derived from the figure 4 in Copeland and Taylor.

the home country has a comparative advantage to produce less polluting or clean goods. However, the strict regulations force the firms to pay high costs as pollution taxes, and encourage the home country to import dirty goods from foreign countries that have lower prices. On the other hand, the foreign country is better off exporting its products to the home country. Therefore, a country's stringent regulatory environmental policy encourages the creation of a "pollution haven" in a country with weaker policy (Copeland and Taylor).

As evidence from the above discussion, the environmental variable within the Heckscher-Ohlin framework explains successfully how regulatory policy can reduce the output level of the firm. Since tough environmental standards negatively influence the firms' output level, the imposition of such regulations can also influence international competitiveness. The other two factor inputs, capital and labor, not only impact production but also influence trade flows by their relative intensive use in the production process. Now the question is, "How does strict environmental policy, keeping all other factors constant, reduce net exports?"

Referring to the Krutilla-Anderson demand-supply framework, as shown in the Figure II.4, the analysis is expanded to a country's trade-environment linkage.

Let us suppose D_d and S_d are the domestic demand and supply curve of a small and open exporting country, with an equilibrium at the domestic price level (P_d). Since it is a small economy, the country's actions have no effect on world prices (P_w). Considering world price that is higher than the domestic price ($P_w > P_d$) the country produces the quantity (Q_w) consuming Q_c in the domestic market and exporting Q_w (the distance X in the figure) in the foreign market. If an efficient environmental policy that includes environmental costs is imposed, the supply curve, as shown in the Figure II.4, shifts leftward to S_E, and results in a new equilibrium at the point *n* associated with falling quantity from Q_w to Q_w^*.

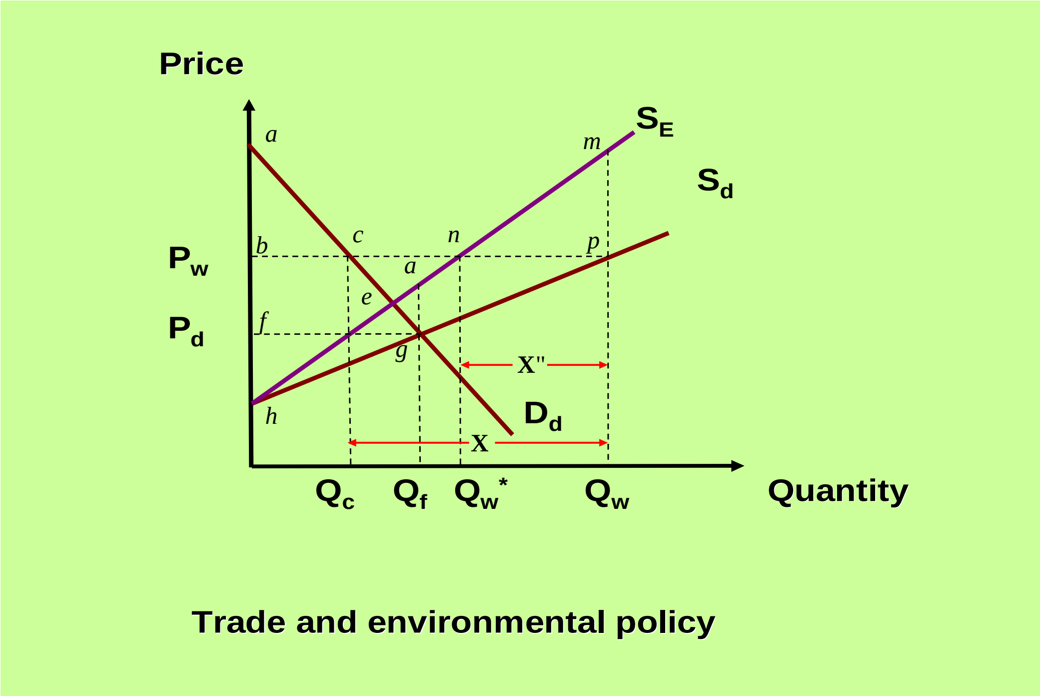

Figure II.4[12]: Trade and environmental policy

This results in a loss of producer surplus (area *nph*), though consumer surplus (area *abc*) remains unchanged. It improves social welfare by the area *mnp*. Exports shrink by the distance X". Thus, the policy causes a loss of competitiveness but it goes with a welfare gain.

Empirical Model:

This study follows an econometric framework based on insights from a standard H-O factor endowment model that explains trade flows as influenced by factor endowments including environmental regulatory policy across industries. The approach which most strongly motivated this study is from Mulatu et al. who demonstrated the relationship between export flows and factor endowments along with environmental policy. The empirical model of this study is:

$$NEX_i = \kappa(FE)'_i + \lambda(ER)_i + \mu_i \qquad \text{(II.12)}$$

where *NEX* represents a vector of net exports by industry, *FE* is the matrix of factors endowments that include capital services and labor as human capital services, *ER* is

[12] The figure is derived from the figure 16.1 in Smith and Espinosa.

environmental regulations measured by compliance costs, μ denotes error terms, and the index i indicates country. According to this model, a country's net export is explained by its factor intensities (capital and labor), technology as measured by research and development (R&D) and environmental regulations. In the model, capital or labor endowments show their relative impact on production. This means that if a good is capital-intensive (or labor-intensive) and if the labor endowment rises, then the output of that good would fall (rise) and the output of the other good would rise (fall), provided output prices of both goods remained the same. The technology (R&D) and environmental regulations are important factors in establishing how capital and labor can be used in order to produce output. The anticipated relationship of technology with exports is positive, and the relation of environmental regulations with exports is negative: stricter environmental regulations decrease export competitiveness.

For this analysis the data by country were treated as panel observations. Assuming that all coefficients (intercepts and slopes) are the same for all countries and the errors (μ_{it}) satisfy all the assumptions of the classical regression model (CRM), we pool the data and estimate an ordinary least squares regression (Pooled OLS). The model can be written as

$$NEX_{it} = \alpha + \beta K_{it} + \gamma SL_{it} + \delta UL_{it} + \phi RD_{it} + \lambda ER_{it} + \mu_{it} \tag{II.13}$$

where α is a constant term, and $\beta, \gamma, \delta, \phi$ and λ are parameters of capital (*K*), skilled labor (*SL*), unskilled labor (*UL*), research and development (*RD*) and environmental regulation variable (*ER*), respectively. μ represents the error term, and E(μ_{it}) = 0 and V(μ_{it}) = σ^2.

Since CRM ignores heterogeneity across countries with respect to unobserved characteristics, the assumptions made about coefficients and the structure of the error term in the CRM may not hold. To examine the cross-sectional variation or heterogeneity of the data, we use dummy variables for countries (*DV*), and run the following regression model, called least squares dummy variables (LSDV) regression:

$$NEX_{it} = \beta K_{it} + \gamma SL_{it} + \delta UL_{it} + \phi RD_{it} + \lambda ER_{it} + \eta DV_{it} + \nu_i + \varepsilon_{it} \tag{II.14}$$

where the ν_i represents country-specific unobserved heterogeneity that is constant over time, and ε_{it} is an idiosyncratic error term that accomplishes the assumptions of standard CRM error terms. Since it would be collinear with the country-specific errors (ν_i), the constant term (α) in CRM equation is omitted in this equation. However, this model provides fixed-effects estimators, and captures both cross-sectional (i.e., the country) and time-series variations in the data.

In Equation II.14, the corresponding slope parameters, β, γ and δ are expected to be either positive or negative depending on their relative impact on exports as discussed earlier. The slope parameter ϕ is probably positive because technology enhances a firm's productivity, and thus exports. We assume that environmental regulations increase costs of production, and thus erode trade competitiveness. So we anticipate that λ may be negative, which implies stringent environmental regulations impair export flows.

The data were checked for any violations of the basic econometric assumptions and the results indicate that autocorrelation and heteroskedasticity exist in some instances. The test for multicollinearity, a variance inflation (VIF) being higher than 10, indicates problems in some equations. Autocorrelation and heteroskedasticity were corrected by transforming data using the estimated ρ and weighted least squares with the SAS software. The data were also checked for outliers. The analysis indicates problems with outliers in some data sets, which were fixed using the robust regression (ROBUSTREG) procedure[13] in SAS version 9.

Since the impact of environmental regulation might depend on the particular circumstances of the industry to which the regulation is applied, we estimate separate regressions of each industry and examine how environmental policy impacts exports of a specific sector. We categorized the industries into three subgroups according to OECD classification (mentioned earlier in Table II.1). Given Equation (II.14), we developed the following industry-specific functional forms of the model for manufacturing exports under each category:

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[13] Robust regression is a statistical tool that is used to detect outliers and limit the influence of those outliers in data set (Chen).

Category 1: Pollution intensive industries:

There are six industries that are named as pollution intensive (*PI*): machinery and equipment nec; basic metals; machinery and equipment; iron and steel; pulp, paper, paper products, printing and publishing; and non-ferrous metals industries. The model looks as:

$$NEX_{it}^{PI} = \beta K_{it}^{PI} + \gamma SL_{it}^{PI} + \delta UL_{it}^{PI} + \phi RD_{it}^{PI} + \lambda ER_{it} + \eta DV_{it} + \nu_i + \varepsilon_{it} \qquad \text{(II.15)}$$

Category 2: Non-pollution intensive industries:

There are four non-pollution intensive (*NPI*) industries: manufacturing nec; food products, beverages and tobacco; wood and products of wood and cork; and textiles, textile products, leather and footwear industries. The model is:

$$NEX_{it}^{NPI} = \beta K_{it}^{NPI} + \gamma SL_{it}^{NPI} + \delta UL_{it}^{NPI} + \phi RD_{it}^{NPI} + \lambda ER_{it} + \eta DV_{it} + \nu_i + \varepsilon_{it} \qquad \text{(II.16)}$$

Category 3: Industries either pollution- or non-pollution intensive:

There are three industries under this category (*PON*): other non-metallic mineral products; fabricated metal products, except machinery and equipment; and chemicals and chemical products industries. The model has the following form:

$$NEX_{it}^{PON} = \beta K_{it}^{PON} + \gamma SL_{it}^{PON} + \delta UL_{it}^{PON} + \phi RD_{it}^{PON} + \lambda ER_{it} + \eta DV_{it} + \nu_i + \varepsilon_{it} \qquad \text{(II.17)}$$

Data Sources and Description:

This study focuses on the factors affecting trade flows with special attention to the impact of environmental policy for different export industries. The standard factor endowment model used in this study requires data on net exports for different manufacturing goods (the dependent variable), and factor intensities for capital and labor, R&D expenditures and environmental regulations as explanatory variables. The panel data set for each country comprises seventeen years, 1987-2003, on ten OECD countries (Belgium, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden and the United States).

The data on exports and imports are collected from the OECD STAN database for industrial analysis. The data are used to calculate net exports for respective industries. Capital is the gross fixed capital formation published in the OECD database. There are two types of labor flows used in this model: skilled labor and unskilled labor. Based on the formula developed by Branson and Monoyios, skilled labor was calculated[14]:

$$SL_{it} = \frac{(\overline{w}_{it} - \tilde{w}_t).E_{it}}{\rho} \qquad \text{(II.18)}$$

where $\overline{w}$ is the average annual wage in each sector, $\tilde{w}$ is average annual wage in the lowest-paying manufacturing industry, E is the total number of full-time employees in the industry, and ρ represents a discount rate in percentile (i.e., 10%). Unskilled labor is measured by the average annual wage in the least-paying sector multiplied by employment in the industry. All these data were collected from the OECD STAN database for industrial analysis.

Reliable data on environmental regulations is lacking. However, there two types of data commonly used in previous studies: environmental regulation indices and data collected by survey. Busse used two environmental indicators in terms of environmental regulations, and environmental conventions and treaties. The indicators used by Busse are collected from the environmental sustainability index (ESI), 2002 developed by the Center for International Earth Science Information Network (CIESIN). In this study, we use ESI to explain environmental regulations. Because we are interested in examining the relationship between environmental regulations and international competitiveness, we choose the environmental governance indicator that is compiled from a number of variables related to environmental regulatory policy. The detailed description of the indicators is stated in Table II.2.

The indicator is calculated from eight variables by country from the 2002 ESI report: the ratio of gasoline price to international average; WEF (World Economic Forum) survey questions on environmental governance; the percentage of land area under protected status; the number of sectoral Environmental Impact Assessment guidelines; the Forest Stewardship Council's accredited forest area as a percentage of total forest area; a measure of corruption; the WEF's subsidy survey question; and the World Wide Fund for Nature's subsidy measure.

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[14] This formula is also used in Han; and Stern and Maskus

Table II.2: Description of Environmental Sustainability Indicators, 2002 and 2005

Indicator (code)	Variable code	Variable description
Environmental Governance (CAP_GOV) 2002	1. GASPR	Ratio of gasoline price to international average
	2. WEFGOV	WEF (World Economic Forum) Survey Questions on Environmental Governance
	3. PRAREA	Percentage of land area under protected status
	4. EIA	Number of sectoral EIA (Environmental Impact Assessment) guidelines
	5. FSC	FSC (Forest Stewardship Council) accredited forest area as a percentage of total forest area
	6. GRAFT	Reducing corruption
	7. WEFSUB	WEF (World Economic Forum) subsidies survey question
	8. SUBFSH	WWF(World Wide Fund for Nature) Subsidy measure
Environmental Governance (CAP_GOV) 2005	1. PRAREA	Percentage of total land area under protected status
	2. GASPR	Ratio of gasoline price to world average
	3. CSDMIS	Percentage of variables missing from the CGSDI (Consultative Group on Sustainable Development Indicators) "Rio to Joburg Dashboard"
	4. KNWLDG	Knowledge creation in environmental science, technology, and policy
	5. IUCN	IUCN (The World Conservation Union) member organizations per million population
	6. AGENDA21	Local Agenda 21 initiatives per million people
	7. GRAFT	Corruption measure
	8. LAW	Rule of law
	9. CIVLIB	Civil and Political Liberties
	10. WEFGOV	World Economic Forum Survey on environmental governance
	11. GOVEFF	Government effectiveness
	12. POLITY	Democracy measure

Sources: Environmental Sustainability Index (2002); Environmental Sustainability Index (2005)

For 2005, the indicator is calculated from the following twelve variables: the ratio of gasoline price to world average; the percentage of land area under protected status; the percentage of variables missing from the Consultative Group on Sustainable Development Indicators "Rio to Joburg Dashboard"; knowledge creation in environmental science, technology, and policy; the number of World Conservation Union member organizations per million population; the number of Local Agenda 21 initiatives per million people; a measure of corruption; a measure of the Rule of Law; a measure of civil and political liberties; World Economic Forum Survey on environmental governance; a measure of government effectiveness; and a measure of democracy.

The data of the indicators (CAP_GOV) range from 0.42 to 1.21 for 2002 ESI and 0.74 to 1.62 for 2005 ESI. The indicators show the stringency of the environmental regulation: the higher the number, the stiffer the environmental policy. Since this study includes 17 years of data for 10 countries, the data for two years (2002 and 2005 the only years data are available) have been extrapolated and interpolated for analysis.

Empirical Results:

The dataset is collected for 13 different industries in 10 countries for 17 years (1987 to 2003). The descriptive statistics for each variable used in the analysis are reported in Table A.1a to Table A.1c (Appendix A). In the analysis, countries are eliminated from the sample based on data availability, so different countries are used in the analysis for different industries. According to test statistics (F test), the null hypothesis that all dummy parameters except one are zero is rejected, so the LSDV model is preferred to the pooled OLS. We present and discuss the preferred model.

We reported estimated results using the LSDV model in three different tables: the result for net exports under pollution intensive industries (Category 1) in Table II.3, for net exports under non- pollution intensive industries (Category 2) in Table II.4, and for net exports under industries either pollution intensive or non- pollution intensive industries (Category 3) in Table II.5. The F-values for all models are statistically significant at the 1% level, that is, the null hypothesis is rejected; one cannot conclude that all coefficients are zero. The coefficients of determinant (R^2 values) are quite high for all equations. This implies that the independent variables used in the model explain a high percentage of the variability in net exports from the sample.

The variables used have a direct relationship to the standard factor endowments approach: capital, labor, technology and environmental policy impact export flows. It is expected that the basic factor inputs (capital or labor) either positively or negatively influence export competitiveness. If a good is capital-intensive (or labor-intensive) and if the labor endowment rises, then the output of that good would fall (rise) and the output of the other good would rise (fall), provided output prices of both goods remained the same. That is, a country's comparative advantage depends on its factor abundance: if a country has an abundance of labor, then capital is more expensive than labor and the marginal productivity of capital in the industry is higher. As a result, there is a substitution of labor for capital, and the country has a comparative advantage to produce labor-intensive goods, and is better off exporting such goods to countries where labor is an expensive factor input (Takayama).

We hypothesizes that the environmental regulation negatively influences export flows. But we need to consider whether an industry is pollution intensive or not. Pollution intensity is determined by the abatement costs or the marginal cost of the environmental variable used in the production process. According to this model, regulatory policy (used as a production factor in the model) increases production costs and, thus, reduces the output level of an industry. The more pollution-intensive an industry, the higher its costs to produce goods and the lower its exports. On the other hand, if an industry is non-pollution intensive, the environmental compliance costs associated with firm production may be too small to influence trade competitiveness so we may expect that the environmental standard has either no significant impact or even a positive impact for non-pollution intensive industries.

Another aspect that needs to be considered is the stringency of environmental regulations: if a country's environmental policy is weak or strict. A country with weaker environmental policy would encourage its 'dirty' industries to expand, and export polluting goods. On the other hand, a country with strict environmental standards has a comparative advantage to produce clean goods, and encourages industries to move to counties with weaker standards. If a factor abundant country uses its intensive-factor inputs in the dirty industries, it produces dirty goods, but if it uses those inputs in the clean industry, it gets clean goods (Copeland and Taylor). So both factor abundance and pollution intensity need to be considered in determining the impact of environmental policy on trade flows.

Table II.3 displays the estimated results of net exports explained by environmental regulation with other variables used in Equation (II.15). As shown in the table, the coefficients for capital and labor services are significantly different from zero on net exports for most pollution intensive industries but the magnitudes of the coefficients are different across industries. The coefficients for capital services for machinery and equipment nec; basic metals; and machinery and equipment have negative signs and they are statistically significant at the 1% level: a unit increase in capital endowment is associated with a 2.8, 2.7 and 4.9 units decrease in net exports for machinery and equipment nec; basic metals; and machinery and equipment sectors, respectively. At the same time, the coefficients of skilled labor for machinery and equipment nec; and machinery and equipment industries are 0.001, and 0.0001, respectively, and are significantly positive at the 1% level while the coefficient of skilled labor for basic metals is 0.01 and is significantly negative at the 1% level. The coefficients of unskilled labor for machinery and equipment nec; and machinery and equipment are significantly negative at the 1% level. The unskilled labor coefficients for basic metals are significantly positive at the 1% level. The results of capital's negative coefficient and labor's (skilled and /or unskilled) positive coefficient imply that the labor endowment for those industries might be less expensive than capital endowments so labor substitutes for capital (we might call these industries as labor intensive industries). These findings are expected with respect to factor endowments hypothesis and supported by some previous studies (Busse and Mulatu et al.). The coefficients for capital endowments are 2.0 and 1.1 for pulp, paper, paper products, printing and publishing; and non-ferrous metals, respectively, and significantly positive at the 1% level. At the same time, the coefficients of unskilled labor for pulp, paper, paper products, printing and publishing; and non-ferrous metals are significantly negative at the 1% level. The coefficient of skilled labor for pulp, paper, paper products, printing and publishing sectors are significantly positive, and quite difficult to explain. The capital services coefficients for iron and steel industries are positive but not statistically significant. For the iron and steel industry, the relationship of unskilled labor with net exports is negative, though the relationship for the iron and steel industry is not statistically significant.

Table II.3: Regression results of net export in pollution intensive industries, 1987-2003

Variables	Intercept	Capital	Skilled labor*	Unskilled labor	Research & Development	Environmental regulations
Machinery and equipment nec	637.95 a	-2.83 [a]	0.001 [a]	-0.03 [a]	-0.95 [a]	-453.84 [a]
	(104.85)	(0.13)	(0.0001)	(0.002)	(0.30)	(94.45)
Basic metals	6278a	-2.69 [a]	-0.01 [a]	0.12 [a]	-24.15 [a]	-21988 [a]
	(2063)	(0.16)	(0.001)	(0.01)	(3.40)	(1631)
Machinery and Equipment	-10271 [a]	-4.87 [a]	0.0001 a	-0.01 [a]	3.37 [a]	-2917 [a]
	(1824)	(0.69)	(0.00002)	(0.002)	(0.71)	(311.45)
Iron and steel	-5132 [a]	185.37		-0.10	12.96 [a]	-1991 [a]
	(743.22)	(66874)		(35.43)	(4.44)	(661.67)
Pulp, paper, paper products, printing and publishing	1964	1.95 [a]	0.00004[a]	-0.002 [a]	5.18 [a]	1031 [b]
	(3245)	(0.23)	(0.00001)	(0.0004)	(1.84)	(458.86)
Non-ferrous metals	-155.75	1.10 [a]		-0.002 [a]	9.66 [a]	17.25
	(155.78)	(0.24)		(0.0002)	(2.21)	(102.08)

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis. Country dummies are shown in tables in Appendix A. *Skilled labor data for iron and steel and non-ferrous metals are not available.

The positive coefficients on the capital endowments with negative coefficients for labor endowments suggest that the respective industries are capital intensive: capital is less expensive than labor, and as a result, capital substitutes for labor. These results are supported again by the H-O factor endowment theorem. These results also show that the signs of the coefficients of skilled and unskilled labor, in most cases, are the opposite of each other. For example, the coefficients of skilled labor for machinery and equipment nec; machinery and equipment; and pulp, paper, paper products, printing and publishing sector are positive while the coefficients of unskilled labor for these industries are negative. The coefficient of skilled for basic metals industry has a negative sign while the coefficient of unskilled for this industry has a positive sign. The magnitude of the coefficients of skilled and unskilled labor is interesting and suggests that industries needing skilled (unskilled) labor do not employ unskilled (skilled) labor to avoid unnecessary production costs.

Table II.3 reveals that the relationship between research and development expenditures (R&D) and net exports is mostly positive in the pollution intensive industries, and significant at the 1% level. The coefficients for machinery and equipment; iron and steel; pulp, paper, paper products, printing and publishing; and non-ferrous metals industries are significantly different from zero at the 1% level, and positive. The coefficients of machinery and equipment nec; and basic metals are statistically significant at the 1% level but negative. Like other factor intensity variables, technology, in theory, enhances productivity growth of the firms so the finding of an inverse relationship is not expected. Busse, Mulatu et al., and Kalt also had positive coefficients for R&D. However, as evidence for the results capital is more expensive than labor in the machinery and equipment nec; and basic metals industries so it is not surprising that the industries incur high expenditures to innovate new technology for their development. The results with negative coefficients could indicate industries where increased research and development expenditures have allowed firms to relocate their plants to other countries that have lower costs. Thus, as R&D expenditures increase, production facilities for these industries move out of the country. One would think that such industries might be unskilled labor-intensive or capital-intensive, which basic metals are, but other machinery and equipment are not.

Table II.3 also shows that environmental regulations negatively impact net exports, and the coefficients for all these sectors in the pollution intensive industries, except pulp, paper, paper products, printing and publishing, are significantly different from zero at the 1% level. The coefficient of non-ferrous metal industries is not statistically different from zero. The table reveals that the coefficients of environmental regulations are 454, 21988, 2917 and 1991 for machinery and equipment nec; basic metals; machinery and equipment; and iron and steel industries, respectively. The results imply that these pollution-intensive industries have higher impact on export markets. The reason behind this findings might be that the more pollution-intensive an industry, the higher its costs to produce goods stemming from compliance costs and the lower its exports. That is, the stringent environmental regulation associated with higher compliance costs might cause a decrease in export competitiveness. These findings that uphold the hypothesis that environmental standards lead to a loss of international competitiveness are supported by the results of Ratnayake, Larson et al., Xu, Kalt, Mulatu et al., Busse, and Han. One industry, pulp, paper, paper products, printing and publishing, had a positive sign for the coefficient, indicating that stringent environmental regulations are associated with higher net exports. The major difference among these pollution-intensive industries is that paper products use a renewable resource that can be managed and advertised as such on products. This could make net exports more responsive to documented environmental regulations. More stringent environmental regulations might be associated with a more sustainable forestry resource, enhancing exports. Porter and Ven de Linde found that environmental standards positively impact international trade.

Estimated results for Equation (II.6), presented in Table 4, show that the impact of environmental standards along with factor endowments on exports in the non-pollution intensive industries. Each non-pollution intensive industry had at least one coefficient for a resource endowment that was significantly different from zero. Manufacturing nec was found to be capital-intensive; food products, beverages and tobacco were found to be skilled labor-intensive; wood and wood products were found to be unskilled labor-intensive, and textiles, textile products, leather and footwear were found to be capital and unskilled labor-intensive. The table reveals that the capital endowments have a significant positive impact on net exports for manufacturing nec; and textiles, textile products, leather and footwear. The coefficients for both skilled and unskilled labor for manufacturing nec are negatively related to net exports, though the relationship for skilled labor is not significantly different from zero. The results imply that both the factor endowments (capital and labor) negatively impact net exports, which is inconsistent with the theoretical model, and difficult to explain.

Table II.4: Regression results of net export in non-pollution intensive industries, 1987-2003

Variables	Intercept	Capital	Skilled labor*	Unskilled labor	Research & Development	Environmental regulations
Manufacturing nec	41273 [a]	3.96 [a]	-0.0001	-0.004 [a]	-6.23 [b]	-292.48
	(2523)	(0.67)	(-0.00004)	(0.0002)	(3.04)	(183.79)
Food products, beverages and tobacco	-18345	0.17	0.0001[a]	-0.002 [a]	13.11 [a]	398.07
	(1101)	(0.18)	(0.00001)	(0.0002)	(2.76)	(209.35)
Wood and products of wood and cork	517.31 [a]	-3.17 [a]		0.0001	0.64	406.70 [a]
	(69.29)	(0.17)		(0.002)	(1.04)	(14.32)
Textiles, textile products, leather and footwear	1604492	211 [a]	-0.007 [a]	0.17 [a]	-18103 [a]	2016513 [a]
	(693733)	(16.27)	(0.0003)	(0.03)	(5638)	(582091)

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis. Country dummies are shown in tables in Appendix A. * Skilled labor data for wood and wood products and cork are not available.

The coefficient of skilled labor for textiles, textile products, leather and footwear has a negative sign while the coefficient of unskilled labor has a positive sign; both coefficient are statistically significant at the 1% level. These results imply that a unit increase in capital endowment increases net exports by 211 units, and a unit increase in skilled labor decreases net exports by 0.007 units, which is consistent conceptually. The capital services coefficients for food products, beverages and tobacco industries are positive but not statistically significant. The coefficient of skilled labor and unskilled labor for food products, beverages and tobacco industries are statistically significant at the 1% level, and the skilled labor’s coefficient is positive but unskilled labor’s coefficient is negative. The coefficients of capital endowments for wood and product of wood and cork industry are significantly negative at the 1% level: a unit increase in capital endowment decreases 3.2 units net exports wood and products of wood and cork industry. The unskilled labor coefficients for wood and products of wood and cork sectors are positive, but the coefficient for wood and products of wood and cork is not statistically different from zero. The results also show alternate impact of skilled and unskilled labor on exports for food products, beverages and tobacco; and textiles, textile products, leather and footwear industries. This suggests that food products, beverages and tobacco industries use more skilled labor than unskilled labor, while textiles, textile products, leather and footwear industries use the opposite.

The coefficients of research and development expenditures (R&D) for manufacturing nec; and textiles, textile products, leather and footwear industries are statistically significant at the 1% level and negative. The coefficients of research and development expenditures for all other industries under non-pollution intensive industries are positive but only the coefficient for food products, beverages and tobacco industries is statistically significant at the 1% level. It is shown that the coefficients of skilled labor and R&D for both manufacturing nec; and textiles, textile products, leather and footwear industries are negatively related to industries' exports, whereas both skilled labor and R&D coefficients are positively related with export flows in food products, beverages and tobacco industries. A reason behind this finding is that industries using new technology might need to employ more skilled labor; all these positively impact export competitiveness.

As expected from the conceptual framework (Equation (II.14)), the coefficient for the environmental variable in the manufacturing nec sector has a negative sign but is not significantly different from zero. The relationship of environmental standards with exports for food products, beverages and tobacco industries is positive, though the coefficient is not statistically different from zero. This finding is consistent with research in the food safety area. People want safe food and are willing to pay more money for it if it adheres to policy regulations on food safety. Research has found that these regulations do not impair export competitiveness (Buzby). The results also show that environmental policy positively impacts exports for wood and products of wood and cork industry. This result suggests that net exports in the post-environmental policy period is about 407 times higher than the net exports in the pre-environmental policy period. The coefficient of environmental policy for textiles, textile products, leather and footwear industries is statistically significant at the 1% level and positive. The positive impact of environmental regulations on net exports for the food products, beverages and tobacco; wood and products of wood and cork; and textiles, textile products, leather and footwear industries is not consistent with our hypothesis but it is not surprising. It is shown that both the industries that use sustainable resources (wood products and textile products) have positive coefficients for the environmental variable. As noticed with paper products, it is possible that these industries use inputs that have a stronger attachment to the final product than in other industries analyzed. People naturally associate furniture and other wood products with forests; they associate cotton with textiles more closely. When purchasing a television or car, one is less concerned about how the inputs were mined or processed to obtain the final product.

Table II.5 displays the regression results of net exports for category 3 industries (either pollution intensive or non-pollution intensive) using equation (II.17). As shown in the table, other non-metallic mineral products were found to be capital and unskilled labor-intensive industry, fabricated metal products was found to be a skilled labor-intensive industry, and chemicals and chemical products were found to be a capital-intensive industry. The relationship between capital and net exports for other non-metallic mineral product industries is significantly positive at the 1% level. The relationship between skilled labor and net exports for other non-metallic mineral products industry is significantly negative at the 1% level. However, the results show that the relationship for unskilled labor for this industry is significantly positive at the 1% level. The positive coefficient of capital and negative coefficient of skilled labor shows the relative use of the factor endowments (capital and labor) as we expected in our conceptual model. The coefficient for capital services for fabricated metal products has negative signs and is statistically significant at the 1% level: a unit increase in capital endowment is associated with only a 0.3 unit decrease in net exports for fabricated metal products sectors. At the same time, the coefficient of skilled labor for fabricated metal product industries is 0.00003, and it is significantly positive at the 1% level. The coefficient of unskilled labor for fabricated metal products has a positive sign but is not statistically different from zero. The coefficients of capital endowments is 1.2 for chemicals and chemical products, and significantly positive at 1% level. At the same time, the coefficient of unskilled labor for chemicals and chemical products is significantly negative at the 1% level. The coefficient of skilled labor for this industry is not statistically different from zero, though. The coefficients of research and development expenditures for all industries under Category 3 are positive as expected but are not statistically different from zero.

Table II.5: Regression results of net export in industries either pollution intensive or non-pollution intensive, 1987-2003

Variables	Intercept	Capital	Skilled Labor	Unskilled labor	Research & Development	Environmental regulations
Other non-metallic mineral products	93.42	0.33 [a]	-0.001 [a]	0.005 [a]	0.35	-153.60 [a]
	(181.19)	(0.09)	(0.0001)	(0.002)	(0.96)	(30.83)
Fabricated metal products, except machinery and equipment	-0.9	-0.29 [a]	0.00003 [a]	0.0004	0.06	105.61 [a]
	(31.3)	(0.07)	(0.00001)	(0.0003)	(0.53)	(17.22)
Chemicals and chemical products	3768	1.23 [a]	0.00002	-0.002 [a]	0.20	4.27
	(2589)	(0.37)	(0.00004)	-0.001	(0.48)	(20.94)

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis. Country dummies are shown in tables in Appendix A.

Table II.5 also shows that the coefficient of environmental regulations for other non-metallic mineral products industries negatively impact net exports, and the coefficients for this industry is significantly different from zero at the 1% level. The finding is reasonable in the sense that increased environmental regulations in the pollution intensive industries are associated with higher compliance costs, which might lead to a loss of export competitiveness. According to the estimated results, the other non-metallic mineral products might be under pollution intensive industries, and the fabricated metal products; and chemicals and chemical products sectors might be categorized as non-pollution intensive industries. The coefficient of environmental standards for fabricated metal products is 106 and is significantly positive at the 1% level. The argument concerning a sustainable resource input does not seem valid for this positive sign in the fabricated metals equation. The coefficient of environmental variable for chemicals and chemical products is positive but it is not statistically different from zero.

Summary and Conclusion:

This study follows the standard factor endowment approach to examine how strict environmental policies impact export competitiveness in different product-based industries. Cross-sectional and time series data for 10 countries and 17 years were used in this model, and least squares dummy variables (LSDV) regressions for each of 13 industries, categorized into three subgroups: pollution intensive, non-pollution intensive industries and industries either pollution intensive or non-pollution intensive, were estimated separately.

The study hypothesized that a country's comparative advantage depends on its factor abundance: factor inputs (capital or labor) either positively or negatively influence export competitiveness. If a good is capital-intensive (or labor-intensive) and if the labor endowment rises, then the output of that good would fall (rise) and the output of the other good would rise (fall), provided output prices of both goods remained the same. That is, if a country has an abundance of labor, then capital is more expensive than labor and the marginal productivity of capital in the industry is higher. As a result, there is a substitution of labor for capital, and the country has a comparative advantage to produce labor-intensive goods, and is better off exporting such goods to countries where labor is an expensive factor input (Takayama). The technology is another important contention in establishing how capital and labor can be used in order to produce output.

We also hypothesizes that environmental regulations negatively influence export flows. Regulatory policy (used as a production factor in the model) increases production costs and thus, reduces the output level of an industry. The more pollution-intensive an industry, the higher its costs to produce goods and the lower its exports. On the other hand, if an industry is non-pollution intensive, the environmental compliance costs associated with firm production may be too small to influence trade competitiveness so we may expect that the environmental standard has either no significant impact or even a positive impact for non-pollution intensive industries. However, a country with weaker environmental policy would encourage its 'dirty' industries to expand, and export polluting goods. On the other hand, a country with strict environmental standards has a comparative advantage to produce clean goods, and encourages industries to move to counties with weaker standards. If a factor abundant country uses its intensive-factor inputs in the dirty industries, it produces dirty goods, but if it uses those inputs in the clean industry, it gets clean goods (Copeland and Taylor).

The empirical results show that the estimated effects of factor endowments (capital and labor), technology (R&D) and stringency of environmental regulations on export competitiveness differ across the 13 industries. The results indicate that each industry is unique in the factors determining net exports and in many instances environmental regulations are important.

Each of the six industries, except iron and steel, under the category of pollution-intensive industries has at least two resource endowments significantly affecting net exports. In each case, at least one coefficient is negative and at least one is positive. Machinery and equipment and machinery and equipment nec were found to be skilled labor-intensive industries – if a country's skilled labor endowment increased, net exports of these two industries would increase. In both cases, if their capital or unskilled labor endowments increased, net exports from these two industries would fall. The basic metals industry was found to be an unskilled labor-intensive industry, whereas iron and steel and non-ferrous metals were found to be capital-intensive industries (though the coefficients for iron and steel were not significantly different from zero). The pulp, paper, paper products, printing and publishing industries were found to be capital and skilled labor-intensive. Four of the six industries (Machinery and equipment; iron and steel; pulp, paper, paper products, printing and publishing; and non-ferrous metals) experience higher net exports when their research and development expenditures increase (whereas two (machinery and equipment nec; and basic metals) have lower net exports)). The two with negative coefficients could indicate industries where increased research and development expenditures have allowed firms to relocate their plants to other countries that have lower costs. Thus, as R&D expenditures increase, production facilities for these industries move out of the country. One would think that such industries might be unskilled labor-intensive or capital-intensive, which basic metals are, but other machinery and equipment are not. Four of the six industries (machinery and equipment nec; basic metals; machinery and equipment; and iron and steel) have negative and significant coefficients for environmental regulations, indicating that increased environmental regulations reduce net exports. One industry (pulp, paper, paper products, printing and publishing) experiences higher net exports with stringent environmental regulations. The major difference among these pollution-intensive industries is that paper products use a renewable resource that can be managed and advertised as such on products. This could make net exports more responsive to documented environmental regulations. More stringent environmental regulations might be associated with a more sustainable forestry resource, enhancing exports.

Each non-pollution intensive industry had at least one coefficient for a resource endowment that was significantly different from zero. Manufacturing nec was found to be capital-intensive, food products, beverages and tobacco were found to be skilled labor-intensive, wood and products of wood and cork were found to be unskilled labor-intensive, and textiles, textile products, leather and footwear were found to be capital and unskilled labor-intensive. Two of the four industries (machinery nec; and textiles, textile products, leather and footwear) had research and development coefficients that were significantly different from zero and negative. They are both industries that have seen significant movement out of more developed countries in the last two or three decades too. Food products had the expected positive coefficient for research and development. There were no non-pollution intensive industries where the environmental coefficient was negative and significantly different from zero. Two of the three positive coefficients (wood and products of wood and cork; and textiles, textile products, leather and footwear) for the environmental regulations variable were significantly different from zero. Both were industries that used sustainable resources, wood products and textile products. As noticed with paper products, it is possible that these industries use inputs that have a stronger attachment to the final product than in other industries analyzed. People naturally associate furniture and other wood products with forests; they associate cotton with textiles more closely. When purchasing a television or car, one is less concerned about how the inputs were mined or processed to obtain the final product.

Other non-metallic mineral products were found to be capital and unskilled labor-intensive industry, fabricated metals was found to be a skilled labor-intensive industry, and chemical products were found to be a capital-intensive industry in the category of neutral industries with respect to pollution intensity. In one industry, other non-metallic mineral products, a negative relationship between net exports and environmental regulations was found, while in another industry, fabricated metal products, this relationship was positive. The argument concerning a sustainable resource input does not seem valid for the positive sign in the fabricated metals equation, though.

Environmental regulations can be a way to combat the flight of manufacturing out of developed countries if the output from these industries can be identified as environmentally-friendly. A positive relationship between net exports and environmental regulations was found for paper products, wood products, and textile products. The challenge is finding a way to link good environmental practices in industries that are not linked to sustainable resources. The current craze in purchasing carbon credits by various companies might be a way that companies can show their environmental stewardship in a tangible way.

This analysis is more refined than most because the investigation is performed on many different industries. However, the results suffer from the fact that companies export and many of these companies operate in many different countries. Their research and development activities might be in their home country, but the results from such activities can be used in company operations throughout the world. Thus, the strength of the results relative to countries is less clear.

It is clear that developed countries have certain manufacturing industries that have more potential to expand (or at least contract more slowly) in the future. Paper products stands out because it is a capital and skilled labor-intensive industry where net exports are positively related to environmental regulations and research and development expenditures. Basic metals is the converse – an industry that used unskilled labor intensively and where net exports are negatively related to environmental regulations and research and development expenditures.

Chapter III

The Impact of Competition Policy on Production and Export Competitiveness: A Perspective from Agri-food Processing[15]*

Introduction:

Over the last 10 years or so, competition policy has emerged as a major issue for the international trade system. Competition policy, simply called competition law, is a set of rules and regulations a country's government pursues to enhance market contestability (Hoekman and Mavriodis). It ensures market competition, protects against monopolies, and maintains sound economic development for the country. When a market exhibits some form of imperfection or monopolistic competition, governments establish competition laws to regulate economic activities in order to ensure that markets operate within the public interest. According to the official OECD webpage,

> *"Well-designed competition law, effective law enforcement and competition-based economic reform promote increased efficiency, economic growth and employment for the benefit of all."*[16]

While competition policy, in economic theory, acts as an efficiency-enhancing factor for economic development: the greater the intensity of competition policy the better the economic performance, many countries still consider competition in product market despite the absence of a formal competition policy (Singh). Especially in most developing countries, there is no competition policy. Instead governments in developing countries intervene time to time any anti-competitive behavior if arisen. Since the governments have control over market behavior and can fix prices, they have tendency to avoid formal competition policy. However, most economists suggest that competition policy is essential for developing economies because they are increasingly subject to

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[15] A part of this study was done when the author was working with the Environmental and Sustainable Division (ESDD) in the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Bangkok, Thailand. The author thanks Dr. Mia Mikic, Economic Affairs Officer, Trade Policy Section, UNESCAP for her innovative ideas and suggestions to develop this research plan.

* This part of research was presented at the Southern Agricultural Economics Association Annual Meeting, February 3-6, 2007. Mobile, Alabama, 2007.

[16] Source: http://www.oecd.org/topic/0,2686,en_2649_37463_1_1_1_1_37463,00.html. Last accessed, May 01, 2006.

international competition due to trade liberalizations and huge foreign merger movements in recent years. In developed countries, competition policy, though it has a wide range of variation from country to country, is comparatively an effective tool enhancing economic development. In some instances, it is forty per cent more effective than in developing countries (World Bank; cited in Singh). However, due to lack of strong evidence, there is still considerable disagreement on the nature of competition in emerging market, and on how intensively competition policy influences economic performance of the country.

A number of empirical studies investigate the impacts of competition policy. Ahn reported that product market competition encourages productivity growth. Kee and Hoekman examined the impact of competition policy on profit margins and concluded that government policies to facilitate entry and exit of firms can have important effects on industry markups. Dutz and Vagliasindi found that competition policy improves enterprise mobility. Zhang et al. found that both regulation and competition introduced before privatization positively impact electricity generation. Another useful piece of evidence comes from an interesting study by Kahyarara that examined the role of competition policy in influencing productivity, investment and exports of Tanzanian manufacturing industries. His results suggest that the existence of competition policy positively impacts firm productivity, but competition, when it is ranked as a production problem, negatively impacts productivity. He also found that competition policy has a positive impact on investment and export flows in the manufacturing enterprise.

Although competition concerns have been around for many years, the formal discussion in WTO was launched in 1997 by establishing a Working Group on competition. The linkage between competition policy and trade has been a growing concern in the last 10 years. There are a number of empirical works that establish the significance of within-firm impacts of competition policy but little attention has focused on the impact of competition policy for food manufacturing. Competition issues arise in the farm input sector with respect to the market structure of the seed and agro-chemicals industries. Competition issues are also present in the processing sector, particularly for fish and livestock industries. There is a need to assess how global agricultural markets could be better regulated with respect to competition policy. This study examines how competition policy impacts productivity growth and international competitiveness in the manufacturing industry paying special attention to processed food industries. The work is important and helps decision makers to measure the policy impacts of competition regulations. The literature is largely silent regarding its impact on food and processed food products both at the domestic and international levels. This study offers a unique opportunity to contribute to the existing literature.

Research Objectives:

This study aims at developing a better understanding of competition policy and its impact on a country's production and international trade flows: testing the hypothesis that competition policy positively impacts production as well as export competitiveness. The specific objectives of this study include:

d. To identify factors that influence production and trade competitiveness;
e. To develop a model to estimate the impact of competition policy on a country's production and export flows in particular on agri-food processing;
f. To compare the policy impacts within manufacturing sectors.

Competition Policy and Trade[17]:

To illustrate how the competition policy interacts through international trade, we consider a three-panel diagram, as shown in the Figure III.1. In this panel, there are two large countries illustrated in the left and right panels, and one good to be traded. The equilibrium of the world market, depicted in the middle panel, is at the price level, P_w. If there is no trade barrier, excess demand (*ED*) in importing country equals to excess supply (*ES*) in exporting country at the export-import quantity level, Q_T.

Let us suppose the exporting country that has no competition policy exports to importing country that has a strict competition policy. The domestic price (P_E) of goods in the exporting country is equal to its marginal costs (C^*). The exporting country with no competition policy considers the demand of its own (D_E) and the excess demand of the importing country (ED_I). So the total demand (D_T) in the world market is the horizontal summation of the D_E and ED_I, which set up the equilibrium price (P_w) at the quantity

[17] To illustrate the principle of competition policy and international trade, we follow MacLaren and Josling's paper.

level (Q_c). Then if the exporting country introduces competition policy keeping domestic and world prices constant, this activity leads to duopoly facilitating free trade and free entry that enhances market contestability in the exporting country.

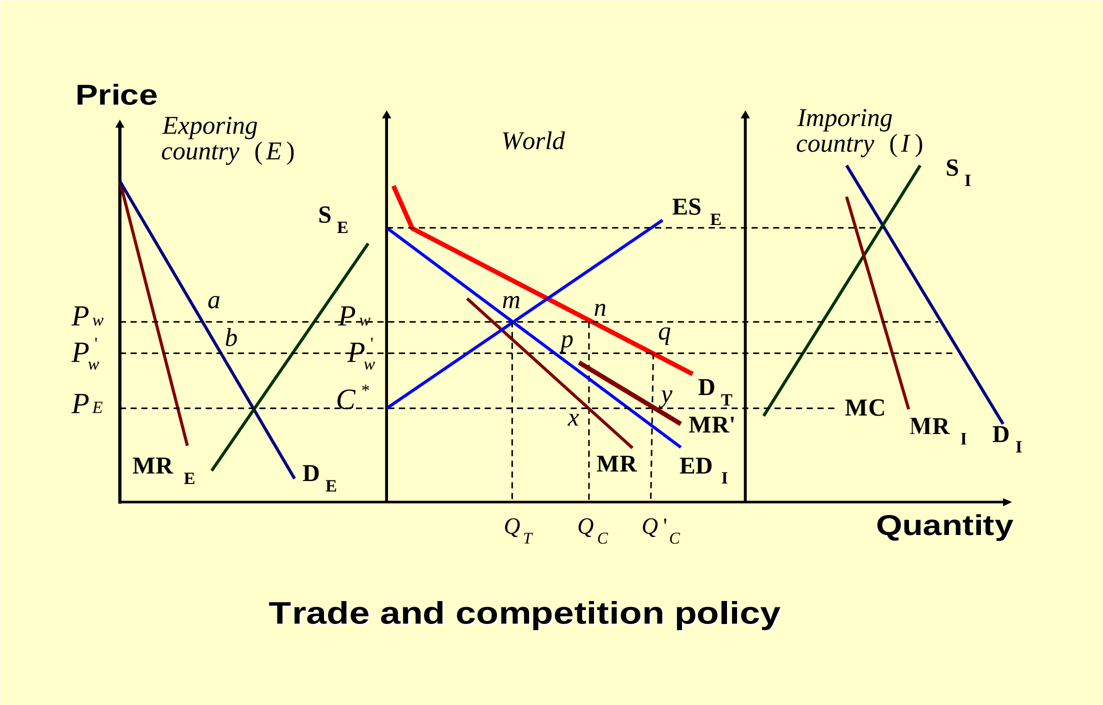

Figure III.1[18]: Trade and competition policy

As a result, the world price (P_w) goes down to P'_w, and the quantity exported increases resulting the Q_c increases to Q'_c. It also invites benefits that include higher consumer surplus and lower excess profits from monopolies. As shown in the Figure, the importing country experiences net welfare gains given by the area $P_w mp P'_w$: consumers gain while producers lose. Consumers in the exporting country gain from the fall in price, the area *mnqp,* which is equivalent to the area $P_w ab P'_w$, but producer profits fall from $P_w nxC^*$ to $P'_w qyC^*$.

Review of Literature:

Competition policy concerns in national and global discussions have been around for many years. A number of empirical studies exist on within-firm impacts of

[18] The figure is derived from the Figure 2.16 (p. 32) in Reed, and from Figure 2 in MacLaren and Josling.

competition policy in the literature. However, the literature is largely silent regarding the impact of competition policy in the agri-food manufacturing. The reason behind this insufficient empirical study on competition policy is a shortage of reliable and adequate data: there were virtually no reliable data on competition policy available for a long time. Although the situation has improved in recent years, some investigators have undertaken surveys to investigate the extent and impact of competition and competition policy. Totally accurate measures of the policy variable are still difficult to obtain. In this chapter, we review thoroughly the existing literature on competition policy and its impact on trade flows.

The enforcement of competition may vary across countries, which may give a somewhat misleading impression of its influence in practice. However, competition policy, in general, facilitates entry and exit of firms that can have important effects on industries: its productivity, investment and exports. We analyze empirical studies, most of which suggest that competition policy is positively related to domestic production and international competitiveness.

Kahyarara investigated the impact of competition and competition policy on firm performance indicators of productivity, investments, and exports. He surveyed the existence of competition within the line of a firm's production in the Tanzanian manufacturing sectors, and investigates if competition is one of the biggest problems that affect firm performance. He developed an empirical framework based on Cobb-Douglas production function as[19]:

$$LogQ_t = LogA_t + \beta_1 LogK_t + \beta_2 LogL_t + \beta_3 LogC_t + \beta_4 COM_t + \varepsilon$$

where, Q represents the value of manufacturing output; K is capital stock; L is labor force; C is indirect costs; COM denotes a dummy variable of competition policy; t indicates year and ε represents error terms. In order to estimate the effect of competition policy on investment and export, he used a Probit model. He defined competition policy into two different measures. One is measured by the existence of competition within the line of production of five major competitors in Tanzania. The second measure of competition is based on whether competition is one of the three problems identified by his survey, and affected the firm. His empirical result suggests that the existence of

[19] The model shows the same notation as in Kahyarara.

competition positively impacts a firm's productivity, but competition, when ranked as major production problem, negatively influences productivity growth of the firm. He also found competition policy has a positive impact on investments and exports in Tanzanian manufacturing sectors.

Kee and Hoekman developed an empirical framework developed by Hall to estimate the impact of domestic and foreign competition on industry markups over time and across a large number of countries. They attempted to solve the shortcomings in the Hall method, and they, following Olley and Pakes, introduced a polynomial form of the two variables, capital and investment, to control for unobserved industry productivity in their model. They determined the relative impact of competition policy by using as a dummy variable that equals 1 if the competition policy exists in a given year. They hypothesized that the introduction of a competition law reduces industry markups when a fixed number of firms exists in the market but in the long run when firms are free to enter and exit, a competition law affects the domestic firms by increasing contestability of markets, particularly import competitiveness. For the empirical results, they did not find any significant impact of competition policy on industry markups. However, the results suggest that the competition policy may impact the industry markups in the long run via its impact on domestic entry.

Zhang et al. investigated the impact of competition and policy reforms in electricity generation. In their empirical study they added a competition dummy that equals 1 if a wholesale market for electricity is introduced, 0 otherwise. They followed a fixed effects panel data approach with non-linear functional specifications[20]:

$$\ln y_{it} = \alpha_i + \beta_1(R_{it}) + \beta_2(P_{it}) + \beta_3(SRP_{it}) + \delta(\ln x_{it}) + v_i + \varepsilon_{it}$$

$$\ln y_{it} = a_i + b_1(C_{it}) + b_2(P_{it}) + b_3(SCP_{it}) + \Delta(\ln x_{it}) + w_i + e_{it}$$

where, *i* and *t* indicate country and year, respectively; *R* is regulation; *C* is competition; *P* is privatization. All of these three variables (*R*, *C*, and *P*) are used as dummy variables in the first equation. In the second regression model, *SRP* and *SCP* represent regulation before privatization and competition before privatization, respectively, and are used as dummy variables. In addition, *x* denotes control variables; *v* and *w* are residuals; ε and *e*

[20] The model shows the same notation as in Zhang et al.

are error terms. In their empirical study, Zhang et al. found that both regulations and competition introduced before privatization increase electricity availability and generation.

Dutz and Vagliasindi attempted to examine the effectiveness of competition policy implementation across countries. In their study, they tried to assess the relationship between competition policy and its intensity under the three dimensions of enforcement, competition advocacy and institutional effectiveness. In their analysis they surveyed the overall performance of firms based on employment and labor productivity, and assessed the influence of external factors that affect the firms' activities. The result of their study suggests that an effective competition policy implementation positively influences the expansion of efficient private firms.

Yano and Dei proposed a conceptual framework on trade and competition policy. In their analysis they argued that suppressing competition in a domestic market leads to an increase in the home country's utility and decrease in the utility of the trading country. In general, promoting domestic competition increases economic activities, and thus benefits the country. But Yano and Dei argued against this perception with the argument that the government regulates a country's competition policy so the number of firms (by entry and exit) in the market depends on government policy, not on existence of economies of scale in production. They analyzed the impact of promotion of competition for both the small and large countries. In a small country, they assumed that Cournot imperfect competition exists. They proposed,

> *"If the imperfect competition is eliminated, both the welfare of the country's consumers and the country's trade increase"* (p. 243).

If the perfect competition exists in both home and foreign countries, they suggested,

> *"A slight suppression of competition in a large country's downstream sector will improve that country's terms of trade, thereby increasing the country's utility and decreasing its trading partner's utility"*(p. 246).

Theoretical Model:

To explore the impact of competition policy on productivity growth and international competitiveness, this study uses the Cobb-Douglas production function.

The production function is:

$$Q_{it} = A_{it} K_{it}^{\beta_1} L_{it}^{\beta_2} \quad \text{(III.1)}$$

where it assumes a firm produces output (*Q*) with a technology that uses capital (*K*) and a labor force (*L*) inputs in year *t*. *A* is an index of total factor productivity or a coefficient that represents the level of technology, and it increases marginal product of all factors simultaneously. β_1 and β_2 are positive parameters satisfying $(\beta_1, \beta_2) > 0; \beta_1 + \beta_2 = 1$ that would imply constant return to scale.

A competition policy variable can be incorporated in the production equation (Kahyarara). The idea behind this incorporation is to ensure that competition enhances market contestability: it leads to improve efficiency, lower prices and higher product quality. Besides that, competition brings wider economic benefits: if firms are efficient, their international competitiveness will improve, which causes a country's exports to increase and imports to decline.

To test the hypothesis that competition policy positively impacts productivity growth and export competitiveness, we incorporate competition policy in the production equation. The competition policy is used as a dummy variable (*C*), which equals 1 if competition policy exists in a given year. Including a competition policy variable, the production equation has the following form:

$$Q_{it} = A_{it} K_{it}^{\beta_1} L_{it}^{\beta_2} e^{\gamma C_{it}} \quad \text{(III.2)}$$

Transforming the above Equation (III.2) into logarithms allows linear estimation where the dependent variable is directly related to explanatory variables. Taking logs and appending an error term, we can write:

$$\ln Q_{it} = \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + \mu_{it} \quad \text{(III.3)}$$

where we assume that the error term (μ_{it}) satisfies all assumption of the classical regression model. Given the above equation, we can calculate an OLS estimate for the error term μ_{it} , provided the coefficients are consistently estimated. For OLS it is assumed that $E(\mu_{it}) = 0$ and $E(\mu_{it}^2) = \sigma^2$ for all *i* and *t*, $E(\mu_{it}\mu_{jt}) = 0$ for all $i \neq j$. But the problem is that the estimation suffers from simultaneity problems, which means that the regressors and the errors are correlated, and thus, this problem makes OLS estimates biased. In fact, in addition to the exogenous variables used in Equation (III.3) there exists other exogenous factors that affect production. If these factors cause the error term in the Equation (III.3) to be correlated across all periods for particular country or among countries for a given period, simple OLS estimates that ignore these correlation will be inefficient. However, we can solve this problem by panel data approach that can capture both cross-sectional and time variations in the data.

We can estimate panel regressions using two common techniques: fixed effects model, and random effects model. This classification depends upon alternative assumptions about error terms and about how the coefficients change over cross sections or time. In fixed effect models, differences over cross-sectional sectors are assumed to be reflected in the intercept term that accounts for time invariant attributes, while in random effects models, this attribute is divided into mean intercept and a group specific error and treated as a random variable in the model (Han). These two models are again divided into two groups: (a) one way model that does not consider a time specific effect, and (b) two way model that includes the time specific effect. The assumptions underlying these estimates are somewhat restrictive.

Given Equation (III.3), the alternative models we used in our study are:

Fixed effects model:

(a) One way model:

$$\ln Q_{it} = \beta_{0i} + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + \mu_{it} \tag{III.4}$$

where β_{0i} is an individual special attribute that is constant over time and μ_{it} is a classic error term with $E(\mu_{it}) = 0$ and $V(\mu_{it}) = \sigma^2$.

(b) Two way model:

$$\ln Q_{it} = \beta_0 + \beta_{0i} + \nu_t + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + \mu_{it} \tag{III.5}$$

where β_{0i} is a group effect and ν_t is a time effect for each period.

Random effects model:

(a) One way model:

$$\ln Q_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + u_i + \mu_{it} \tag{III.6}$$

where β_0 is a constant and u_i is an error characterizing the *i*th observation and constant over time, with $E(u_i) = 0$, and $V(u_i) = \sigma^2$, $E(u_i u_j) = 0$ for $i \neq j$, and $Cov(u_i, \mu_{it}) = 0$.

(b) Two way model:

$$\ln Q_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + u_i + \mu_{it} + w_t \qquad \text{(III.7)}$$

where w_t is an error reflecting the time effect for each period.

Both the fixed and random effects models are recognized econometric techniques to solve simultaneity problems but each has its own limitations and can produce quite different results. The preference of one model over another is still arguable (Mulatu et al.). In the fixed effects model, the unit-specific effect (β_{0i}) is correlated with the other regressors, whereas the random effects are uncorrelated with the explanatory variables. So the fixed effects model is substandard to the random effects model in terms of degrees of freedom. (Greene).

Empirical Model:

Given the framework discussed in the previous section (Equations (III.4), (III.5), (III.6) and (III.7)), the study explores the impact of competition policy on a country's manufacturing production and exports, including production and exports in the food and food product industries. The study develops the following regression equations:

$$MP_{it}^{S} = f\left(\overset{+/-}{E_{it}}, \overset{+}{C_{it}}\right) + \mu_{it} \qquad \text{(For manufacturing production)} \qquad \text{(III.8)}$$

$$MX_{it}^{S} = f\left(\overset{+/-}{E_{it}}, \overset{+}{C_{it}}\right) + \mu_{it} \qquad \text{(For manufacturing exports)} \qquad \text{(III.9)}$$

where, the *MP* represents gross output in the manufacturing industry of a country and *MX* is exports in manufacturing sectors of the country. The dependent variable of the above equations is determined by the explanatory variable *E* that includes gross fixed capital formation (*K*), labor force (*L*) and import penetration (*M*); *C* denotes competition policy used as a dummy variable, which equals 1 if competition policy exists in a given year; μ are error terms; ^{S} is the sector, either total manufacturing or manufacturing for food and food products; *i* represents country (Australia, Austria, Canada, Denmark, Finland, Hungary, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, United Kingdom and the United States), and *t* is time (1980-2003). In these econometric equations, the signs above the explanatory variables are the expected direction of their impact on production and export flows. It is expected that factor inputs (capital and labor) positively or negatively impact both production and exports (as discussed in factor endowment model in the chapter II). According to Kee and Hoekman, import penetration is negatively related to production and exports. This study adds this variable in both regression equations to see its relationship with production and export flows. The relationship between import penetration and production and exports is expected to be negative. The sign of the competition policy indicates that there is a positive relationship between competition policy and a firm's production as well as exports. If a country introduces competition policy, it is expected that the competition policy enhances competitions among firms (both domestic and foreign), and thus increases production of the firm and exports.

In order to examine the relationship between competition policy and a country's manufacturing production and exports, we employ all the four panel models, fixed effects one way (*FIXONE*), fixed effects two way (*FIXTWO*), random effect one way (*RANONE*), and random effects two way (*RANTWO*) models discussed in the previous section. The functional forms of the models for manufacturing production and exports are as follows:

For manufacturing production:

$$\text{\textit{FIXONE:}}\ \ln MP_{it}^{S} = \beta_{0i} + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 M_{it} + \gamma C_{it} + \mu_{it} \quad \text{(III.10)}$$

$$\text{\textit{FIXTWO:}}\ \ln MP_{it}^{S} = \beta_0 + \beta_{0i} + \nu_t + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 M_{it} + \gamma C_{it} + \mu_{it} \quad \text{(III.11)}$$

$$\text{\textit{RANONE:}}\ \ln MP_{it}^{S} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + \beta_3 M_{it} + u_i + \mu_{it} \quad \text{(III.12)}$$

$$\text{\textit{RANTWO:}}\ \ln MP_{it}^{S} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + \beta_3 M_{it} + u_i + \mu_{it} + w_t \quad \text{(III.13)}$$

For manufacturing exports:

$$FIXONE: \ \ln MX_{it}^{S} = \beta_{0i} + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 M_{it} + \gamma C_{it} + \mu_{it} \quad \text{(III.14)}$$

$$FIXTWO: \ \ln MX_{it}^{S} = \beta_0 + \beta_{0i} + \nu_t + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 M_{it} + \gamma C_{it} + \mu_{it} \quad \text{(III.15)}$$

$$RANONE: \ \ln MX_{it}^{S} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + \beta_3 M_{it} + u_i + \mu_{it} \quad \text{(III.16)}$$

$$RANTWO: \ \ln MX_{it}^{S} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + \beta_3 M_{it} + u_i + \mu_{it} + w_t \quad \text{(III.17)}$$

Data Sources and Description:

The country panel data utilized in this model are collected for twenty four years, 1980-2003, on OECD countries. Data for all variables come from World Development Indicators (WDI) and OECD STAN Database.

The sources and description of all the variables used in the model are shown in the following table (Table III.1):

Table III.1: Data sources and description

Variables	Description	Sources
Total manufacturing production	Production of total manufacturing industries	OECD STAN Database for Industrial Analysis
Food Manufacturing production	Total production of food products, beverages and tobacco	OECD STAN Database for Industrial Analysis
Total manufacturing exports	Total exports of goods in manufacturing industries	OECD STAN Database for Industrial Analysis
Food manufacturing exports	Exports of goods in food products, beverages and tobacco	OECD STAN Database for Industrial Analysis
Import penetration	Import penetration is the ratio between the values of imports as a percentage of total production	OECD STAN Database for Industrial Analysis
Capital	Gross capital formation (Constant 2000 US$) for total manufacturing and manufacturing exports	World Development Indicator (WDI)

	Gross capital formation for food manufacturing and food manufacturing exports	OECD STAN Database for Industrial Analysis
Labor	Total labor force for total manufacturing and manufacturing exports	World Development Indicator (WDI)
	Labor for food manufacturing and food manufacturing exports is only skilled labor	OECD STAN Database for Industrial Analysis
Competition policy	Competition policy is used as a dummy variable, which equals 1 if competition policy exists in a given year	Kee and Hoekman, 2003

Total manufacturing is the production of total manufacturing industries in each country, and food manufacturing is the total production of food products, beverages and tobacco in each country. Annual data for both the variables for 20 countries (Australia, Austria, Canada, Denmark, Finland, Hungary, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, United Kingdom and the United States) are collected from OECD STAN Database for Industrial Analysis. Annual data for total export of goods in manufacturing industries, and data for exports of goods in food products, beverages and tobacco sectors in each of the 20 countries are also collected from OECD STAN Database for Industrial Analysis. Then calculated average production and exports in total manufacturing industries and average production and exports for food manufacturing in each year are presented in Figure III.2 and Table III.3.

The Figures indicates that the estimated production for total manufacturing decreases gradually, and then it had a strong upward trend. The production in food products, beverages and tobacco sectors increased gradually during the period, 1981-2003. The exports for both total manufacturing and food manufacturing increased gradually during the study period, 1980-2003.

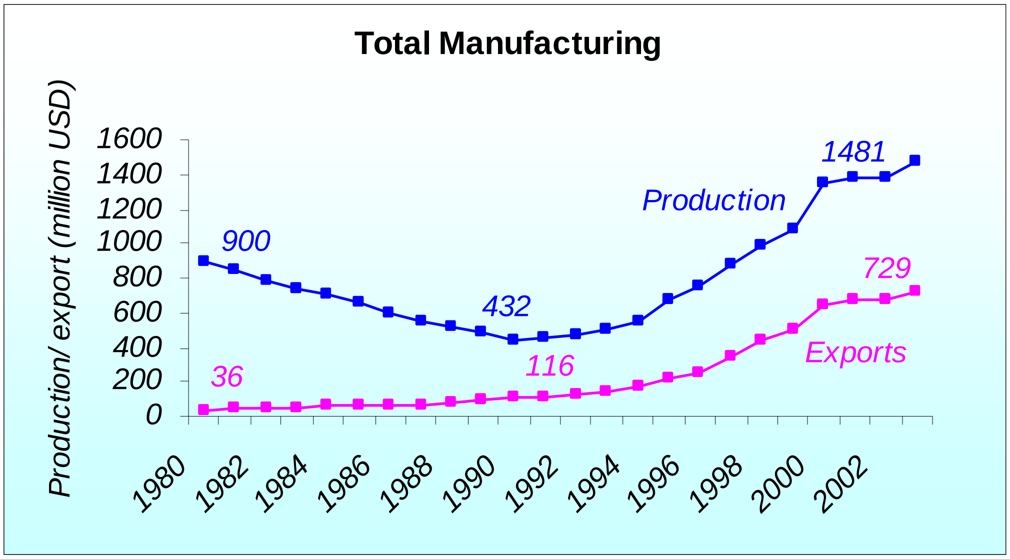

Figure III.2: Production and exports in total manufacturing industries

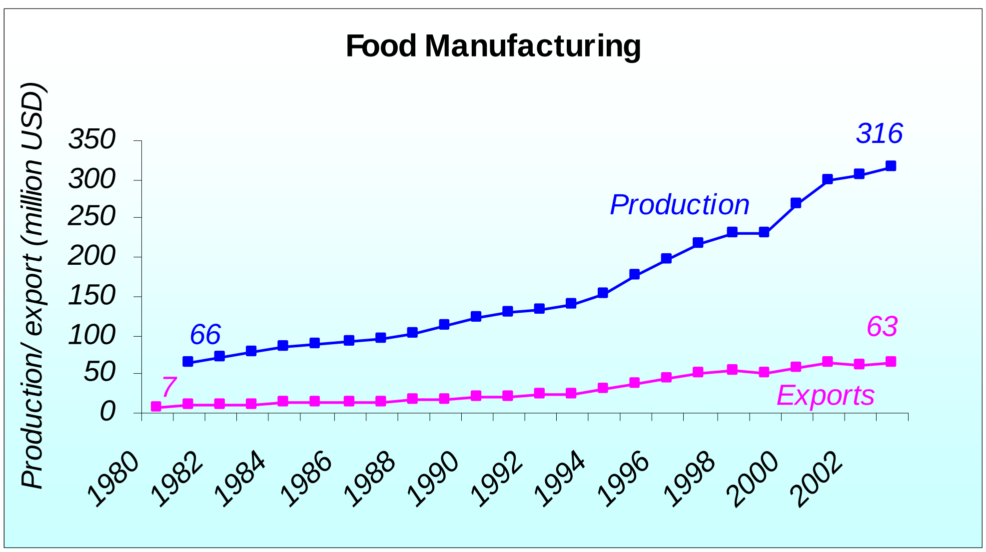

Figure III.3: Production and exports in food manufacturing industries

In particular, the production of total manufacturing decreased from US$ 900 million in 1980 to US$ 432 million in 1990, and then it increased gradually and this upsurge continued in the following year until 2003, and reached to the export value of US$ 1481 million. The export for total manufacturing increases gradually from 1980 to 2003: it rose in value from US$ 36 million in 1980 to US$ 116 million in 1991 and grew almost twenty-fold (US$ 729 million) in 2003. The production in food products, beverages and tobacco increased gradually during the studied period, 1981-2003: it rose in the value from US$ 66 million in 1981 to US$ 316 million in 2003. The export value increased from US$ 7 million in 1980 to US$ 63 million in 2003.

The import penetration for total manufacturing and manufacturing exports are calculated as the values of imports as a percentage of total production. Import penetration for food products, beverages and tobacco are collected directly from the OECD STAN Database for Industrial Analysis. Capital is the gross capital formation (Constant 2000 US$) for total manufacturing and manufacturing exports, and labor is the total labor force for total manufacturing and manufacturing exports; both of the data were collected from World Development Indicator (WDI). But the capital for food manufacturing and food manufacturing exports is the gross capital formation collected from OECD STAN Database for Industrial Analysis. The labor for food manufacturing and food manufacturing exports is only skilled labor, which is calculated by the formula developed by Branson and Monoyios (mentioned detailed in Chapter II), and collected from OECD STAN Database for Industrial Analysis. The competition policy variable is used as a dummy variable in this study, which equals 1 if competition policy exists in a given year. Table III.2 lists all 20 countries according to the adoption year of the competition policy.

Table III.2: Adoption of competition policy

Country	Year	Country	Year
Australia	1906	Mexico	1992
Austria	1951	Netherlands	1957
Canada	1889	New Zealand	1986
Denmark	1937	Norway	1926
Finland	1958	Poland	1990
Hungary	1990	Portugal	1983
Ireland	1991	Spain	1963
Italy	1990	Sweden	1953
Japan	1947	United Kingdom	1948
South Korea	1980	United States	1890

Source: Kee and Hoekman, 2003.

As shown in the table, Canada was the first country to adopt competition laws, in 1889, followed by United States in 1890. Hungary, Italy, Poland, Ireland and Mexico adopted competition laws in 1990s.

Empirical Results:

The study hypothesizes that a country's production and export competitiveness are positively related to competition policy. We used aggregate data for countries' total manufacturing sectors to regress a competition policy variable with control variables such as capital stock, labor force and import penetration on manufacturing production and exports. Since the impact of competition regulation depends upon the particular circumstances of the industry to which the policy is applied, we examine how competition policy impacts production and exports of a specific sector, in particular the agri-food processing sector. We estimated equations with a panel regression model for twenty four years for the period 1980 to 2003 with twenty OECD countries for total manufacturing industries and eleven OECD countries for food manufacturing industries. Descriptive statistics of the variables are reported in Table C.1 (Appendix C).

The estimation results using the fixed effects and the random effects model are reported in four different tables (Table III.3- III.6). Table III. 3 displays the results for total manufacturing production, Table III.4 for food manufacturing production, Table III.5 for total manufacturing exports, and Table III.6 for food manufacturing exports. All four models for both manufacturing production and exports (Equation (III.10) - (III.17)) perform well. The F values for all regression equations are statistically significant at the 1% level. The R^2 values indicate that the overall goodness of fit of the regressions is quite good. The coefficients in most cases are highly significant, indicating that these four models have considerable explanatory power. According to test statistics, F values for all fixed effects models are significant at the 1% level. The F test compares the pooled OLS and fixed effects model. Hence, the F statistics rejects the null hypothesis that all dummy parameters (country and/ or year) except one are zero. We may conclude that the fixed effects model is better than the pooled OLS model (we present and discuss the preferred model).

To compare a fixed effects and a random effects model, we used Hausman specification (HS)[21] test. The HS test compares the fixed effects and random effects model under the null hypothesis that the individual effects are uncorrelated with the other regressors in the model. If there is such correlation (the null hypothesis is rejected), the random effects model would be inconsistently estimated and the fixed effects model would be the model of choice (Han). As shown in the results, the Hausman statistic is high so we can reject the null hypothesis, and adopt the estimates of the fixed effects model. In fact, there are no big differences between estimates of the two models. Breusch Pagan's Lagrange (LM)[22] statistics are also reported to check specific effects of each industry in the random effects model, in that we reject the null hypothesis that the variance of random disturbance is zero. In our study, we present and discuss the fixed effects model.

Table III.3 displays the regression analyses for production of countries' total manufacturing, and the estimators of the fixed effect models (Equation (III.10) and (III.11)) are presented in column 2 and 3. The results show that the policy variable has a significantly positive coefficient as expected in the regression model (Equation (III.10)): a competition policy leads to an increase in the manufacturing production by 35 percent. This result suggests that competition policy enhances competition by reducing entry barriers, and makes a favorable endowment shock that may cause firms to produce more output with lower prices. The coefficient value on the import penetration is negatively related to the countries' total manufacturing output, and the result implies that 0.38 per cent decrease in import penetration results in a one per cent increase in total output production in the total manufacturing sectors. That is, the increased production of a good may satisfy the domestic demand of that good, and as a result, the import demand of that

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[21] Hausman's statistic is the difference between the estimated covariance of the parameter estimates in the LSDV model (robust) and that of the random effects model (efficient):

$$m = \left(b_{robust} - b_{efficient}\right)' \hat{\Sigma}^{-1} \left(b_{robust} - b_{efficient}\right) \sim \chi^2(k),$$

$$\hat{\Sigma} = Var\left(b_{robust} - b_{efficient}\right) = Var\left(b_{robust}\right) - Var\left(b_{efficient}\right),$$ where k is the degree of freedom (Park).

[22] $$LM = \frac{nT}{2(T-1)}\left[\frac{e'DDe}{e'e} - 1\right]^2 = \frac{nT}{2(T-1)}\left[\frac{T^2 \bar{e}'\bar{e}}{e'e} - 1\right]^2 \sim \chi^2(1),$$ where n is the number of cross sections; T represents time series length; and *e'e* is the *SSE* of pooled OLS regression (Park).

good may decline. The results also show that the coefficient of labor is positively related to manufacturing production, but the coefficient of capital is statistically not different from zero. The policy variable has a significantly positive coefficient for the two way model (Equation (III.11)): competition policy leads to an increase in manufacturing production by 10 per cent as expected.

Table III.3: Regression results of total manufacturing production in OECD countries, 1980-2003

Variables	Fixed Effects Model		Random Effects Model	
	One Way	Two Way	One Way	Two Way
Intercept	-75.95 [a]	-32.74 [a]	-38.61 [a]	-16.64 [a]
	(3.79)	(4.90)	(3.03)	(3.11)
Import penetration	-0.38 [a]	-0.49 [a]	-0.42 [a]	-0.51 [a]
	(0.03)	(0.03)	(0.03)	(0.03)
Capital	-0.003	-0.22 [a]	0.05	-0.18 [a]
	(0.05)	(0.04)	(0.05)	(0.47)
Labor	4.92 [a]	2.98 [a]	3.18 [a]	-2.20 [a]
	(0.22)	(0.25)	(0.20)	(0.19)
Competition policy	0.35 [a]	0.10	0.47 [a]	0.17 [a]
	(0.07)	(0.07)	(0.09)	(0.08)
R^2	0.94	0.96		
F	280.02 [a]	179.72 [a]		
HS			32.27 [a]	34.98 [a]
LM			3302.43 [a]	3318.47 [a]

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis. All the variables except competition policy are in logs. The Hausman statistic (HS) is a test which has a χ^2 distribution with 3 degree of freedom. LM represents the Breusch Pagan's Langrage multiplier statistic which has a 1 degree of freedom.

Estimated results for Equation (III.14) and Equation (III.15), presented in Table III.4, show that the existence of competition policy for the one way model has a significantly positive impact on manufacturing exports: competition policy leads to an increase in manufacturing exports by 137 per cent. This result is consistent with the finding with Kahyarara. Both coefficients of capital and labor have positive signs, and are statistically significant at the 1% level: a 1 per cent increase in capital and labor leads to an increase in total manufacturing exports by 1.1 and 2.8 per cent, respectively. The import penetration coefficient is statistically significant at the 1% level, and negatively related to the manufacturing export. The relationship between competition policy and manufacturing exports is also significantly positive in the two way model presented in column 3.

Table III.4: Regression results of total manufacturing exports in OECD countries, 1980-2003

Variables	Fixed Effects Model		Random Effects Model	
	One Way	Two Way	One Way	Two Way
Intercept	-69.76 [a]	3.04	-31.08 [a]	-5.91 [b]
	(5.65)	(7.13)	(3.54)	(3.53)
Import penetration	-0.19 [a]	-0.37 [a]	-0.23 [a]	-0.34 [a]
	(0.04)	(0.04)	(0.05)	(0.04)
Capital	1.14 [a]	0.80 [a]	1.18 [a]	0.86 [a]
	(0.07)	(0.06)	(0.07)	(0.06)
Labor	2.75 [a]	-0.57	0.78 [a]	-0.25
	(0.32)	(0.36)	(0.24)	(0.21)
Competition policy	1.37 [a]	0.85 [a]	1.50 [a]	0.98 [a]
	(0.11)	(0.10)	(0.12)	(0.10)
R^2	0.88	0.92		
F	141.32 [a]	94.84 [a]		
HS			75.76 [a]	29.79 [a]
LM			2211.34 [a]	2278.13 [a]

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis. All the variables except competition policy are in logs. The Hausman statistic (HS) is a test which has a χ^2 distribution with 3 degree of freedom. LM represents the Breusch Pagan's Lagrange multiplier statistic which has a 1 degree of freedom.

Table III.5 displays the estimated results of food manufacturing production that is explained by competition policy with other variables used in the model (Equation (III.10) - (III.13)). In column 2 and column 3, we interact countries food manufacturing production with competition dummies using one way and two way models. It is shown that the parameter estimates on the policy variable are positive and statistically significant at the 1% level for both the regressions.

Table III.5: Regression results of food manufacturing production in OECD countries, 1980-2003

Variables	Fixed Effects Model		Random Effects Model	
	One Way	Two Way	One Way	Two Way
Intercept	5.47 [a]	8.42 [a]	3.78 [a]	5.47 [a]
	(0.60)	(0.73)	(0.46)	(0.57)
Import penetration	0.16 [a]	-0.11	0.08	-0.07
	(0.08)	(0.09)	(0.07)	(0.09)
Capital	0.40 [a]	-0.03	0.46 [a]	0.19 [a]
	(0.06)	(0.09)	(0.06)	(0.08)
Labor	0.17 [a]	0.26 [a]	0.18 [a]	0.23 [a]
	(0.04)	(0.0.04)	(0.04)	(0.04)
Competition policy	0.31 [a]	0.29 [a]	0.25 [a]	0.25 [a]
	(0.07)	(0.07)	(0.07)	(0.07)
R^2	0.98	0.98		
F	21.07 [a]	9.02 [a]		
HS			7.43 [a]	22.80 [a]

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis. All the variables except competition policy are in logs. The Hausman statistic (HS) is a test which has a χ^2 distribution with 3 degree of freedom.

In the one way model, the results suggest that food manufacturing production in the post-competition policy period is about 31 per cent higher than the production in the pre-competition period. This positive sign implies that the production for food manufacturing is higher when competition policy is introduced than the production when competition policy is not introduced. The results also show that the coefficients of capital and labor are 0.40 and 0.17, respectively, and significantly positive at the 1% level. The coefficient of import penetration (0.16) is significant at the 1% level and has a positive sign. This positive sign for import penetration is unexpected and difficult to explain in the one way model. Competition policy is positively correlated to food manufacturing production: the estimated coefficient of competition policy implies that the production increases almost 29 per cent in the two way when competition policy exists.

Table III.6 shows the regression analyses (Equation (III.14) - (III.17)) for countries' food manufacturing exports as influenced by competition policy with other variables.

Table III.6: Regression results of food manufacturing exports in OECD countries, 1980-2003

Variables	Fixed Effects Model		Random Effects Model	
	One Way	Two Way	One Way	Two Way
Intercept	2.14 [a]	4.62 [a]	0.02	1.23 [b]
	(0.62)	(0.73)	(0.55)	(0.63)
Import penetration	1.19 [a]	0.88 [a]	1.14 [a]	0.97 [a]
	(0.08)	(0.09)	(0.08)	(0.09)
Capital	0.45 [a]	013	0.47 [a]	0.34 [a]
	(0.07)	(0.09)	(0.06)	(0.08)
Labor	0.09 [a]	0.14 [a]	0.10 [a]	0.11 [a]
	(0.04)	(0.04)	(0.04)	(0.06)
Competition policy	0.69 [a]	0.65 [a]	0.65 [a]	0.65 [a]
	(0.07)	(0.07)	(0.07)	(0.07)
R2	0.99	0.99		
F value	110.82	43.71		
HS			8.95	22.01

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis. All the variables except competition policy are in logs. The Hausman statistic (HS) is a test which has a χ^2 distribution with 3 degree of freedom.

As shown in the one way model, the coefficient of competition has a positive sign and is significant at the 1% level. This indicates that food manufacturing export in the post-competition policy period is about 69 per cent higher than the export in the pre-competition period. Kahyarara investigated the competition policy impact on exports but he found positive policy impacts on exports but the results are not statistically significant. The coefficient of import penetration for the exports in the food manufacturing sector is significantly positive at the 1% level. This result of a positive sign is difficult to explain conceptually. The coefficients of capital and labor are significantly positive for food manufacturing exports: a 1 per cent increase in capital and labor results in an increase in food manufacturing exports by 0.45 and 0.09 per cent, respectively. In the two way model, the policy variable has a significantly positive sign: competition policy leads to an increase in food manufacturing exports by 65 per cent.

Conclusion:

The purpose of this study is to examine the impact of competition policy on a country's production and export competitiveness. We derive our empirical regression model from a Cobb Douglas production function that considers that production and exports are influenced by competition policy along with factor endowments. We hypothesize that competition policy is positively related to a country's production and export flows. With the framework, we tested these hypotheses using panel data for total manufacturing for 20 countries, and food manufacturing for 11 countries during 1980-2003. We employ fixed effects and random effects models in our regression analyses. Since the impact of competition regulation depends upon the particular circumstances of the industry to which the policy is applied, we examine how competition policy impacts production and exports of a specific sector, in particular, in the agri-food processing sector.

The results show that the existence of competition policy has a significantly positive impact on total manufacturing production. Food manufacturing production is higher when competition policy is introduced than production when competition policy is not introduced. This result suggests that competition policy enhances competition by reducing entry barriers. The results also show that exports for both total manufacturing and food manufacturing are positively related to competition policy: in both cases exports in the post-competition policy period is higher than the exports in the pre-competition period. So competition policy enhances a firm's production as well as leads to an increase in export flows. The increased production caused by competition policy decreases the import demand of the firm, and thus, the country's import flows decline in the post competition policy period.

In this study, we had difficulties in finding reliable data for the competition policy variable. We are not confident enough about the impact of the competition policy because we use a dummy variable for this policy variable in our regression analyses. The major difficulty lies in trying to measure the exact influences that a policy imposes on manufactures. Many efficiency-enhancing factors that the firm might have along with competition policy factors may influence a country's production and exports. It would be very difficult to separate competition policy's impact from other factors that explain the firm's performance. Moreover, we use aggregate data for both manufacturing production and exports but the impact of competition regulation exclusively depends upon the particular circumstances of the industry to which the policy is applied. So, we recommend further research be focused on the harmonization of competition policy, factor intensity, and relative factor abundances of countries, rather than the consideration of competition policy in isolation.

Chapter IV

Food Safety Standards and Export competitiveness in the Food and Processed Food Industries in Asia-Pacific Countries[23]

Introduction:

International trade in food and processed food products has expanded enormously over the last ten years. World exports of processed food increased at the rate of 8.5% per year during 1970-2003, and the share of processed products in agricultural exports increased from 42% in 1990-91 to 48% in 2001-02 (AP, 2006, cited in Mohanty). The countries in Asia and the Pacific increased food production not only to meet their basic needs, but also to increase food exports to other countries in the world. The share of food exports in total agricultural exports has an upward trend in Nepal, China and Vietnam in the 1989-2002 period, and the increase in trade for processed food is also remarkably increasing in the region in 2002[24] (Mohanty). The reason behind this upward trend in the region's outflow in processed products is developed countries' changing food consumption patterns and their growing demand for "ready to eat" food.

While the growth in demand for ready to eat food creates exciting opportunities for food processing industries in Asia and the Pacific, developed countries' environmental and health related requirements act as important non-tariff barriers to exports for the region. The region's producers face several constraints. Among them is increasingly more stringent food safety standards imposed by developed countries. For example, with its strict food safety requirements, the United States has been a very tough market for Asia-Pacific countries. The European Union and Japan also have strict requirements on food and processed food products. Differing standards across markets are other constraint (Alimi, Jayasuriya, Prasad). For example, chlorine is used in many countries to destroy pathogenic bacteria in food but in other countries it is completely forbidden in food contact applications. The exporters in Asia-Pacific countries face

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[23] This part of research has been accepted to present at the 1st Mediterranean Conference of Agro-Food Social Scientists, April 23- April 25, 2007, Barcelona, Spain, 2007.
[24] More information is illustrated in Table D.1 and Table D.2 in Appendix D.

problems in meeting such standards in the different markets, which limits the export competitiveness of the region (Mohanty).

The food safety concerns by developed countries are not without merit. A wide range of chemical substances including pesticides and additives are commonly used in food production and processing, and residues of these chemicals may remain in the end products. These residues can be harmful for humans, animals and plants, and the environment in which they live. So, consumers in developed countries have exhibited a high level of food safety concern related to their processed food supply, though their growing demand for "ready to eat" food has increased. Developed countries have increasingly called for assurances that food is free from substances such as pesticides, chemical additives, hormones, and antibiotics. However, the economic nature of the food safety issue in developing countries, including Asia and the Pacific, is somewhat different from developed countries. Their concern is about food safety regulations enforced by developed countries that act as important non-tariff barriers: these standards increase compliance costs of suppliers and thus reduce their export competitiveness (Gunawardena, Jayasuriya).

Despite the concern of the term "Food safety" in both national and global discussion, little attention has been paid to examining its empirical relationship with international competitiveness. A number of studies now exist on different dimensions of food safety and international trade. Among them is the work of Jayasuriya et al. which discusses food safety issues and challenges facing Indian food industries in exporting food products to developed countries. In their study, Jayasuriya et al. used a constructed index of food safety standards from a survey of food industries in India, and found that Indian food exporters received significant losses from the stringent food safety regulations set by developed countries and the variations in such standards across the countries. In two other studies, Swann, and Moenius used indices constructed from different heterogeneous food safety standards, and they used these standards as a proxy for severity of standards. Using such an aggregated index for technical standards to determine impacts on trade flows is subject to serious limitation, and is particularly complex to find the clear-cut answer whether the standards promote or limit trade flows (Lacovone). However, Lacovone used a country's aflatoxin standard as a direct measure of its safety standard on food exports, and found that the aflatoxin standard adversely impacts trade flows. Using the same standards of maximum tolerable level of aflatoxin, Otsuki et al. and Wilson and Otsuki also concluded that food safety standards reduce competitiveness for exporters to the countries.

This study aims at reviewing challenges Asia-Pacific food exporters are facing in exporting to developed countries, contributing a better understanding of food safety regulations, and examining the impact of food safety standards on exports from Asia-Pacific countries.

Research Objectives:

The purpose of this study is twofold: first is to address the challenges facing firms in Asia-Pacific countries in exporting food products to developed countries, and second is to examine the hypothesis that food safety standards in importing countries inversely impact export flows from the exporting countries. The specific objectives include:

(a) To identify producers' constraints associated with production for exports of food and processed food products in six countries in Asia and the Pacific;

(b) To identify factors affecting export flows with respect to food safety standards;

(c) To measure the effects of food safety standards on exports from the selected countries.

Producers' Constraints to Export Processed food[25]:

Exports in food and processed food products increased dramatically in Asia and the Pacific. But countries of this region are facing problems with more stringent food safety regulations imposed by developed countries. These regulations along with conformity assessment (a standard or technique such as testing, inspection and certification issued by a recognized standards body, and used to determine if a product

[25] The first part of the study was done while the author was working as an intern with the Environment and Sustainable Development Division (ESDD), United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) in Bangkok, Thailand. The author benefited from helpful suggestions and comments from Lorenzo Santucci, Associate Environmental Affairs Officer (ESDD).

meets a defined specification) and lack of access to information limit the availability of exporters in this region to meet food safety requirements in various countries (Alimi). As an introduction, this study compiles information about food and processed food exports in this region and singles out the constraints to export food products to world markets. Six countries (China, Fiji, Indonesia, Nepal, Sri Lanka and Vietnam) are selected as sample countries from Asia and the Pacific. A brief overview of each country's production and exports are presented as part of case studies[26]. The case studies report constraints producers and exporters face in exporting food and food products to developed countries. Exporters of the six countries have to meet the stiffer food safety standards by importing countries such as Japan, EU and the U.S, which are costly and often difficult to attain. Governments along with non-government organizations are trying to improve the situation in some of these countries by monitoring farm activities, providing financial support, and arranging training for the farmers and producers. However, these exporters still face problems in ensuring quality food products for international markets. According to the report, lack of expert manpower and adequate technologies to process food and food products, insufficient coordination among government and other organizations involved in producing and processing food and food products, and corruption might be major causes for this failure.

The food and food product export of the six Asia-Pacific countries, and constraints producers face in exporting the products to developed countries are described below:

Indonesia:

There are three major food commodities (palm oil, shrimp/ fish and cocoa/ coffee) that contribute to the national economy and international trade in Indonesia. Japan and the United States are the major export markets for Indonesian food and food products. As shown in the Figure IV.1, the value of Indonesian food and food exports to the United States increased gradually until 2003, but jumped from then. Overall they grew almost four-fold in the 1989-2005 period. But the export value to Japanese markets shows a

[26] These case studies were conducted by six different consultants (Alimi, Gunawardena, Prasad, Karki, Lu, and Truong) in the respective countries employed by the UNESCAP, and are available online at http://www.unescap.org/esd/environment/cap/meeting/regional/index.asp. Last accessed, October 29, 2006.

dramatic change: the food and food product exports increased gradually from 1989 to 1995 (the value was US$ 1269 million in 1995), and then there was a decline in activity which reached only US$ 717 million in 2005. In Australia, Canada and United Kingdom, the export trend was quite stable from 1989 to 2005, except when the United Kingdom experienced a slight upsurge during the 1994-96 period and in 2005.

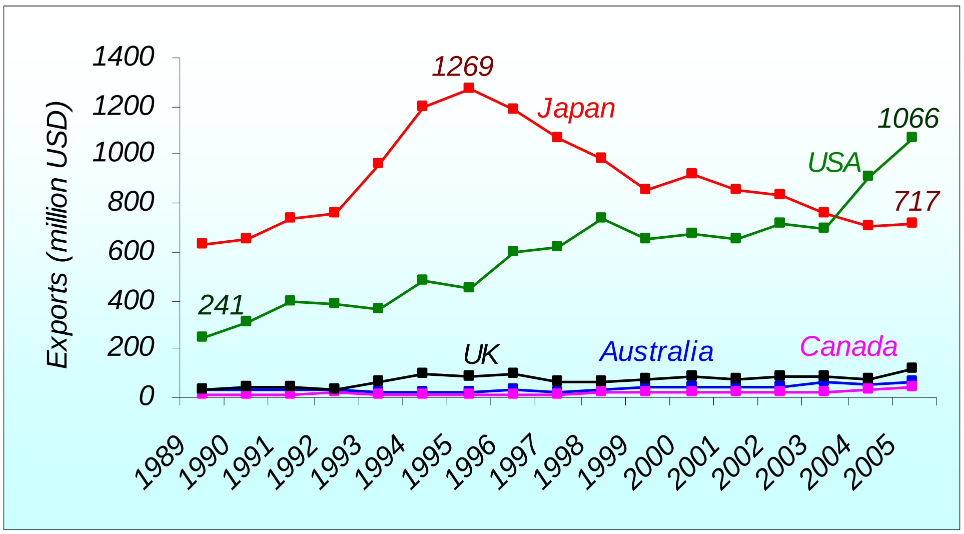

Figure IV.1: Exports of Indonesia[27]

With respect to food and food products, Indonesian shrimp exports play an important role in the national economy but producers face tremendous problems (Alimi). Unsustainable practices resulting from excessive use of antibiotics and other drugs, the inability to exclude *bycatches*, and the inability to prevent bacterial contamination in stored shrimp and other sea and coastal farming products hurt the producers' competitiveness in world markets. Three major shrimp importing countries (U.S., Japan and Europe) refused to allow Indonesian shrimp and other sea food products to enter their markets in 2001. The U.S. says that Indonesian companies do not comply with requirements of the Turtle Excluder Device (TED) so their fishing techniques kill turtles.

The U.S. requires that Indonesian suppliers go through assessment and verification according to Hazards Analysis Critical Control Point (HACCP). They also

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[27] Source: Author's calculation based on United Nations Statistics division available online at http://unstats.un.org/unsd/comtrade/. Last accessed, December 04, 2006.

require an assessment of residue levels of heavy metals, bacteria and antibiotics in seafood. Because of such stiff standards, the value of Indonesia's shrimp exports have declined from US$ 1 billion in 2000 to US$ 940 million in 2001 and US$ 840 million in 2002 (Alimi).

European countries refused entry of Indonesian shrimp and other seafood products based on health and sanitary reasons. They are concerned with *chloramphenicol* antibiotics used in shrimp farming and decay of food products and bacteria from improper handling. These countries require these products to be inspected for residual bacteria. Such strict requirements reduced shrimp and other seafood exports from Indonesia in 2002. Japanese importers refused entry of Indonesian shrimp and sea food products because of health and sanitary reason. Japanese markets are particularly concerned with high content of histamine, mercury and other toxic substances used in shrimp farming. These requirements have significant impacts on the Indonesian exports of seafood and coastal farming products.

Sri Lanka:

The trend in food and food manufacturing exports from Sri Lanka differs among developed countries. As shown in Figure IV.2, there is an upsurge trends in Sri Lankan food and food product exports to all five countries (Japan, United Kingdom, United States, India and Canada) in the 1990-2004 period. The figure shows that Japan was the biggest buyer of Sri Lankan food and food products during the 1990-2004 period, while the United Kingdom was second in most years and the United States was usually third during this period. The figure also shows that the exports to Japan and India during the 1994-2004 are variable from year-to-year. India showed the most growth and was second in 2005. For the United States, a gradual increase occurred in food and food product exports starting from US$ 15 billion in 1990 and almost doubled (US$ 35 million) in 2005. For the United Kingdom, exports increased gradually during the 1991-1994 period, and then declined in 1995 and the downward trend continued in the following years until 2004, when they reached the same value as in 1994 (US$ 35 million). The value of Sri Lankan exports to Australia increased gradually until 2003, but decreased slightly then.

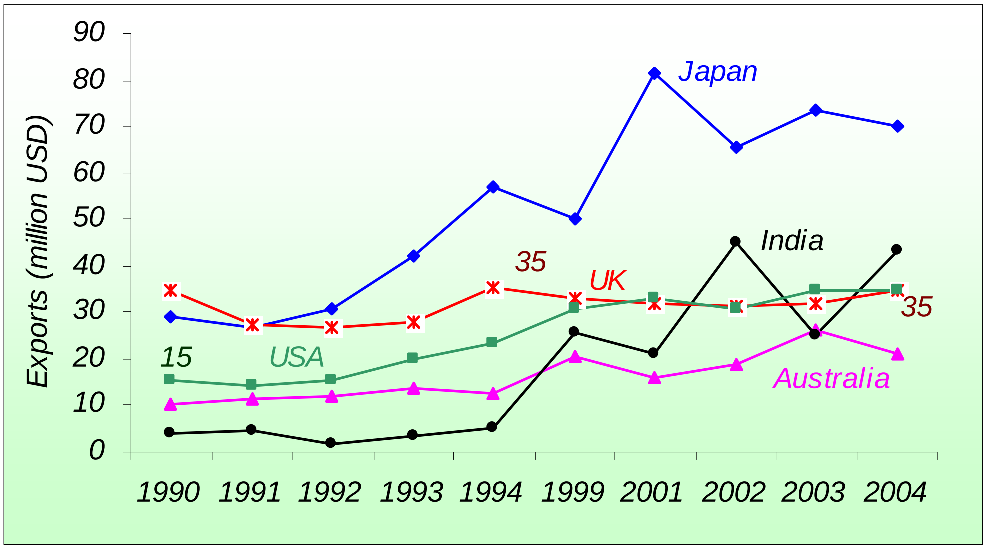

Figure IV.2: Exports of Sri Lanka[28]

There are three important food processing industries (tea, desiccated coconut and prawns) in Sri Lanka. To export tea to the EU, HACCP (Hazards Analysis Critical Control Point) certification is a mandatory requirement for Sri Lankan exporters. The HACCP certification is an internationally recognized standard for world food trade under the WTO. This standard requires significant investment so a few, mostly large, exporters have the capacity to implement this HACCP certification system. Small and medium sized enterprises are facing problems in complying with the HACCP requirements because of a lack of technical capacity and funds.

The export quality of desiccated coconut from each processing mill is monitored locally by the Coconut Development Authority (CDA). In addition, HACCP is demanded by the EU, so every exporter needs to comply with it. However, most of the desiccated coconut millers are not interested in complying with the added regulations because of high compliance costs.

Prawn exporters need to follow both national (Fish Product (Export) Regulations of 1998 and Aquaculture (Monitoring of Residues) Regulations of 2000) and international regulations (HACCP) that require high investment costs and technical facilities to export prawns to the EU. To comply with the standards, fresh prawns must be

[28] Source: Author's calculation based on United Nations Statistics division available online at http://unstats.un.org/unsd/comtrade/. Last accessed, December 04, 2006.

tested very carefully, but the problem is that exporters cannot monitor fishing activities during the production period. This results in high rejection rates due to high antibiotic counts.

Fiji:

The three most important food and food processing industries in Fiji are sugar, fish, and fruits, vegetables and root crops. According to the report, the major problem in exporting quality sugar in Fiji is the inability of the Fiji Sugar Corporation (FSC) to improve its mills' efficiency and provide proper coordination among the government and other agencies involved in sugar production (Prasad). For example, the FSC invested about $300 million dollars in mill upgrading in the last decades, averaging about $20 million dollars a year, but the upgraded mills' capacity is still lower than that of older mills. Bad governance, corruption and mismanagement in the FSC may be the cause of their failure, but these allegations are not yet properly investigated. The role of government is questionable: the government owns 67% of the FSC shares but there is no good evidence of any marked improvement in the milling capacity or export quality of sugar production.

As shown in Figure IV.3, Fiji exports a major portion of its food and food products to the United States. However, yearly exports of food and food products to the United States are unstable: the export of food and food products grew up to 1991, and then fell suddenly for two years. They have then maintained a wave-like pattern. The figure also shows that the value of food and food product exports to United Kingdom started increasing from 1993, and grew slowly until 2004. For the Canada, exports increased gradually during the 1991-1994 period, and then declined in 1994 and maintained almost the same level until 2004. Fiji's exports of food and food products to Japan were quite unstable, fluctuating from US$ 7 million in 2000 to US$ 13 million in 2003.

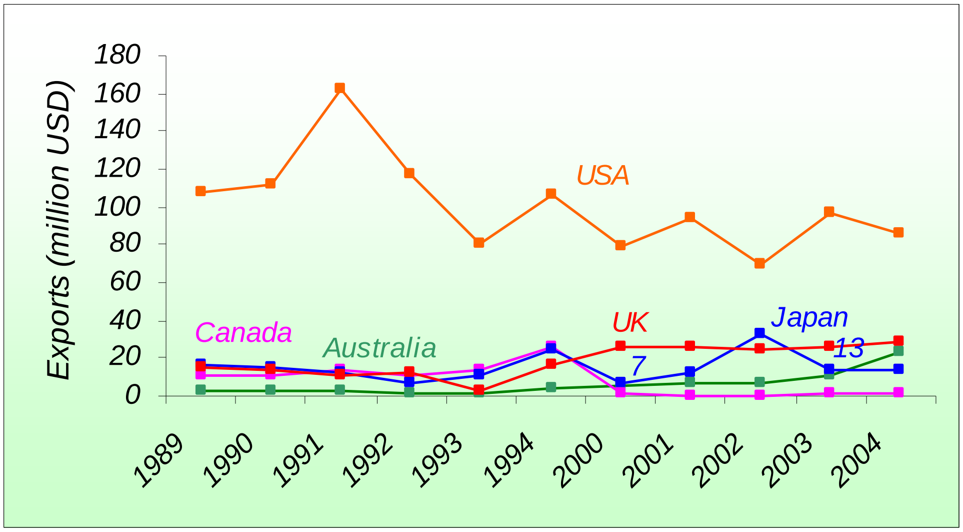

Figure IV.3: Exports of Fiji[29]

Exporters of fish and fruits, vegetables and root crops face problems in understanding important details about the importer's food safety standards. Fish and fish products are not properly assessed in Fiji due to lack of laboratory facilities and skilled technicians. Buyers' food safety standards are heterogeneous: exporters face different food safety requirements from different buyers for the same products. Among the buyers, Fiji exporters face stiffer regulations from the U.S. They also face problems in meeting increasingly stringent food safety regulations set by developed countries like Japan, Canada and United Kingdom. These technical barriers limit Fiji's export competitiveness in food and food manufacturing (Prasad).

Nepal:

The United States and United Kingdom are the two major importing countries for Nepalese food and food products. As shown in Figure IV.4, the United States is the largest buyer of Nepalese food and food products, representing 56% of the total food and food product exports during 1994-2003. United Kingdom purchased the second highest quantity of food and food products from Nepal (25%). Besides that, Japan captured 15%

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[29] Source: Author's calculation based on United Nations Statistics division available online at http://unstats.un.org/unsd/comtrade/. Last accessed, December 04, 2006.

and Australia purchased 4% of the total food and food products from Nepal during the 1994-2003 period.

The most important food commodities for Nepalese exports are tea, honey, and vegetable ghee. Nepal produces annually 10.6 million kg of cut, tear and curl (CTC) and 1.2 million kg of orthodox tea (Karki). In order to export tea to the US market, the exporter has to obtain product acceptance from the Food and Drug Administration (FDA) after meeting quality specifications. So exporters are required to implement good practices in production, processing and handling to improve the tea quality. Exporters face buyer complaints regarding banned pesticides such as *phorate* and *metacid*, which are still being used in Nepal. According to Karki's report, a shipment of Nepalese orthodox tea was rejected in Germany on the grounds that it contained *tetradifone*. The absence of a Codex standard for tea and other plantation products is another limiting factor in the export trade in Nepal.

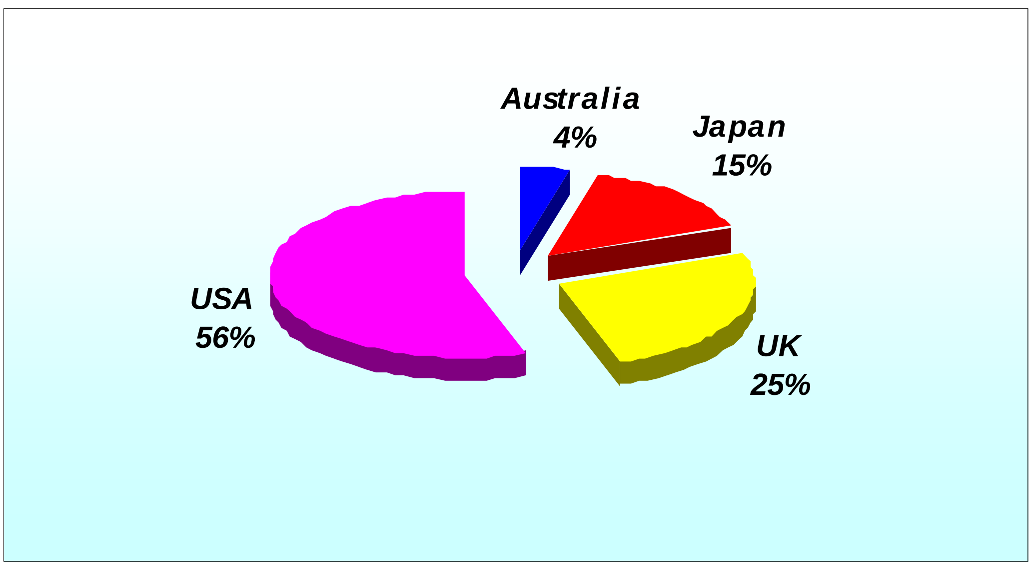

Figure IV.4: Exports of Nepal, 1994-2003[30]

Nepal has a hard time in meeting food safety standards set by developed countries, and it is an example of how a small developing country is faced with a serious constraint in the export market after the mandatory regulation enforcement. For example,

[30] Source: Author's calculation based on United Nations Statistics division available online at http://unstats.un.org/unsd/comtrade/. Last accessed, December 04, 2006.

Nepal exported 20% of its honey (864 m tons) to Norway in 2003. After joining to the EEA, Norway followed EU regulations making the residue control program for animal products mandatory. Since Nepal has not established a residue control program, Norway has banned the import of Nepalese honey. Nepal also exports vegetable ghee to India under the Indo-Nepal Treaty of Trade. The only constraint in this export item is that India charges a 30% tariff.

China:

As shown in Figure IV.5, Japan held the highest position in importing Chinese food and food products, and this country purchased almost three-fourth of the Chinese exported food and food products during the period, 1992-2005. Chinese food and food exports to Japan increased gradually from 1992 to 2005: it rose in value from US$ 2236 million in 1992 to US$ 4844 million in 2001 and grew almost three-fold (US$ 7179 million) during 1992-2005. The United States is the second largest importing countries of Chinese food and food products. Exports of Chinese food and food products to the United States grew gradually from 1992 to 2001, and the value reached US$ 959 million in 2001. Then it more than doubled (US$ 2452 million) in 2005.

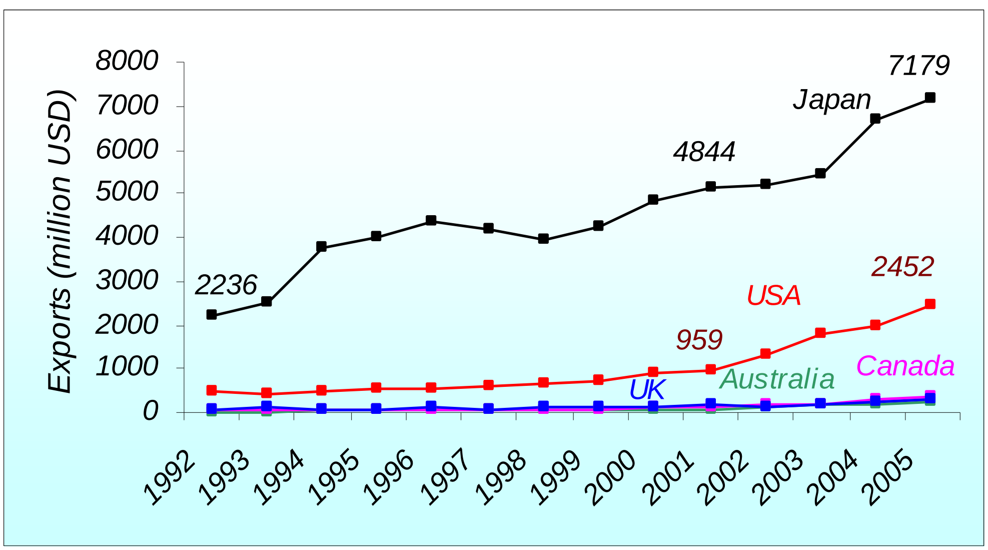

Figure IV.5: Exports of China[31]

[31] Source: Author's calculation based on United Nations Statistics division available online at http://unstats.un.org/unsd/comtrade/. Last accessed, December 04, 2006.

The figure also shows that Chinese food and food product exports to Australia, Canada and United Kingdom are almost static during the 1992-2005 period.

Since technologies in most Chinese small and medium enterprises (SMEs) are less advanced and dominated by traditional approaches, SMEs are facing problems with meeting food safety standards. High chemical residue level is an important constraint for Chinese products. The technological trade barriers and sanitary and phytosanitary standards are the main constraints for Chinese food exporters. For example, since August 1996, the EU has terminated importation of Chinese poultry meat and some aquatic and animal products because Chinese exports cannot meet phytosanitary requirements (Lu). For fish products, the EU requires all products to be properly labeled. They are concerned with residue levels of bacteria and antibiotics in vegetable, fruits and other horticulture products. They also require all food products from China to go through proper inspection of residual bacteria.

The Japanese standard also refers to the levels of pesticide residues in Chinese vegetables and fruits. Chinese processed meat and aquatic products are often constrained by Japanese authorities due to stringent food safety requirements. The United States implemented some strict market access barriers based on sanitary and phytosanitary standards, which restricts Chinese frozen shrimp and honey to export to the United States because of excessive residues of antibodies and *chloramphenicol* resulting from inappropriate processing.

Vietnam:

Both in Japan and the United States, export flows of Vietnam’s food and food products had a sudden fall in 1998, but then the exports of these commodities increased dramatically from 1998 to 2003 (Table IV.6). East Asian financial crisis of 1997-98 might be the cause of this sudden fall of exports. The figure shows that there was an upsurge in exporting food and food products to Japan during the 1998-2003 period. They rose in value from US$ 63 million in 1998, to US$ 439 million in 1999, and US$ 722 million in 2003. In United States, the import value for food and food products from Vietnam increased sharply from 1998, and reached US$ 1026 million in 2003, almost 11 times the US$ 74 million value in 1998. The figure also shows the export totals to the developed countries such as Australia, Canada and United Kingdom, which are volatile.

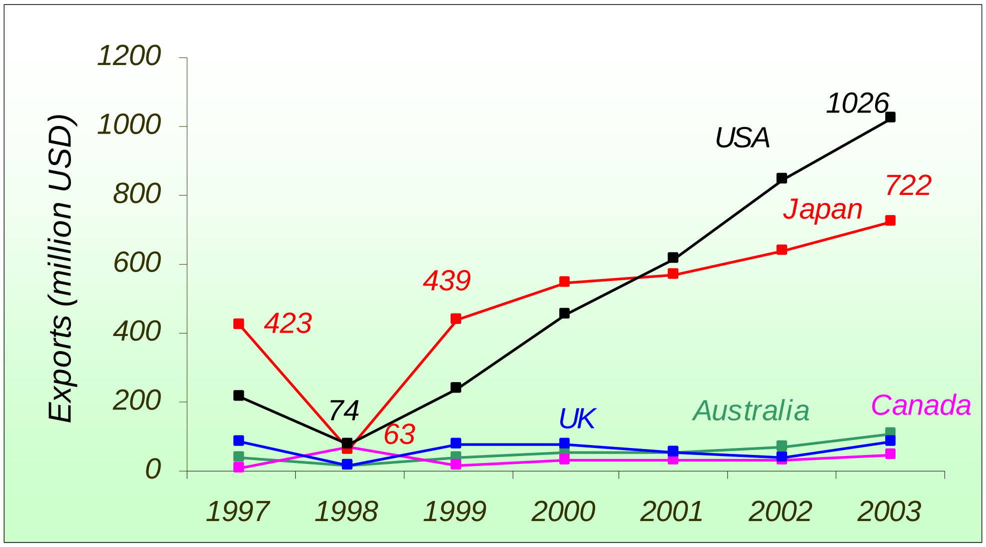

Figure IV.6: Exports of Vietnam[32]

Vietnam exports 3.3 millions of tons of processed seafood products (frozen shrimp, fish, squid and dried fish) to 105 countries, but mainly to Japan, European Union, the United States and China (Truong). The major challenge for Vietnamese exported seafood is to meet the requirements on the content of antibiotic and chemical residuals in the products set by the European Union and United States. The EU is strict in its regulations on residue limits in food and seafood products. The US and Japan also have severe requirements on the content of antibiotic or chemical residuals in seafood. So food product exporters in Vietnam have a hard time in meeting food safety regulations set by importing countries.

Vietnamese seafood export enterprises are also confronting difficulties in understanding requirements of food hygiene. To export their products, exporters have been faced with sophisticated and volatile layers of standards set by international,

[32] Source: Author's calculation based on United Nations Statistics division available online at http://unstats.un.org/unsd/comtrade/. Last accessed, December 04, 2006.

national and private bodies. Small enterprises face problems with different requirements imposed by different countries on the same product. For example, the US bans *fluoquenolines* but the EU allows a limited use for this drug. This causes problems because it is currently very hard in separating aquaculture areas for different export markets.

Despite all of the constraints regarding food safety regulations, exports of food and processed food products, in some instances, showed upward trends for Asia-Pacific countries. From a theoretical point of view, imposition of strict food safety regulation causes extra costs for the firm and thus reduces exports of the product. However, improved performance caused by food safety regulations may induce cost savings and increase sales; thus improving exports. The case studies did not examine the empirical relationship between food safety regulations set by the developed countries and the region's export flows but instead gave insights into food safety standards and question on the empirical issue: "Does a developed country's imposition of food safety regulations impact export competitiveness of an Asia-Pacific country?" We examine this issue in the second chapter to see if the findings support the region's upward trends of exports with existing stringent food safety standards.

Review of Literature:

The literature on several dimensions of food safety and international trade is reviewed in this chapter. There are a considerable number of studies regarding this issue that range from theoretical and policy analyses to empirical analyses. However, empirical analyses of the impact of standards and technical regulations on trade, in particular food safety standards, on export flows in the food and food manufacturing in Asia-Pacific countries are relatively sparse. There are different methodologies used in order to empirically estimate the impact of food safety standards. Concisely, the literature includes two types of studies. One group of studies performs case study or surveys for policy analysis on food safety standards and the challenges exporting firms face due to increasingly more stringent food safety standards. Another group of studies employs econometric models in order to determine how domestic policies impact bilateral trade flows. The econometric approach which is most often used in the literature is the gravity model. Some investigators construct policy indices (food safety standards) by survey and use these indices as proxy for the severity of standards in the gravity model. Other investigators use direct measures of food safety standards. This chapter reviews all of these empirical analyses closely related to this study.

The gravity model:

The gravity model was developed by Tinbergen (1962) and Linneman (1966). The model has the following structure in its simplest form:

$$Trade_{ij} = \kappa \frac{GDP_i GDP_j}{Distance_{ij}}$$

where, κ is a constant of proportionality. According to this model, bilateral trade between country *i* and country *j* is explained by their income (in term of *GDP*) and geographical distance. The gravity model can also include some other factors such as the country's population and a set of dummy variables incorporating trade barriers such as adjacency, and a common identity for currency and regional or global trade membership. Including all these factors that explain the bilateral trade, Harris et al. and Xu propose an extended framework of the gravity model in their studies. They also add an environmental regulation variable in their model and examined its impact on export competitiveness.

The gravity model is also used to study several dimensions of food safety and international trade. Thus, the gravity model explains the impacts of various economic activities both on exporting and importing country's trade flows, and has been a successful model in economics since its emergence. But this model has not been free from criticism. A number of authors claimed that its basic framework lacks theoretical foundation. However, this model has eradicated its shortcoming gradually and has become a well constructed model in international trade. Anderson first developed an econometric foundation of this gravity model. Furthermore, Anderson and Wincoop improved this model incorporating multilateral resistance variables, which helped solve the omitted variable bias in the model.

The gravity model developed by Anderson and Wincoop is specialized as[33]:

$$\ln X_{ij} = k + \ln y_i + \ln y_j + (1-\sigma)\rho \ln d_{ij} + (1-\sigma)\ln b_{ij} - (1-\sigma)\ln P_i - (1-\sigma)\ln P_j$$

where, *ln* is the logarithm; *i* and *j* represent the exporting country and importing country, respectfully; *X* is the exports from country *i* to country *j*; *y* represent income of a country; d is the distance between the importing and exporting country; *b* represents border between the importing and exporting country; and *P* is the price index of a country. This extended form of the gravity model has only two additional terms compared to the basic gravity model such as price indices and border measures. These two terms of the equation represent the multilateral resistance variables, which are positively related to a country's inward trade flows. Anderson and Wincoop claimed that this model can capture all trade barriers and provide consistent and efficient estimates. Incorporation of price indices in the gravity model is also supported by Bergstrand who also introduced factor endowment variables in his extended gravity model.

Standards and technical regulations in the gravity model:

The gravity model is commonly used to determine whether a domestic policy positively or negatively influences the competitiveness of international trade. A number of authors set up domestic standards and technical regulations as proxies for their impact (environmental stringency) or severity (food safety standards) in the gravity model. Among the noteworthy works are Harris et al. and Xu for environmental policy impacts, and Jayasuriya et al., Wilson and Otsuki, Otsuki et al., and Lacovone for food safety regulations.

Using a gravity model, Harris et al. investigated the relationship between environmental regulations and international competitiveness. In their study Harris et al. examined the effect of environmental stringency by six different indicators, which are based on energy consumption or energy supply. However, they did not find any significant impact of environmental regulations on international competitiveness. In their model, they used bilateral imports (*IPM*) as a dependent variable, and income in terms of *GDP*; countries' population (*POP*), the distance between the exporting and importing

[33] The model shows the same notation as in Anderson and Wincoop.

country (*DIST*), land areas of a country (*LAND*), stringency of environmental regulations in a country (*SC*) as explanatory variables. They also include a set of dummy variables that explain the bilateral import: *ADJ* is a dummy variable, equal to 1 if importing and exporting countries are adjacent, and zero otherwise; *EEC*, a dummy variable that equals to 1 if importing and exporting countries are members of *EEC*, and zero otherwise; *EFTA*, a dummy variable that equals to 1 if importing and exporting countries are members of *EFTA*, and zero otherwise; *NAFTA*, a dummy variable that equals to 1 if importing and exporting countries are members of *NAFTA*, and zero otherwise.

They used the following form of the gravity equation[34]:

$$\begin{aligned}\ln IMP_{ijt} = {} & \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} \\ & + \beta_5 \ln DIST_{ij} + \beta_6 ADJ_{ij} + \beta_7 \ln EEC_{ijt} + \beta_8 \ln EFTA_{ijt} \\ & + \beta_9 \ln NAFTA_{ijt} + \beta_{10} \ln LAND_i + \beta_{11} \ln LAND_j \\ & + \beta_{12} \ln SC_{it} + \beta_{13} \ln SC_{it} + u_{ijt}\end{aligned}$$

where, *ln* represents natural logarithm; *i* denotes the importing of country and *j* is exporting country and *t* is time in year.

Xu developed the following extended gravity model to investigate the impact of environmental regulations on international trade[35]:

$$\begin{aligned}\ln(X_{ij}) = {} & \alpha_0 + \beta_1 \ln(Y_i) + \beta_2 \ln(N_i) + \beta_3 \ln(Y_j) + \beta_4 \ln(N_j) + \beta_5 \ln(D_{ij}) \\ & + \beta_6 \ln(ENV_i) + \beta_7 \ln(ENV_j) + \varepsilon_{ij}\end{aligned}$$

where, X_{it} is the exports from country *i* to country *j* (*i* represent exporting and *j* represents importing country); *Y* is the country's GDP; *N* is the country's population; *D* is the geographic distance between importing and exporting country; *ENV* is environmental stringency indices; and α and ε represent the intercept term and error term, respectively. In this study, Xu used the environmental stringency indices developed by World Bank. However, he did not find any significant evidence to support the proposition that increasingly environmental regulation decreased a country's exports.

[34] The model shows the same notation as in Harris et al.
[35] The model shows the same notation as in Xu.

Jayasuriya et al. investigated the impact of increasingly stringent and differing standards set by developed countries in the Indian food processing industries. In their research, they constructed an index of food safety standards through a survey of processed food industries, and examined the impact of the standards on food exports to developed countries. They used the gravity model and the index of food safety standards was used as proxy of its severity. The extended form of the gravity model used in their study is as follows[36]:

$$\ln EXP_{ij,t} = \alpha + \beta_1 GDP_{it} + \beta_2 GDP_{jt} + \beta_3 IMP_{ijt} + \beta_4 DIS_{ij} + \beta_5 POPI_{it} + \beta_6 POP_{jt} + \beta_7 SPS_{ijt} + \varepsilon_{ijt}$$

where, *EXP* represents bilateral exports of processed food products; *GDP* is the income of a country; *IMP* is bilateral imports of the processed food products; *DIS* is the distance between importing and exporting country; *POPI* and *POP* represent population of exporting and importing country, respectively; *SPS* is the index of food safety standards set by country importing country; α is the constant and ε denotes the error term; and *ln* denotes natural logarithm; *i* and *j* represent exporting and importing country, respectively; and *t* is time in year.

Jayasuriya et al. constructed the *SPS* variable as an index by the following equation:

$$SPS_{ij,t} = \left(\frac{\sum W(SPSNN_{ij,t} / Codex_{t2000})}{\sum W} \right) * 100$$

where, *i* represents exporting country's (India's) processed food products such as shrimp, mango pulp, poultry and mushrooms; *j* represents the exporting countries (United States, Japan, Australia, United Kingdom, France, Germany and the Netherlands); and *t* represents the years 2000 to 2003. *SPSNN* represents the weighted value of different groups of standards (microbial hazards, pesticides, antibiotics, toxic chemicals etc), and *Codex* is the value of the corresponding parameters contained in *SPSNN*. The ratio of the value of the two parameters indicates the restrictiveness faced by the food products. Jayasuriya et al. pointed out that the most of the food commodities exported to EU countries, Australia and the US were highly restrictive, while exports of those food

[36] The model shows the same notation as in Jayasuriya et al.

products to Canada and Japan were moderately restrictive. They singled out that compliance costs for food safety standards in exporting Indian processed food products were on average 5% of sales revenue, though the compliance costs ranged from 10-15% in some food processing industries. Based on the empirical results Jayasuriya et al. concluded that the stringent food safety standards limit Indian processed food exports to these seven importing countries.

Using such an aggregated index for technical standards to determine impacts on trade flows is subject to serious limitation. The aggregated index constructed from different standards provides results inconsistent with conceptual expectation. For example, Swann (1996) and Moenius (1999) worked with two different standards such as shared standards (standards were used separately), and unilateral standards (a number of heterogeneous standards were aggregated, and used as indices). Swann's findings suggested that share standards positively impact exports, but had a little impact on imports; unilateral standards positively influence imports but negatively influence exports. However, Moenius found that the shared standard has a positive impact on trade, and the unilateral standard enhances manufacturing trade, but limits trade in non-manufacturing sectors (Lacovone). However, Lacovone's investigation tells us how to overcome those shortcomings. He used maximum tolerated levels of aflatoxin B1, a commonly used determinant in food and food products, as a direct measure of the severity of the aflatoxin standard. Two other studies (Otsuki et al. and Wilson and Otsuki) are supportive of using this direct measurement method.

Wilson and Otsuki initiated an innovative study on food safety standards. They used a gravity model that explains bilateral import flows using a food safety standard variable that is measured in maximum allowable contamination. They extended the gravity model by adding a number of dummy variables to the model[37]:

$$\ln V_{ij} = b_0 + b_1 \ln GNPPC_i + b_2 \ln GNPPC_j + b_{ij} \ln DIST_{ij} + b_4 \ln ST_i$$
$$+ b_5 Dcol + b_6 D_{EU} + b_7 D_{ASEAN} + b_8 D_{NAFTA} + b_9 D_{MERCOSUR} + \varepsilon_{ij}$$

where, *ln* represents the natural logarithm; *i* is importing country, and *j* is exporting country; *V* denotes the import value of country *i* from country *j*; G*NPPC* denotes a

[37] The model shows the same notation as in Wilson and Otsuki.

country's real per-capita GNP; *DIST* is the geographical distance between importing and exporting country; *ST* represents the maximum tolerable level of aflatoxin B1 imposed on imports by the importing country; and *b* is the constant term and ε is the normally distributed error term. They also included a number of dummy variables of a common identity for regional or global trade membership that explains the bilateral imports. In their investigation, they concluded that the import flows of cereals and nuts are negatively affected by the aflatoxin standard.

To investigate the impact of EU food safety standards on African export of cereals, dried fruits and nuts to Europe, Otsuki et al. utilized the following gravity equation[38]:

$$\ln M_{ij}^{k} = b_0 + b_0^k + b_1^k \ln(PCGNP_i) + b_2^k \ln(PCGNP_j) + b_3^k \ln(DIST_{ij}) + b_4^k YEAR + b_5 COL_{ij} + b_6 \ln(ST_i^k) + \varepsilon_{ij}^k$$

where *M* represents trade value of product *k* from African country (*j*) to EU country member (*i*); *PCGNP* is real per capita GNP; *DIST* is geographical distance between country *i* and *j*, and *YEAR* is year: 1989-1998; *COL* is a colonial tie dummy; *ST* is the maximum aflatoxin level imposed on imports of African food product (*k*) by EU counties; ε is the error term; *ln* denotes the natural logarithm. In this model Otsuki et al. used aflatoxin B1 as a direct measure instead of a constructed index of food safety standards. They concluded that tightening the aflatoxin level by EU countries reduces the African food product exports by 64 percent or US$ 670 million to EU countries. They also found that the health risk in EU countries was reduced by approximately 1.4 deaths per billion a year due to these stiffer food safety standards.

To address food safety regulations in terms of aflatoxin standards, Lacovone developed the following extended gravity model[39]:

$$\ln M_{ij} = A + \ln Y_i + \ln Y_j + \ln(Y/P)_i + \ln(Y/P)_j + \ln D_{ij} + \ln ST_i + DLang_{ij} + Trend + \varepsilon_{ij}$$

where, *ln* is the natural logarithm; *i* represents European countries and *j* represents Latin American country; *M* represents imports of nuts of the European country from the Latin

[38] The model shows the same notation as in Otsuki et al.
[39] The model shows the same notation as in Lacovone.

American country; Y is the real GDP and P is the population; D is the geographical distance between the importing and exporting countries; and ST denotes the standard (the maximum allowable level of aflatoxin B1); A is the constant and ε is the error term. Lacovone also included a dummy for common language (*DLang*), and a trend that captures eventual dynamic effects. In his extended gravity framework, Lacovone used a Tobit model to estimate the equation explaining Latin American nuts export to Europe and found that tightening of the aflatoxin standards in the European countries results in a potentially significant loss in Latin-American nut exports.

Model Specification:

To construct an empirical model for the relationship between bilateral trade flows and a country's various economic activities including food safety regulations, many different approaches have been taken in the literature. Among them two are noteworthy. First, Joyasuriya et al. proposed an econometric model based on a gravity model to examine the proposition that stiffer food safety standards lead to a loss of export flows in India. In their study, Joyasuria et al. used a food safety standard index constructed on the basis of sample survey among exporting industries in India. Second, Lacovone used the direct measure of aflatoxin standards with the gravity model, and found that food safety standards imposed by European countries adversely impact trade flows from Latin American countries. Besides that, a number of studies examine the impact of food safety regulations on trade competitiveness. Only a few used a direct measure of the severity of food safety standards in their econometric analyses, though. This study follows the gravity model approach with its extended form gradually developed by Harris et al., Xu, and Anderson and Wincoop to determine the effect of aflatoxin standards (as a measure of food safety standards) on trade flows.

The gravity model used in this study is derived from the demand and supply functions of importing and exporting countries at the general market equilibrium conditions as reflected in Anderson and Wincoop. Let us suppose consumers' CES (Constant Elasticity of Substitution) utility function of an importing country is:

$$U(X_i) = \left(\sum_i X_{ij}^{\rho} \right)^{\frac{1}{\rho}} \qquad \text{(IV.1)}$$

and their expenditures are constrained by income:

$$P_{ij} X_{ij} = I_{ij} \tag{IV.2}$$

We assume each country produces only one good and the supply of the good is fixed. We also assume homothetic preferences[40] in the utility function. The consumers' demand equation of the importing country for goods of an exporting country is derived by maximizing the consumers' utility function (Equation (IV.1)) subject to the constraint (Equation (IV.2)):

$$X_{ij} = \frac{P_{ij}^{\frac{-1}{1-\rho}}}{\sum_j P_j^{\frac{-\rho}{1-\rho}}} I_j = \frac{\left(P_i C_{ij}\right)^{\frac{-1}{1-\rho}}}{P_j} I_j \tag{IV.3}$$

where $P_{ij} = P_i C_{ij}$, and $P_j = \sum_j P_j^{\frac{-\rho}{1-\rho}}$ (IV.4)

X_{ij} - exports from country *i* to *j* $\equiv P_{ij} C_{ij}$

$P_{ij} = P_i C_{ij}$ where P_i - supply price of the exporting country

P_j - consumer's price indices of the importing country

C_{ij} - trade (transportation) costs between exporting and importing country

ρ - elasticity of substitution between all goods

At the market clearing condition, the aggregate import demand equals the aggregate supply:

$\sum_j X_{ij} = I_i$, which implies that $I_i = \frac{\left(P_i C_{ij}\right)^{\frac{-1}{1-\rho}}}{P_j} I_j$ (IV.5)

where, $I_i I_j$ - total income of country *i* and *j*, respectively

[40] Where *"the isoquants are equally spaced as output expands; thus, they exhibit the constant proportional relationship between increases in all inputs and increases in outputs"* (Nicholson, p 300).

Substituting Equation (IV.5) in to (IV.3), we get:

$$X_{ij} = \frac{I_i I_j}{\sum_j I_j} \left(\frac{C_{ij}}{\Pi_i P_j} \right)^{\rho} \tag{IV.6}$$

In Equation (IV.5), two factors need to be considered. One is the profit function of the exporting country that can be expressed as:

$$\Pi_i \equiv \left[\sum_j \left(\frac{C_{ij}}{P_j} \right)^{\rho} \frac{I_j}{\sum_j I_j} \right]^{\frac{1}{\rho}} \tag{IV.7}$$

From Equation (IV.4) and (IV.7), we get the following relationship for the country's price indices under the symmetric bilateral trade barrier condition, $\Pi_i = P_i$:

$$P_j^{\frac{1}{\rho}} = \sum_j P_i^{\frac{-1}{\rho}} \frac{I_j}{\sum_j I_j} C_{ij}^{\frac{1}{\rho}} \tag{IV.8}$$

Second is the trade (transportation) cost factor C_{ij}. This factor is unobservable, but assumed to be a log linear function of observables, bilateral distances (*D*), and adjacency or border (*B*) between importing and exporting countries:

$$C_{ij} = D_{ij} B_{ij} \tag{IV.9}$$

Now incorporating the price indices and trade cost factors, the Equation (IV.6) turns to the following final form of the gravity equation subject to Equation (IV.8):

$$X_{ij} = \frac{I_i I_j}{\sum_j I_j} \left(\frac{D_{ij} B_{ij}}{P_i P_j} \right)^{\frac{1}{\rho}} \tag{IV.10}$$

Then taking logs and appending error terms, we can write the following empirical form of the gravity model:

$$\ln X_{ij} = k + \ln I_i + \ln I_j + \tfrac{1}{\rho} \ln D_{ij} + \tfrac{1}{\rho} \ln B_{ij} - \tfrac{1}{\rho} \ln P_i - \tfrac{1}{\rho} \ln P_j + \mu_{ij} \tag{IV.11}$$

In this empirical analysis, we incorporate a food safety standard variable with the expectation that this standard downsizes a country's export competitiveness. The two price terms in the above equation (so called multilateral resistance variables) are not observable, and difficult to measure so we did not use the terms but instead incorporate two price indices (export and import price indices) as reflected in Bergstrand. Including all these factors that explain bilateral exports, the extended gravity equation for this study has the following form:

$$\ln EX_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln Dis_{ij} + \beta_4 \ln EPI_{it} + \beta_5 \ln IPI_{jt} + \beta_6 \ln FSS_j + \varepsilon_{ijt} \quad \text{(IV.12)}$$

where,

EX_{ijt} - exports from country *i* to country *j* at time *t*;

GDP_{it} - per capita *GDP* of country *i* at time *t*;

GDP_{jt} - per capita *GDP* of country *j* at time *t*;

EPI_{it} - export price index of country *i* at time *t*;

IPI_{jt} - import price index of country *j* at time *t*;

Dis_{ij} - distance between country *i* and *j*;

FSS_j - food safety standards in terms of aflatoxin with maximum allowable level imposed on imports by country *j*; and

ε_{ijt} - error term assumed to be normally distributed.

Equation (IV.12) is the classical double-log specification so variables are transformed by natural logarithm (*ln*). The explanatory variables used in this model have a direct relationship to bilateral export flows. In this model, GDP_i measures the potential demand of the importing country, while GDP_j represents the potential supply of the exporting country. Therefore, the corresponding slope parameters, β_1 and β_2, are expected to be positive. The rational for geographical distance is that a higher distance between trading partners leads to higher transportation costs and increased differences in preferences. Dis_{ij} is a proxy for resistance to trade, thus it is anticipated that β_3 will be negative. The slope parameter β_4 is probably negative because exporter's high prices reduce outward trade flows. On the other hand, it is anticipated that β_5 will be positive because importer's increased prices may cause production in home country to fall and inward trade flows to rise (Bergstrand). Finally, FSS_j measures how strict the food safety standards are in importing countries. In line with the assumption that strict standards lead to relatively lower exports. In this model, the strictness of the standards depends on the tolerable level of aflatoxin B1: a lower level of aflatoxin standard indicates a more restrictive standard. Therefore, we anticipate that β_6 will be positive, which implies stiffer standard impact exports negatively.

Data Sources and Description:

This study focuses on the factors affecting bilateral trade with special attention on the impact of food safety standards for different importing countries. The gravity model used in this study requires the following data for each country: exports of food and food products as dependent variables, country's total GDP, per capital GDP, population, geographical distance, export price index, import price index and food safety regulations in terms of aflatoxin standards as explanatory variables. The data utilized in this model are collected for seventeen years, 1988-2005, on 16 countries that include OECD and Asia-Pacific countries (Australia, Austria, Canada, China, Fiji, France, Germany, India, Indonesia, Italy, Japan, Nepal, Sri Lanka, United Kingdom, the United States and Vietnam). The sources and description of data are:

Bilateral Trade:

The data for bilateral trade, in particular, the value of total exports and imports of food and food products in US dollar under the classification of SITC Rev.3 are collected from United Nations Statistics division available online at http://unstats.un.org/unsd/comtrade/

GDP:

Each country's Gross Domestic Product (GDP) based on constant 2000 US dollar, and per capita GDP (constant 2000 US dollar) are collected from World Bank Development Indicator (WDI) available online at http://devdata.worldbank.org/dataonline/

Food safety standards:

To measure the effect of food safety standards on trade flows we use aflatoxin standards as an explanatory variable. In this case, we follow Lacovone's work adapted from Otsuki et al. and Wilson and Otsuki, but we use different data and a different econometric model to estimate the impact of the standard on bilateral exports. Most previous studies constructed indicators from the data of food chemicals and additives, and used these indicators as a proxy for the restrictions on chemicals and additives used in the food and food products. However, following Lacovone, we use the direct measures of maximum tolerable level of aflatoxin in our model. The data for maximum allowable levels of aflatoxin in parts per billion (*ppb*) are stated below (Table IV.1):

Table IV.1: Maximum tolerated levels of aflatoxin in food and food products

Country	Maximum tolerated levels of aflatoxin (*ppb*)		Country	Maximum tolerated levels of aflatoxin (*ppb*)	
Australia	5	For all foods	India	30	For all foods
Austria	1	For all foods	Italy	5	For all foods
Canada	15	For nut (product)s	Japan	10	For all foods
France	10		UK	4	For nut (product)s, dried fig (product)s
Germany	2	For all foods	USA	20	For all foods

Source: Food and Agriculture Organization of the United Nations, 1997

These data are obtained from the FAO publication, Worldwide Regulations for Mycotoxins 1995: A Compendium. Aflatoxin is present in foods as natural contaminants and causes acute toxicity in animals and humans. It is not possible to completely eliminate this substance from the food chain (Otsuki et al.) so it needs to keep this toxic substance in food as low as possible. The most potentially toxic aflatoxin is designated as aflatoxin B1. The maximum allowable level of aflatoxin B1 imposed for food and food products is considered to determine the level of food safety standard in a country: the greater value of aflatoxin B1 in foods implies a more lax standard.

Distances:

The data for geographical distances are collected on the basis of the average distance between the major sea ports of two countries. There are six exporting countries such as China, Fiji, Indonesia, Sri Lanka, Nepal, and Vietnam and ten importing countries: Australia, Austria, Canada, France, Germany, India, Italy, Japan, United Kingdom and United States. The Distances of the important seaports of the countries are shown in Figure IV.7.

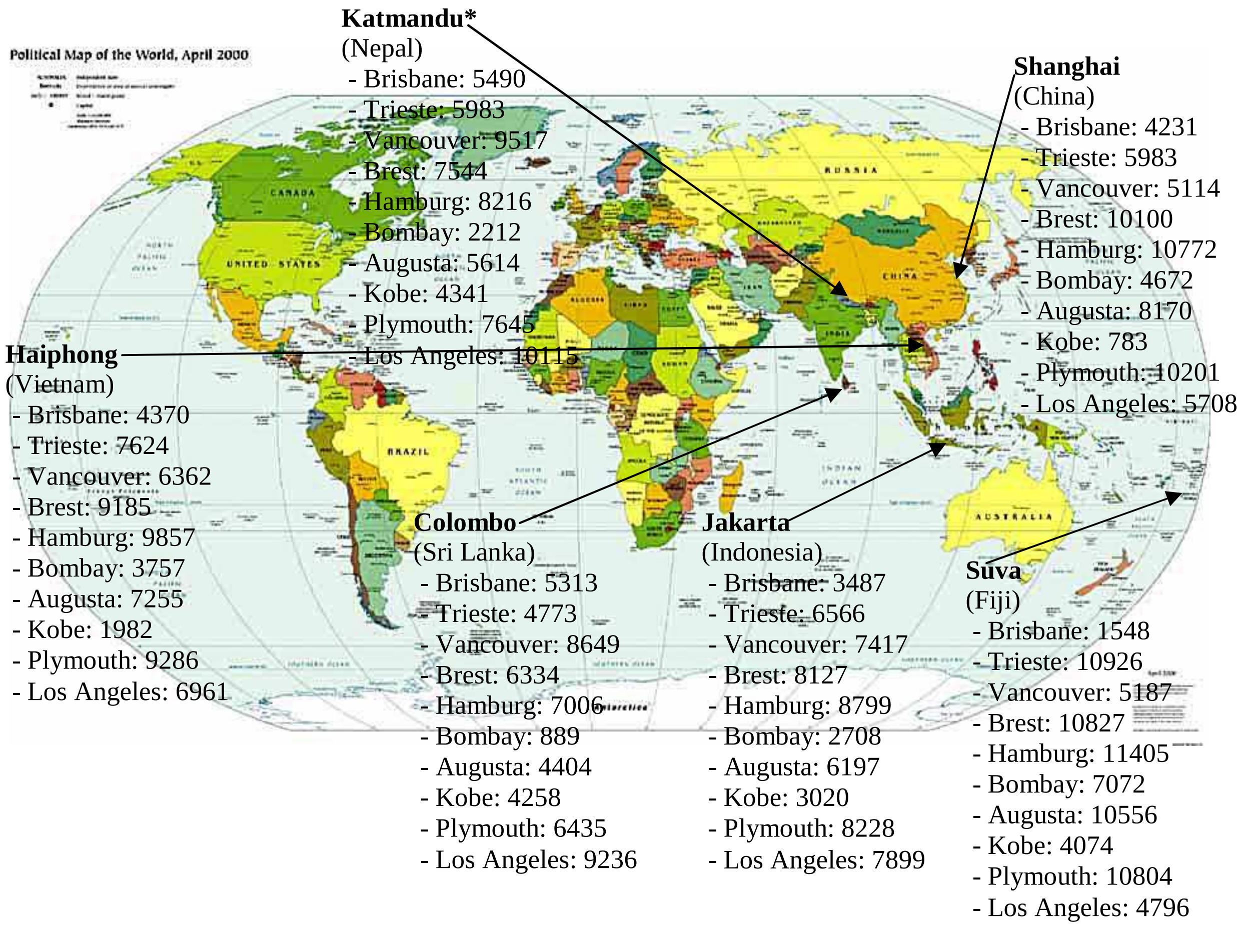

Figure IV.7: Distances between important seaports of exporting and importing countries in nautical miles. Importing countries with seaports in parenthesis: Australia (Brisbane), Austria (Trieste), Canada (Vancouver), France (Brest), Germany (Hamburg), India (Bombay), Italy (Augusta), Japan (Kobe), UK (Plymouth), USA (Los Angeles). * The distance adds road distance from Calcutta, India to Katmandu, Nepal.

Source: World map: http://www.hawaii.edu/powerkills/WF1.WORLD.JPG
Source: Distances: www.distances.com.

The data for distance are measured in nautical miles, and collected online at http://www.distances.com. Since there are no waterways in Nepal, and the only practical seaport for goods bound for Katmandu, the capital city of Nepal, is Calcutta in India, we used the distance to Calcutta (including road distance in miles from Calcutta to Katmandu) for the country, Nepal. The geographical distances between seaports of exporting and importing countries are also stated in Table D.3 (Appendix D).

Population:

Each country's population is collected from Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2004 Revision and World Urbanization Prospects: The 2003 Revision, http://esa.un.org/unpp, 15 October 2006; 1:2

Price indices:

The export price index of the exporting countries and the import price index of the importing countries are collected from World Bank Development Indicator (WDI) available online at http://devdata.worldbank.org/dataonline/

Empirical Results:

To determine the possible influence of food safety standards on trade flows, we estimate regressions based on an extended gravity model. We use aggregate data for bilateral exports of food and processed food products, and data for factors affecting bilateral export flows for 17 years on 16 OECD and Asia-Pacific countries. The descriptive statistics of each variable used in the model is reported in Table D.4 (Appendix D). The major question that surfaces from imposing food safety regulations in importing countries is whether and what extent are exports in the food and processed food industry influenced by the food safety regulations? To address this question, we examine the relationship between bilateral exports and importers' imposition of food safety standards along with other control variables affecting bilateral exports. We estimate a linear version of the empirical model given in Equation (IV.12), and provide results for a common estimator: ordinary least squares (OLS). The results of OLS estimates are reported in Table IV.2.

The problem in this simple analysis using OLS is that the estimation suffers from simultaneity problems which mean that the regressors and the errors are correlated. This problem makes OLS estimates biased. In fact, due to the simultaneity bias, the model (Equation (IV.12)) might fail to take account of unobserved factors of the firm that bias estimates of the coefficients used in the model. To solve this problem, several approaches have been taken in the literature. Some use a translog specification with a set of controls, some use weighted quadratic least square regression, and some use a panel data approach with a fixed effects model and a proxy for a firm's unobservable productivity. The Olley and Pakes technique[41] is a bit different but noteworthy. They develop a semi-parametric estimator that introduces unobserved factors affecting a firm's productivity (Arnold). This technique does not need a specific functional form, but it involves a semi-parametric estimator that can be approximated by a polynomial expansion (such as 2nd, 3rd, 4th or 5th order polynomials) of the variables used in the model. According to the Olley and Pakes approach, this study adds quadratic polynomials of variables (GDP, Distance and FSS) in the regression equation, so the model has the following form:

$$\begin{aligned}\ln EX_{ijt} &= \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln Dis_{ij} \\ &\quad + \beta_4 \ln EPI_{it} + \beta_5 \ln IPI_{jt} + \beta_6 \ln FSS_j + \beta_7 (\ln GDP_{ti})^2 \\ &\quad + \beta_8 (\ln GDP_{jt})^2 + \beta_9 (\ln Dis_{ij})^2 + \beta_{10} (\ln FSS_j)^2 + \varepsilon_{ijt}\end{aligned} \qquad \text{(IV.13)}$$

The equation is a partially linear form with semi parametric regression model. The results of the regression estimation are reported in Table IV.3.

Estimated results show that the F values for both regressions (Equation (IV.12) and Equation (IV.13) are statistically significant at the 1% level. The R^2 values indicate that the overall goodness of fit of the regressions is satisfactory. But it is interesting that the R^2 value almost doubles in the regression when we formulate equations with polynomials of the variables used in the equations. We hypothesize that the greater the food safety standards, the lower its restrictiveness, and higher the bilateral trade flows. That is, imposition of stiffer food safety regulations impact bilateral exports negatively.

[41] The Olley and Pakes technique is detailed in Appendix E.

In all our regression analyses, we found that the food safety standards (*FSS*), in terms of aflatoxin standards, of importing countries is highly significant and shows the negative impact on export flows.

Table IV.2 shows the regression analysis (Equation (IV.12)) for food and food products exports as influenced by aflatoxin B1 (*FSS*) with other factor variables, exporter's per capita GDP (*GDPX*), importer's per capita GDP (*GDPM*), geographical distances (*DIST*), exporter price index (*EPIX*) and importer's import price index (*IPIM*). A double-log specification is used in the model so the coefficient of a variable can be interpreted as the elasticity.

Table IV.2: Regression results of bilateral exports in the food and food product sector

Variable	Parameter estimates	Standard Error	t Value	Pr > |t|
Intercept	-7.31 [a]	2.58	-2.83	0.0048
Exporter' s per capita GDP (*GDPX*)	2.93 [a]	0.23	12.85	<.0001
Importer' s per capita GDP (*GDPM*)	0.55 [a]	0.08	6.75	<.0001
Distances (*DIST*)	0.34	0.40	0.86	0.3908
Exporter's export price index (*EPIX*)	-0.68	0.58	-1.17	0.2407
Importer's import price index (*IPIM*)	-0.02	0.15	-0.10	0.9202
Food Safety Standard (*FSS*)	0.98 [a]	0.11	8.80	<.0001
F value	54.40			
R^2	0.39			
Adjusted R^2	0.39			

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. All the variables are in logs.

As shown in the table, the parameter estimate on the policy variable (aflatoxin B1) is positive and statistically significant at the 1% level. Since a greater value of aflatoxin B1 implies relaxation of aflatoxin contamination, the positive sign of the coefficient implies that the bilateral trade increases with relaxation of the standard. The result suggests that the impact of aflatoxin standard is negative on bilateral exports: a 1% tightening of the standard reduces bilateral exports by 0.98%. Jayasuriya et al. also found that Indian food exporters received significant losses from stringent food safety regulations. This result is also consistent with the findings of Lacovone, and Otsuki et al.

The results also show that the coefficients both for exporter's per capita *GDP* and importer's per capita *GDP* are significantly positive at the 1% level. The results suggest that a 1 per cent increase in the per capita *GDP* in the exporting country is associated with a 2.9% increase in bilateral exports, whereas a 1 per cent increase in the per capita *GDP* in the importing country is associated with a 0.55% increase in exports. These results are expected and supported conceptually. The coefficients of other variables, distances (*DIST*), exporter price index (*EPIX*) and importer's import price index (*IPIM*) are not statistically different from zero.

The effects of food safety regulations seem rather small, except that they can change drastically for a country. Moving the aflatoxin tolerance from 20 (the US's standard) to 4 (the UK's standard) is a 500% increase in the standard. Thus, if the US adopted the UK's food safety standards, exports by these countries would be only 20% of what they were before – a tremendous decrease. This would seriously impair developing country food exporters.

In the regression (Equation (IV.13)) presented in Table IV.3, we formulate second order polynomials of the variables (*GDPX*, *GDPM*, *DIST* and *FSS*) in the model. In this analysis, we found that the coefficients for the food safety standard had the expected sign. Table IV.3 reveals that the relationship between the food safety standard and food and food products exports is significant at the 1% level and positive. This result implies that a 1 per cent increase in maximum level of aflatoxin B1 increases export flows by 3.4 per cent. The results also show that the coefficient for the exporter's per capita *GDP* has a positive sign, and it is statistically significant at the 1% level: a 1 per cent increase in the per capita *GDP* in the exporting country leads to an increase in bilateral exports by 55.7

percent. The coefficient of per capita *GDP* in the importing country is significantly negative. The sign of exporter's per capita *GDP* is expected but the sign of importer's per capita *GDP* is not expected and difficult to explain. Bergstrand also found mixed results for a country's income on export competitiveness.

Table IV.3: Regression results of bilateral exports in the food and food product sector

Variable	Parameter estimates	Standard Error	t Value	Pr > |t|
Intercept	-45.55 [a]	16.25	-2.80	0.0053
Exporter' s per capita GDP (*GDPX*)	55.70 [a]	4.22	13.21	<.0001
Importer' s per capita GDP (*GDPM*)	-10.33 [a]	1.65	-6.27	<.0001
Distances (*DIST*)	-21.68 [a]	2.17	-10.00	<.0001
Exporter's export price index (*EPIX*)	1.36 [a]	0.34	3.96	<.0001
Importer's import price index (*IPIM*)	-0.01	0.46	-0.02	0.9874
Food Safety Standard (*FSS*)	3.38 [a]	0.28	11.99	<.0001
GDPX square	-4.25 [a]	0.34	-12.51	<.0001
GDPM square	0.63 [a]	0.10	6.33	<.0001
DIST square	1.34 [a]	0.13	10.19	<.0001
FSS square	-0.85 [a]	0.09	-9.41	<.0001
F value	92.23			
R^2	0.65			
Adj_R^2	0.64			

Notes: [a] and [b] indicate significant at 1% and 5% level, respectively. All the variables except quadratic terms are in logs.

Table IV.3 reveals that the coefficient of geographical distance is 21.7 and significantly negative at the 1% level. This implies that a 1 per cent increase in geographical distance between two trading partner countries is associated with a 21.7 per cent decrease in exports between the trading countries. As expected, the coefficient of export price index in the exporting country is 1.4 and statistically significant at the 1% level. The coefficient of import price index in the importing country is negative, but is statistically not different from zero. The results also show that the coefficients of *GDPX* square, *GDPM* square, *DIST* square and *FSS* square are 4.3, 0.6, 1.3, and 0.9, respectively, and all quadratic forms of the variables are statistically significant at the 1% level.

The results reveal that the overall significance of the estimates is higher in the model (Equation (IV.13)) with the quadratic form of variables than the model (Equation (IV.12)) without it. Kee and Hoekman, and Abuka also used polynomial expansion of the variable in their studies, and obtained better results. From Equation (IV.13) the partial derivatives of exports with respect to GDPX, GDPM, DIST and FSS are:

$$\frac{\partial \ln EX_{it}}{\partial \ln GDP_{it}} = \beta_1 + 2\beta_7 (\ln GDP_{it}) \qquad \text{(IV.14)}$$

$$\frac{\partial \ln EX_{it}}{\partial \ln GDP_{jt}} = \beta_2 + 2\beta_8 (\ln GDP_{jt}) \qquad \text{(IV.15)}$$

$$\frac{\partial \ln EX_{it}}{\partial \ln Dis_{ij}} = \beta_3 + 2\beta_9 (\ln Dis_{ij}) \qquad \text{(IV.16)}$$

$$\frac{\partial \ln EX_{it}}{\partial \ln FSS_{j}} = \beta_6 + 2\beta_{10} (\ln FSS_{i}) \qquad \text{(IV.17)}$$

The calculated partial derivatives of exports with respect to *GDPX*, *GDPM*, *DIST* and *FSS* are reported in Table D.5 (Appendix D). As shown in the Table IV.3, the estimation of β_6 and β_{10} are 3.38 and -0.85, respectively, so the value of the derivative[42] equals 0.10, and is positive when ln*FSS* is positive. The positive sign of the derivative implies that bilateral exports increase with relaxation of the standard. In other words, tightening food safety standards reduce exports.

Conclusion:

In this study, we estimate regressions based on an extended gravity model to determine the possible influence of food safety standards on export flows of six Asia-Pacific countries to ten importing countries. We studied the constraints and challenges

[42] $\frac{\partial \ln EX_{it}}{\partial \ln FSS_{i}} = 3.38 + 2 * (-0.85) * (1.93) = 0.10$

exporters in Asia and the Pacific face in exporting food and food products in world markets. Six countries (China, Fiji, Indonesia, Nepal, Sri Lanka and Vietnam) are facing problems in meeting increasingly more stringent food safety requirements imposed by developed countries such as Japan, EU and the U.S. The major question that surfaces from imposing food safety regulations in importing countries is whether and what extent are exports in the food and processed food industry influenced by the food safety regulations? To address this question, we examine the relationship between bilateral exports and importers' imposition of food safety standards along with other control variables affecting bilateral exports. In our study, we use the common estimator: ordinary least squares (OLS), but employ the Olley and Pakes semi-parametric estimator to solve the simultaneity problem in the empirical estimation. We obtain empirical evidence on the adverse impact of food safety standards on export performance in food and food manufacturing.

The empirical results show that the value of exports in food and food products is negatively affected by aflatoxin standards: higher aflatoxin tolerances mean lower restrictiveness, and higher bilateral export flows. A one percent increase in food safety standards decrease exports by approximately one percent. This means that large changes in food standards (which are common these days) will have salutary, deleterious impacts on food exports by developing countries. The result also shows that economic activities in the exporting and importing countries (specifically their GDPs) have significant impacts on food exports. These variables are moving upward each year so these factors will have a positive impact on developing country food exports in the future. The results indicate that prices do not have significant impacts on food exports of developing countries. If distribution systems are established between developing and developed countries, changes in prices do not seem to deter international trade.

Despite all of the constraints and challenges Asia-Pacific exporters face in meeting food safety regulations, exports of food and processed food products have grown for the region. We have found empirical evidence on the adverse impact of food safety regulations on trade performance in the food and processed food sector. In our study, we had limitation on availability of uniform cross-sectional data so some important countries that could enrich database, were omitted. This study gives an insight into food safety standards, but given the lack of robustness of research results in this area, and the increasing importance for food safety policy-making over international trade in both developing and developed countries, further empirical research is necessary. The research could focus on a simultaneous research project that includes consumers' concern about the safety of food supply in developed countries and the impact of food safety regulations on specific food exports from the developing country.

Chapter V

Summary and Conclusion

This study has taken an initiative to overview the policy context driving standards in manufacturing industries. The study consists of three different essays that examine the role of technical regulations and standards and their relationship with trade using different econometric models.

In the first article, we construct an econometric model that includes factor endowments and environmental regulations to examine how strict environmental policies impact export competitiveness. The study hypothesizes that a country's comparative advantage depends on its factor abundance. The regulatory policy (used as a production factor in the model) increases production costs, and, thus, reduces the output level of an industry. The empirical results show that the estimated effects of factor endowments, technology and stringency of environmental regulation on export competitiveness differ across the 13 industries.

The findings support the H-O theorem: if a good is capital-intensive (or labor-intensive) and if the labor endowment rises, then the output of that good would fall (rise) and the output of the other good would rise (fall), provided output prices of both goods remained the same (Takayama). According to the results, machinery and equipment; machinery and equipment nec; and pulp, paper, paper products, printing and publishing industries were found to be skilled labor-intensive; basic metals industry was an unskilled labor-intensive industry, whereas iron and steel and non-ferrous metals were capital-intensive industries under the category of pollution intensive industries. In the non-pollution intensive industry category, food products, beverages and tobacco industries were found to be skilled labor-intensive; wood and products of wood and cork industries were unskilled labor-intensive; manufacturing nec was capital-intensive; and textiles, textile products, leather and foot wear industries were found to be capital and unskilled labor-intensive. Fabricated metal products industries were found to be a skilled labor-intensive; other non-metallic mineral products were capital and unskilled labor-intensive industry; and chemicals and chemical products were found to be a capital-intensive industry in the neutral category with respect to pollution intensity. Environmental regulations imposed on machinery and equipment nec; manufacturing nec; basic metals; machinery and equipment; iron and steel; and other non-metallic mineral products industries have significantly negative impacts on net exports. But a positive relationship between net exports and environmental regulations was found for paper products, wood products, and textile products. The challenge is finding a way to link good environmental practices in industries that are not linked to sustainable resources. The current craze in purchasing carbon credits by various companies might be a way that companies can show their environmental stewardship in a tangible way.

In the second essay, we investigate the impact of competition policy on a country's production and export competitiveness. We base our empirical regression model on a Cobb Douglas production function that considers that production and exports are influenced by competition policy along with factor endowments. We hypothesizes that competition policy is positively related to a country's manufacturing production and exports. Since the impact of competition regulation depends upon the particular circumstance of the industry to which the policy is applied, we examine how competition policy impacts production and exports of a specific sector, in particular in the agri-food processing sector. We employ panel data fixed effects and random effects model in our regression analyses. The results show that the existence of competition policy has a significantly positive impact on total manufacturing production. Food manufacturing production is higher when competition policy is introduced than the production when competition policy is not introduced. This result suggests that competition policy enhances competitiveness by reducing entry barriers, causes firms to produce more output with lower prices. The results also show that exports for both total manufacturing and food manufacturing are positively related to competition policy: in both cases exports in the post-competition policy period are higher than exports in the pre-competition period.

In the third essay, we estimate regressions based on an extended gravity model to determine the possible influence of food safety standards on export flows of six Asia-Pacific countries to ten importing countries. We also studied the constraints and challenges exporters in Asia and the Pacific face in exporting food and food products in world markets. Six countries (China, Fiji, Indonesia, Nepal, Sri Lanka and Vietnam) are facing problems in meeting increasingly more stringent food safety requirements imposed by developed countries such as Japan, EU and the U.S. In our study, we examined the relationship between bilateral exports and an importers' imposition of food safety standards, along with other control variables affecting bilateral exports. We obtained empirical evidence on the adverse impact of food safety standards on export performance in food manufacturing. In particular, the results show that the value of food exports is negatively affected by aflatoxin standards: the greater the food safety standards, the lower its restrictiveness, and higher the bilateral export flows. The effects of food safety regulations seem rather small, except that they can change drastically for a country. Moving the aflatoxin tolerance from 20 (the US's standard) to 4 (the UK's standard) is a 500% increase in the standard. Thus, if the US adopted the UK's food safety standards, exports by these countries would be only 20% of what they were before – a tremendous decrease. This would seriously impair developing country food exporters.

This study is more refined than most because the investigation is performed on many different industries. However, the results suffer from the fact that industries export goods, and many of these industries operate in many different countries. Their research and development activities might be in their home country, but the results from such activities can be used in industry operations throughout the world. Thus, the strength of the results relative to countries is less clear. This study gives an insight into domestic policies, and their impact on international competitiveness, but it lacks robustness of research results due to inadequate cross-sectional and time series data for each variable with respect to export flows. Given the increasing importance for domestic policies including technical regulations and standards over international competitiveness, further research is necessary. The research could focus on identifying important variables that determine industries' comparative advantage, explaining exports and assessing how these variables impact export competitiveness in the manufacturing in particular agri-food manufacturing.

APPENDICES

Appendix A

Table A.1a: Descriptive statistics of the variables for the period, 1987-2003

Variables	Mean and standard deviation (in parenthesis)			
	McNEC	ManfN	Bmet	Nmet
Export	25073	6082	14884	3472
	(26502)	(4992)	(12528)	(2376)
Import	18346	9309	15205	3646
	(14452)	(13244)	(11174)	(3048)
Net	6727	-3227	-321.38	-174.18
Export	(17047)	(10826)	(7931)	(2605)
Skilled	81166310	13924311	14120342	3950131
Labor	(1.42E+08)	(18598887)	(21328791)	(4585291)
Unskilled	1159364	2306773	2015802	1385582
Labor	(1701770)	(5509001)	(4277928)	(3160702)
Capital	1919	907.85	2360	1614
	(2027)	(809.10)	(2211)	(1712)
Research &	591.33	72.17	159.80	122.02
Development	(893.51)	(178.52)	(217.51)	(190.87)
Environmental	-0.004	0.20	0.19	0.20
regulation	(0.99)	(1.14)	(1.15)	(1.14)
N	153	170	136	170
n	9	10	8	10

McNEC: Machinery and equipment nec
ManfN: Manufacturing nec
Bmet: Basic metals
Nmet: Other non-metallic mineral products

Notes: N is the number of total observation, n is the number of countries (Belgium, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden and the United States). Depending on data availability we eliminate countries from the sample and use different countries in the analysis for different industries.

Table A.1b: Descriptive statistics of the variables- continued

Variables	Mean and standard deviation (in parenthesis)			
	Mach	Iron	Food	Fmet
Export	71098	7717	14581	7271
	(76324)	(7921)	(8915)	(6342)
Import	71333	7236	14055	6878
	(76626)	(5598)	(9133)	(5814)
Net	-234.14	481.80	525.42	393.57
Export	(26866)	(5112)	(6568)	(4011)
Skilled	1.13E+09	17082	1.01E+08	90656642
labor	(2.48E+09)	(29324)	(1.69E+08)	(1.41E+08)
Unskilled	10705913	1017524	4207005	4357121
labor	(25952059)	(2140865)	(9654274)	(9013658)
Capital	8339	1342	4447	2604
	(12626)	(1364)	(4077)	(2574)
Research &	11920	87.91	261.75	249.82
Development	(23890)	(98.54)	(445.89)	(473.29)
Environmental	0.20	0.10	0.20	0.19
regulation	(1.14)	(1.16)	(1.14)	(1.15)
N	170	153	170	136
n	10	9	10	8

Mach: Machinery and equipment
Iron: Iron and steel
Food: Food products, beverages and tobacco
Fmet: Fabricated metal products, except machinery and equipment

Notes: N is the number of total observation, n is the number of countries (Belgium, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden and the United States). Depending on data availability we eliminate countries from the sample and use different countries in the analysis for different industries.

Table A.1c: Descriptive statistics of the variables- continued

Variables	Mean and standard deviation (in parenthesis)				
	Wood	Textile	Paper	Nfer	Chem
Export	4036	10867	13822	6628	29267
	(7267)	(9492)	(19308)	(6728)	(23860)
Import	2080	19175	7743	7053	25535
	(1553)	(22049)	(5786)	(5711)	(18961)
Net Export	1955	-8308	6078	-424.67	3731
	(6415)	(20431)	(16715)	(4671)	(9182)
Skilled labor		43752000	1.96E+08		64006961
		(85821613)	(4.32E+08)		(1.19E+08)
Unskilled	360225	3788342	5637189	794414.9	2711118
labor	(386940)	(9134248)	(13565531)	(1974717)	(6072321)
Capital	855.91	1290.69	5106	793.46	5158
	(1056)	(1546)	(6140)	(1067)	(6648)
Research &	8.19	84.16	258.94	64.99	3313
Development	(9.24)	(121.20)	(652.97)	(115.86)	(5563)
Environmental	-0.07	0.13	0.30	0.10	0.30
regulation	(0.94)	(1.18)	(1.12)	(1.16)	(1.12)
N	119	153	153	153	153
n	7	9	9	9	9

Wood: Wood and products of wood and cork
Textiles: Textiles, textile products, leather and footwear
Papers: Pulp, paper, paper products, printing and publishing
Nfer: Non-ferrous metals
Chem: Chemicals and chemical products

Notes: N is the number of total observation, n is the number of countries (Belgium, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden and the United States). Depending on data availability we eliminate countries from the sample and use different countries in the analysis for different industries.

Table A.2a: Regression results of net export in different industries

Variables	McNEC	ManfN	Bmet	Nmet
Intercept	637.95 [a]	41273 [a]	6278[a]	93.42
	(104.85)	(2523)	(2063)	(181.19)
Skilled labor	0.001 [a]	-0.0001	-0.01 [a]	-0.001[a]
	(0.0001)	(0.00004)	(0.001)	(0.0001)
Unskilled labor	-0.03 [a]	-0.004 [a]	0.12 [a]	0.005 [a]
	(0.002)	(0.0002)	(0.01)	(0.002)
Capital	-2.83 [a]	3.96 [a]	-2.69 [a]	0.33 [a]
	(0.13)	(0.67)	(0.16)	(0.09)
Research &	-0.95 [a]	-6.23 [b]	-24.15 [a]	0.35
Development	(0.30)	(3.04)	(3.40)	(0.96)
Environmental	-453.84 [a]	-292.48	-21988 [a]	-153.60 [a]
regulation	(94.45)	(183.79)	(1631)	(30.83)
d1	-1498	-41650	-11215	1719 [b]
	(90922)	(2587)	(6939224)	(759.20)
d2	-667529 [a]	-41410	238874	-308.44
	(191585)	(2548)	(6939348)	(754.44)
d3	-621.27	-46033	-123760361 [a]	2115 [a]
	(90922)	(2469)	(19234432)	(768.38)
d4	-216161 [b]	-41970	-721.23	2838
	(91660)	(2480)	(6939223)	(1678)
d5	13873	-35505	396.47	8000 [a]
	(90925)	(2596)	(6939223)	(763.20)
d6	-4420	-39416	-33014	-3975 [a]
	(-4420)	(3033)	(6939224)	(1385)
d7	-14732	-47431	107860	-2573 [a]
	(90922)	(2593)	(6939232)	(750.20)
d8	-339.71	-42047		1856 [b]
	(90922)	(2601)		(749.60)
d9		-38543		
		(2858)		
R2	0.99	0.98	0.99	0.99
Adj_R2	0.99	0.98	0.99	0.99
F_value	107501	589.36	83156	40440

McNEC: Machinery and equipment nec
ManfN: Manufacturing nec
Bmet: Basic metals
Nmet: Other non-metallic mineral products

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis.d1- d9 are country dummies.

Table A.2b: Regression results of net export- continued

Variables	Mach	Iron*	Food	Fmet
Intercept	-10271 [a]	-5132[a]	-18345	-0.90
	(1824)	(743.22)	(1101)	(31.30)
Skilled labor	0.0001 [a]		0.0001[a]	0.00003[a]
	(0.00002)		(0.00001)	(0.00001)
Unskilled labor	-0.01 [a]	-0.10	-0.002 [a]	0.0004
	(0.002)	(35.43)	(0.0002)	(0.0003)
Capital	-4.87 [a]	185.37	0.17	-0.29 [a]
	(0.69)	(66874)	(0.18)	(0.07)
Research &	3.37 [a]	12.96[a]	13.11 [a]	0.06
Development	(0.71)	(4.44)	(2.76)	(0.53)
Environmental	-2917 [a]	-1991 [a]	398.07	105.61 [a]
regulation	(311.45)	(661.67)	(209.35)	(17.22)
d1	0.04	3977	3035 [b]	66760 [a]
	(9175)	(9208)	(1189)	(14809)
d2	12142	3469	923.90	60.09
	(9226)	(3634)	(1173)	(14611)
d3	213.99	11430	823.42	4113
	(11325)	(37831)	(1498)	(8469)
d4	9964	3628	-5056 [a]	-917.22
	(17947)	(7382)	(1583)	(5987)
d5	702.54	2375	-184.03	-4950
	(9175)	(31285)	(420.82)	(8466)
d6	10213	-305.50	8193 [a]	-56.02
	(9243)	(11835)	(1205)	(8466)
d7	-18426 [b]	-1156	2168 [a]	1749
	(9228)	(7065)	(620.95)	(8471)
d8	-12912	26850	-74.25	
	(11149)	(16890)	(1229)	
d9	70717 [a]		-441.60	
	(11522)		(423.08)	
R2	0.99	0.96	0.87	0.99
Adj_R2	0.99	0.95	0.86	0.99
F_value	35917	111.07	79.32	1914

Mach: Machinery and equipment
Iron: Iron and steel
Food: Food products, beverages and tobacco
Fmet: Fabricated metal products, except machinery and equipment

Notes: [a] and [b] indicate significant at the 1% and 5% level, respectively. Standard errors are given in parenthesis.d1- d9 are country dummies. * The results of variable polynomials are not shown here in this table due to lack of space but could be obtained from the authors upon request. Skilled labor data for iron and steel are not available.

Table A.2c: Regression results of net export- continued

Variables	Wood	Textiles	Papers	Nfer	Chem
Intercept	517.31[a]	1604492	1964	-155.75	3768
	(69.29)	(693733)	(3245)	(155.78)	(2589)
Skilled labor		-0.007 [a]	0.00004[a]		0.00002
		(0.0003)	(0.00001)		(0.00004)
Unskilled labor	0.0001	0.17 [a]	-0.002 [a]	-0.002 [a]	-0.002[a]
	(0.002)	(0.03)	(0.0004)	(0.0002)	(0.001)
Capital	-3.17 [a]	210.97 [a]	1.95 [a]	1.10 [a]	1.23 [a]
	(0.17)	(16.27)	(0.23)	(0.24)	(0.37)
Research &	0.64	-18103 [a]	5.18 [a]	9.66 [a]	0.20
Development	(1.04)	(5638)	(1.84)	(2.21)	(0.48)
Environmental	406.70 [a]	2016513 [a]	1031 [b]	17.25	4.27
regulation	(14.32)	(582091)	(458.86)	(102.08)	(20.94)
d1	650586	0.02	-57.96	7.75	-1708
	(789058)	(1.52E11)	(808.16)	(306.01)	(2630)
d2	1856	-1051737	2527	852.18	-4980
	(479869)	(1.52E11)	(3370)	(496.21)	(2723)
d3	892.94	-30818102	-11121 [a]	-53.01	-537.04
	(479871)	(1.52E11)	(3463)	(282.87)	(1236)
d4	1537	4.22E11[b]	-8339 [b]	-660.89 [b]	7938 [a]
	(479869)	(2.11E11)	(3301)	(284.11)	(3033)
d5	-38845	-9234919	-0.003	-83.99	-15635 [a]
	(479873)	(1.52E11)	(809.74)	(319.95)	(2600)
d6	324.51	-1666501	-3292	8600 [a]	859.14
	(479869)	(1.52E11)	(3255)	(430.67)	(2637)
d7		-240356	-3254	-414.52	-9751 [a]
		(1.52E11)	(3322)	(308.07)	(2653)
d8		1267399	19325 [a]	-1122	-9173 [a]
		(1.52E11)	(4152)	(344.93)	(2957)
R2	0.99	0.99	0.96	0.93	0.81
Adj_R2	0.99	0.99	0.96	0.92	0.79
F_value	6488	43446	317.60	145.38	43.42

Wood: Wood and products of wood and cork

Textiles: Textiles, textile products, leather and footwear

Papers: Pulp, paper, paper products, printing and publishing

Nfer: Non-ferrous metals

Chem: Chemicals and chemical products

Notes: [a] and [b] indicate significant at 1% and 5% level, respectively. Standard errors are given in parenthesis.d1- d9 are country dummies. Skilled labor data for wood and wood products and cork and non-ferrous metals are not available.

Appendix B

Rybczynski theorem[43]:

In the context of the factor endowment model, the Rybczynski theorem demonstrates the effects of changes in the supply of endowments on outputs of the two goods. Let us suppose an economy producing two goods, *X* and *Y* with factor endowments, labor (*L*) and capital (*K*). According to the Rubczynski, if a factor endowment in a country rises (falls), then the output of the good that uses that factor intensively will rise (fall) while the output of the other good will fall (rise), provided prices of the outputs remain the same. To verify this theorem, let us use the following factor constraint conditions that satisfy in equilibrium:

$$a_{L_X} X + a_{L_Y} Y = L \tag{B.1}$$

$$a_{K_X} X + a_{K_Y} Y = K \tag{B.2}$$

where a_L and a_K are the optimal levels derived from the cost minimization exercise and are functions of the wage, *w*, and the rental rate on capital, *r*. We assume that wages and rents remain fixed which implies that output prices remain fixed as well.

Differentiating (B.1) and (B.2) with respect to *L* yields:

$$a_{L_X} \frac{\partial X}{\partial L} + a_{L_Y} \frac{\partial Y}{\partial L} = 1 \tag{B.3}$$

$$a_{K_X} \frac{\partial X}{\partial L} + a_{K_Y} \frac{\partial Y}{\partial L} = 0 \tag{B.4}$$

[43] To illustrate the Rybczynski theorem, we follow Suranovic.

Writing the above equations in matrix form yields:

$$\begin{pmatrix} a_{L_X} & a_{L_Y} \\ a_{K_X} & a_{K_Y} \end{pmatrix} \begin{pmatrix} \frac{\partial X}{\partial L} \\ \frac{\partial Y}{\partial L} \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \tag{B.5}$$

Using the Cramer's Rule, the above expression can be solved as:

$$\frac{\partial X}{\partial L} = \frac{a_{K_Y}}{a_{L_X} a_{K_Y} - a_{K_X} a_{L_Y}} \tag{B.6}$$

$$\frac{\partial Y}{\partial L} = \frac{-a_{K_X}}{a_{L_X} a_{K_Y} - a_{K_X} a_{L_Y}} \tag{B.7}$$

Whether the partial derivatives (Equation (B.6) and (B.7)) are positive or negative depends on the signs of the denominator. If we assume the denominator of each expression is less than zero, then

$$a_{L_X} a_{K_Y} - a_{L_Y} a_{K_X} < 0 \tag{B.8}$$

$$=> \frac{a_{K_Y}}{a_{L_Y}} - \frac{a_{K_X}}{a_{L_X}} < 0 \tag{B.9}$$

Which is true if, $\frac{K_Y}{L_Y} - \frac{K_X}{L_X} < 0 \quad => \quad \frac{K_Y}{L_Y} < \frac{K_X}{L_X}$ (B.10)

This means that the denominator is negative if and only if production of good one (*X*) is capital-intensive and production of good two (*Y*) is labor-intensive.

If good X is capital-intensive and good Y is labor-intensive, then Equation (B.6) and Equation (B.7) are:

$$\frac{\partial X}{\partial L} = \frac{a_{K_Y}}{a_{L_X} a_{K_Y} - a_{K_X} a_{L_Y}} = \frac{+}{-} < 0 \qquad \text{(B.11)}$$

$$\frac{\partial Y}{\partial L} = \frac{-a_{K_X}}{a_{L_X} a_{K_Y} - a_{K_X} a_{L_Y}} = \frac{-}{-} > 0 \qquad \text{(B.12)}$$

This implies that if good X is capital-intensive and good Y is labor-intensive, with an increase in labor endowment may cause the output of good X to fall and the output of good Y to rise, provided output prices of both goods remained the same.

If good X is capital-intensive and good Y labor-intensive, and if the assumption remains same, then with a change in the capital endowment (capital endowment rises), we can show the following expressions:

$$\frac{\partial X}{\partial K} > 0, \text{ and } \frac{\partial Y}{\partial K} < 0 \qquad \text{(B.13)}$$

Now, if we assume that good one (X) is labor intensive and good two (Y) is capital intensive, then the signs of all of the above derivatives will be reversed.

Graphically, if a country experiences an increase in labor endowment, then that would cause an increase in output of labor-intensive goods (such as clothing), and a decrease in the output of capital-intensive goods (such as steel), provided the relative prices are held constant.

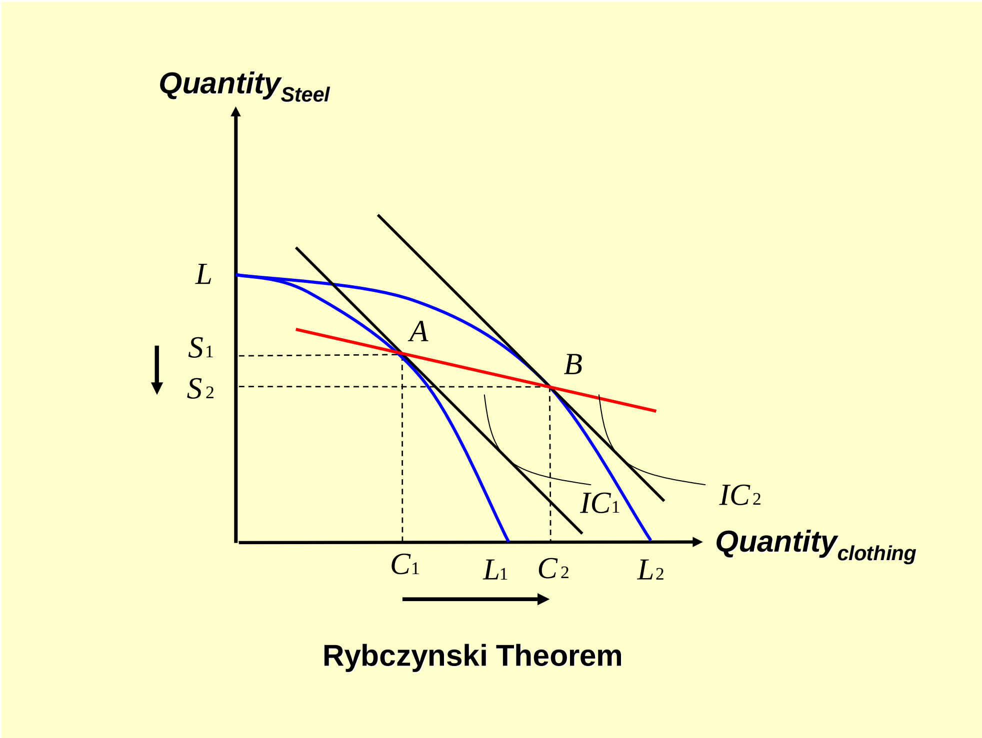

Figure B.1[44]: Rybczynski Theorem

As shown in Figure B.1, if the endowment of labor increases (from L_1 to L_2), the amount of labor-intensive good (clothing) produced increases (C_1-C_2), and the amount of capital intensive good (steel) produced decreases (S_1-S_2). The downward sloping AB line (the so called Rybczynski line) reflects the decrease in the steel production under the condition of increasing labor endowment.

[44] The figure is derived from the figure in Suranovic.

Appendix C

Table C.1: Descriptive statistics of the variables for the period 1980-2003

Variable	Total Manufacturing		Food Manufacturing	
	Mean	Standard deviations	Mean	Standard deviations
Manufacturing Production	798,573	1,960,053	161,806	330,815
Manufacturing Exports	238,751	864,679	30,503	76,392
Import Penetration	360.83	3,677	16.08	9.39
Capital	171,363,901,635	352,259,488,586	8,921	20,669
Labor	19,574,625	29,866,595	210,895,239	504,235,869
N	480		264	
n	20		11	

Notes: N is the number of total observation, n is the number of countries (20 countries for total manufacturing: Australia, Austria, Canada, Denmark, Finland, Hungary, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, United Kingdom and the United States, and 11 countries for food manufacturing: Austria, Denmark, Finland, Hungary, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and the United States).

Appendix D

Table D.1: Importance of Agricultural Exports in Selected Asia-Pacific Countries

Country	Share of Agricultural Exports in GDP (%)		Share of Food Exports in Total Agricultural Exports (%)		Share of Processed Food Exports in Total Agricultural Exports (%)	
	1989-1991	2002	1989-1991	2002	1989-1991	2002
Nepal	1.51	1.39	83.96	49.02	16.41	58.47
Sri Lanka	8.55	5.86	17.67	18.73	62.39	47.11
China	0.02	0.01	53.21	67.16	57.72	62.49
Indonesia	2.59	3.59	33.74	67.49	56.21	53.29
Viet Nam	8.94	6.03	69.46	63.67	79.00	83.63
Fiji	15.04	8.98	97.27	87.40	96.47	92.97

Source: FAO (2004), Statistical Yearbook, FAO, Rome. This table is adapted from Mohanty 2006.

Table D.2: Export of Food Products in 2002 in Asia-Pacific Countries: By HS Chapter (% total food export)

Description	Nepal	China	Fiji	Indonesia	Vietnam	Sri Lanka
Live Animals	0.5	2.2	0.0	0.5	0.4	0.0
Meat and edible meat offal	0.0	4.2	0.0	0.3	0.9	0.1
Fish & crustaceans, molluscs	0.0	18.0	16.9	21.9	42.4	8.8
Diary produce: birds, eggs	54.9	1.2	0.0	1.6	1.1	0.1
Edible vegetables & certain roots	20.7	11.8	4.2	0.7	1.6	0.7
Edible fruits & nuts: peel or melon	0.0	3.5	0.3	2.1	8.0	4.1
Coffee, tea, mate and spices	8.5	3.4	0.3	8.2	17.6	79.8
Cereals	0.0	10.4	0.0	0.2	12.1	0.1
Products of the milling industry	0.0	0.5	0.1	0.2	0.0	0.9
Oil seeds and leoginous fruits	0.9	3.8	0.0	0.3	1.2	1.1
Animal or vegetable fats & oils	0.0	0.7	1.7	41.8	0.4	0.3
Preparations of meat and fish	0.0	14.6	22.2	1.6	9.9	0.0
Sugars and sugar confectionery	0.0	1.4	43.6	1.1	0.2	0.0
Cocoa & cocoa preparations	0.0	0.2	0.0	11.0	0.0	0.0
Prep. of cereals, floor, starch, etc.	5.2	2.8	2.1	1.4	1.4	0.1
Prep. of vegetables, fruit, nuts, etc.	0.0	11.0	1.7	2.2	0.9	0.9
Miscellaneous edible preparations	0.2	2.9	0.0	0.5	0.9	1.2
Beverages, spirits & vinegar	0.0	3.5	6.5	0.3	0.3	0.1
Residues & waste from food industries	9.1	2.6	0.3	1.7	0.5	1.6
Tobacco & manufactured tobacco	0.0	1.5	0.0	2.7	0.2	0.2

Source: Calculated by the author based on PC-TAS 2005, UNCTAD, ITC, WTO, World Bank and other documents. This table is adapted from Mohanty 2006.

Table D.3: Distances between important seaports in nautical miles

Country (Seaport)	Country (Seaport)	Distances	Country (Seaport)	Country (Seaport)	Distances
Australia (Brisbane)	China (Shanghai)	4231	India (Bombay)	China (Shanghai)	4672
	Fiji (Suva)	1548		Fiji (Suva)	7072
	Indonesia (Jakarta)	3487		Indonesia (Jakarta)	2708
	Nepal (Katmandu*)	5490		Nepal (Katmandu*)	2112
	Sri Lanka (Colombo)	5313		Sri Lanka (Colombo)	889
	Vietnam (Haiphong)	4370		Vietnam (Haiphong)	3757
Austria (Trieste)	China (Shanghai)	5983	Italy (Augusta)	China (Shanghai)	8170
	Fiji (Suva)	10926		Fiji (Suva)	10556
	Indonesia (Jakarta)	6566		Indonesia (Jakarta)	6197
	Nepal (Katmandu*)	5983		Nepal (Katmandu*)	5614
	Sri Lanka (Colombo)	4773		Sri Lanka (Colombo)	4404
	Vietnam (Haiphong)	7624		Vietnam (Haiphong)	7255
Canada (Vancouver)	China (Shanghai)	5114	Japan (Kobe)	China (Shanghai)	783
	Fiji (Suva)	5187		Fiji (Suva)	4074
	Indonesia (Jakarta)	7417		Indonesia (Jakarta)	3020
	Nepal (Katmandu*)	9717		Nepal (Katmandu*)	4341
	Sri Lanka (Colombo)	8649		Sri Lanka (Colombo)	4258
	Vietnam (Haiphong)	6362		Vietnam (Haiphong)	1982
France (Brest)	China (Shanghai)	10100	UK (Plymouth)	China (Shanghai)	10201
	Fiji (Suva)	10827		Fiji (Suva)	10804
	Indonesia (Jakarta)	8127		Indonesia (Jakarta)	8228
	Nepal (Katmandu*)	7544		Nepal (Katmandu*)	7645
	Sri Lanka (Colombo)	6334		Sri Lanka (Colombo)	6435
	Vietnam (Haiphong)	9185		Vietnam (Haiphong)	9286
Germany (Hamburg)	China (Shanghai)	10772	USA (Los Angeles)	China (Shanghai)	5708
	Fiji (Suva)	11405		Fiji (Suva)	4796
	Indonesia (Jakarta)	8799		Indonesia (Jakarta)	7899
	Nepal (Katmandu*)	8216		Nepal (Katmandu*)	10114
	Sri Lanka (Colombo)	7006		Sri Lanka (Colombo)	9236
	Vietnam (Haiphong)	9857		Vietnam (Haiphong)	6961

Source: www.distances.com. * The distance adds road distance from Calcutta, India to Katmandu, Nepal.

Table D.4: Descriptive statistics of the variables used for food and food product exports

Variables	Number of observation	Mean	Standard deviation
Exports of country *i* to country *j*	595	226,971,028	747,418,057
Exporter' s total GDP	595	315,336,365,615	491,761,918,730
Importer' s total GDP	595	2147957200000	2689,751,800,000
Exporter' s per capita GDP	595	901.77	513.77
Importer' s per capita GDP	595	22,099.54	9,028.08
Exporter’s export price index	595	85.53	42.25
Importer’s import price index	595	90.90	26.95
Distance	595	6,433.17	3,120.41
Food Safety Standard	595	10.16	8.44

Notes: *i* indicates exporting countries (China, Fiji, Indonesia, Nepal, Sri Lanka and Vietnam), and *j* indicates importing countries (Australia, Austria, Canada, France, Germany, India, Italy, Japan, United Kingdom, and United States of America).

Table D.5: Partial derivatives of the variables used as quadratic forms in Equation (IV.13)

Year	Exporter's per capita GDP (*GDPX*)	Importer's per capita GDP (*GDPM*)	Distances (*DIST*)	Food safety standards (*FSS*)
1989	1.717	1.514	1.102	-0.090
1990	1.377	1.539	0.914	-0.090
1991	0.867	1.589	1.075	0.149
1992	1.462	1.602	1.209	0.149
1993	0.867	1.614	1.209	0.149
1994	2.227	1.627	1.370	0.047
1995	-0.408	1.677	1.397	0.149
1996	-1.089	1.702	1.397	0.149
1997	0.952	1.752	1.477	0.149
1998	2.822	1.739	1.504	0.081
1999	1.377	1.765	1.316	0.098
2000	1.802	1.790	1.504	0.064
2001	-0.493	1.852	1.316	0.149
2002	-0.919	1.865	1.316	0.149
2003	0.612	1.877	1.343	0.081
2004	-3.469	1.915	1.209	0.149
2005	-4.319	1.940	1.397	0.149
Total	0.612	1.752	1.316	0.098

Appendix E

The Olley and Pakes technique[45]:

To solve the simultaneity problem in simple OLS estimates, Olley and Pakes developed a semi-parametric estimator using the firm's investment decision to proxy unobserved productivity shocks. They used the following log linear function derived from a Cobb-Douglas production function:

$$(Q_{it} = A_{it} K_{it}^{\alpha_1} L_{it}^{\alpha_2}) \qquad \text{(E.1)}$$

$$\ln Q_{it} = \alpha_1 \ln K_{it} + \alpha_2 \ln L_{it} + \mu_{it} \qquad \text{(E.2)}$$

where it is assumed a firm produces output (*Q*) with a technology that uses capital (*K*) and a labor force (*L*) in year *t; A* is an index of total factor productivity or a coefficient that represents the level of technology; α_1 and α_2 are positive parameters satisfying $(\alpha_1, \alpha_2) > 0; \alpha_1 + \alpha_2 = 1$.

Given the above equation, one can calculate an estimate for the error term, μ_{it}, provided the coefficients are consistently estimated. But the problem is that the estimation suffers from a simultaneity problem, which means that the regressors and the errors are correlated, and thus, this problem makes OLS estimates biased. In fact, a firm's knowledge of its productivity affects its decision about its choice of investing new capital, hiring labor, and purchasing materials, yet this process is unobserved by researchers. This information asymmetry induces simultaneity bias, and the model (Equation (B.2)) fails to take account of unobserved productivity variables of the firm that provide biased estimates of input coefficients (Arnold).

To solve this problem, Olley and Pakes assumed that μ_{it} is the firm-specific efficiency because the residual of Equation (E.2) is the logarithm of total factor productivity (A_{it}). They split up this term into two terms as:

$$\mu_{it} = u_{it} + e_{it} \qquad \text{(E.3)}$$

where u_{it} is the productivity term assumed to be observed by the firm and e_{it} is the true error term containing both unobserved productivity shock and measurement errors.

[45] To illustrate the Olley and Pakes's technique, we follow Olley and Pakes, and Arnold.

Including the error terms the model is:

$$\ln Q_{it} = \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \gamma C_{it} + u_{it} + e_{it} \tag{E.4}$$

According to their proposition, capital is a state variable (though labor is assumed to be freely variable) affected by the distribution of the productivity shock, and investment is used to model the productivity shock. The productivity shock (u_{it}) is also a state variable which affects a firm's decision. Assuming higher values of u_{it} will induce higher investment, a function for the optimal investment decision can be written as:

$$I_{it} = I_t(u_{it}, K_{it}) \tag{E5}$$

which can be inverted to yield:

$$u_{it} = I_t^{-1}(I_{it}, K_{it}) = \varphi_t(I_{it}, K_{it}) \tag{E6}$$

Inverting such a function allows the unobserved productivity shock to be controlled with the observed variables. Under this assumption, Equation (E.5) can be written as:

$$\ln Q_{it} = \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \varphi_t(I_{it}, K_{it}) + e_{it} \tag{E.7}$$

Then define the function:

$$\psi_t(I_{it}, K_{it}) = \beta_1 \ln K_{it} + \varphi_t(I_{it}, K_{it}) \tag{E.8}$$

According to the Olley and Pakes technique, Equation (E.8), including a constant term (β_0) can be approximated by the polynomial (2^{nd}, 3^{rd}, 4^{th} or 5^{th} degree polynomials) in log-capital and log-labor. The partially linear model in Equation (E.7) is a semi parametric regression model, which identifies the production function coefficient of labor but not the coefficient of capital. That is, the equation does not allow us to separate the effect of capital on the investment decision from its effect on output. Thus, the use of a polynomial expansion of capital and investment as a control for unobserved productivity shock reduces the bias on the labor coefficient. The polynomials help provide industry specific and time varying productivity (Arnold).

Kee and Hoekman, and Abuka used the Olley and Pakes approach successfully in their studies. This technique does not need a specific functional form, yet it provides tractable solutions to the simultaneity problem without using instrumental variables that may be questionable (Driemeier).

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M.Sc.(Ag.), Horticulture	Bangladesh Agricultural University	1987

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Recent:

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Others:

Scientific articles- (2 nos.) and abstracts- (2 nos.) on production management of horticultural crops published in scientific journals;

Reports-(3 nos.) on socioeconomic condition of rural people;

Report (Edit)- Annual research publications (Bangladesh Agricultural Research Institute); Computer manual for researchers and field staffs;

Popular articles- (11 nos.) on different agricultural development aspects published in different Newspapers and magazines.

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