Sustainable Upgrading of Smallholders in Global Agri-food Chains

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Preface

When I started this research, I wanted to identify ways for people to cooperate toward a better use of natural resources and of the environment, especially in export-oriented agricultural activities. It was in discussions with my friend and colleague Rafael Díaz about his Ph.D. thesis where I realized the importance of studying these issues in a global chain perspective. By considering the global chain, we may see farmers as located at the initial stage of a long process of product transformation and transportation, where many agents with different levels of power are present. Therefore, the issue of cooperation in benefit of the environment must be analysed in a wide perspective, where collective strategies ought to consider all agents in the chain. In that context, with the guidance of Dr. Wim Pelupessy, I started my journey by developing a research proposal with the following purpose: *to study the benefits of cooperation in the use of environmentally friendly techniques to improve small producer income along global agri-food chains.* The research was complemented at its beginning with courses in Microeconomics, Econometrics and Industrial Organisation at the CentER, School of Economics and Management, Tilburg University.

Many people and institutions have contributed to this research, and with them I am very much indebted. At the institutional level, I must express my thanks for the financial support received from Dutch Cooperation, which, through the MHO Programme, financed my internships to the Netherlands, as well as other expenses associated with my visits to Tilburg University. I also want to acknowledge the support of my home institution in Costa Rica, the *Universidad Nacional,* which, through its Board of Scholarships, allowed me to dedicate time to this research. I am grateful for the patience they showed in spite of the delays in the presentation of the final product.

I want to recognize the academic environment in the two institutions where I worked on this research. My visits to the Development Research Institute (IVO) at Tilburg University were always very productive. At IVO, I found a strong academic environment and favourable conditions to read, find up-to-date literature and discuss the progress of the thesis. Meeting scholars from around the world was an invaluable experience and a source for me of personal development and transformation.

At my home institution, I also enjoyed a supportive academic environment for this research. My colleagues from CINPE served as a good discussion group, especially the Global Chains and Innovation Systems teams; they were always available when I asked for their support. Generally speaking, all my colleagues and friends at CINPE never failed to encourage me to keep working and finish this thesis.

A great contribution to this research was the opportunity I had to integrate it with the Central American research project entitled *Improved Sustainability of Agri-food Chains in Central America: a Techno Managerial Approach*, financed by the INCO DEV Programme from the European Union and coordinated by IVO, with the participation of CINPE and other Central American and European institutions. This project provided the opportunity to develop an important part of my fieldwork - especially that related to the Guatemalan snow peas case - and to discuss the ongoing results of my work. Special thanks to Mynor Maldonado, Byron Medina and Carolina Salazar for their support during my fieldwork in Guatemala. For the work in Costa Rica (coffee), I have to thank

Suyen Alonso, Randall Hidalgo and Arianova Garmendia, all former students of the Economic Policy Masters Programme at CINPE. They carried out the application of some of the questionnaires and accompanied me during some of the interviews and workshops. I also would like to thank Randall Hidalgo and my colleague Randall Arce for their help in the development of the model used to estimate the role of price on farmer decision making. This research would have not been possible without the contribution of farmers, processors, exporters and importers. To all of them I want to express my deep gratitude.

I owe my thanks to prof. dr. ir. Siem Korver for serving as the promoter of this thesis. His comments and suggestions were always challenging and forced me to delve deeply into the main findings and innovative issues of this thesis. I also want to thank dr. J.C. Engwerda for the previous review of the chapters related to game theoretical applications and for agreeing to be part of the Evaluation Committee. My thanks as well to prof. mr. R. C. J. Galle, prof. dr. ir. M. A. J. S. van Boekel and prof. dr. ir. J. G. A. J. van de Vorst for participating with the Evaluation Committee. I am especially grateful to prof. dr. Aart de Zeeuw, whose comments were of great help at the beginning of the process, when I was elaborating the game theory framework for analysis of the Guatemalan snow peas case.

I have no words to thank dr. Wim Pelupessy for his help, patience and constant support during the process of this thesis. His probing questions and helpful suggestions often implied a lot of work for me and served as the motivation and orientation of this research. Dr. Pelupessy was not only an academic adviser; he became the friend who was always worried about how we were living while we were in the Netherlands. Likewise, my deep gratitude goes to Elisabeth van Tilburg for her constant support in many respects - and for the excellent meals we enjoyed at their home.

Emi and the kids probably paid an important price during this process. They always encouraged me to finish, and helped in many ways. They never lost the conviction that this process was going to have an end, even when difficulties arose along the way. For them, I hope this thesis is an example to never give up in pursuing important goals in life. I also want to thank my brothers and sisters for their support, and dedicate this work to the memory of my parents, from whom I learnt that good things can be achieved with honesty and effort.

Finally, I want to thank Perry Miller for accepting the challenge of checking the English in this document, as well as Juan Manuel Chaves and Suyen Alonso (again) for their help in editing the book. In this respect, my gratitude comes once again for Elisabeth van Tilburg, whose qualified support at the final step of edition made the document ready to be printed.

Heredia, Costa Rica, April 2011.

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Acronyms

AGEXPRONT:	Asociación Gremial de Exportadores no Tradicionales de Guatemala
APHIS:	Animal and Plant Health Inspection Service
CBI:	Caribbean Basin Initiative
CENMA:	Centro Nacional de Mayoreo (National Wholesale Centre)
CEPAL:	Comisión Económica para América Latina (Economic Comission for Latin American Countries)
CIMS:	Centro de Inteligencia sobre Mercados Sostenibles (Intelligence Centre for Sustainable Markets)
CINPE:	Centro Internacional de Política Económica para el Desarrollo Sostenible (International Centre of Economic Policy for Sustainable Development)
Coopedota:	Cooperativa de Productores de Café de Dota (Cooperative of Coffee Producers of Dota)
Coopeleco:	Cooperativa de Productores de Café de León Cortés (Cooperative of Coffee Producers of León Cortés)
Coopellanobonito:	Cooperativa de Productores de Café de Llano Bonito (Cooperative of Coffee Producers of Llano Bonito)
Coopetarrazu:	Cooperativa de Productores de Café de Tarrazú (Cooperative of Coffee Producers of Tarrazú)
Coopeunion:	Cooperativa de Productores de Café de La Unión (Cooperative of Coffee Producers of La Unión)
ESECA:	Escuela de Economía Agrícola (Agricultural Economics School), Universidad Nacional Autónoma de Nicaragua
EU:	European Union
EUREPGAP:	Euro Retailer Group for Good Agricultural Practices
FAO:	Food and Agriculture Organisation of the United Nations
FAS:	Foreign Agricultural Service,
FOB	Free on board
FUNCAFE:	Fundación de la Caficultura para el Desarrollo Rural (Coffee Foundation for Rural Development)

FUNDE:	Fundación para el Desarrollo (Foundation for Development), El Salvador
FUNRURAL:	Fundación para el Desarrollo Rural (Foundation for Rural Development), Guatemala
GAFC:	Global Agri-food Chain
GCC:	Global Commodity Chain
ICAFE:	Instituto del Café de Costa Rica (Costa Rican Coffee Institute)
INCO-DEV:	European Research Cooperation for Development Programme
INEC:	Instituto Nacional de Estadísticas y Censos (National Institute of Statistics and Census), Costa Rica.
IRET:	Instituto Regional de Estudios en Sustancias Tóxicas (Regional Institute for Toxic Substances
LCA:	Life Cycle Assessment
LCI:	Life Cycle Inventory
MAGA:	Ministerio de Agricultura, Ganadería y Alimentación de Guatemala (Guatemalan Ministry of Agriculture, Livestock and Food)
NGO:	Non-Governmental Organisations
NSA:	Non-state actors
OCIA:	Organic Crop Improvement Association
OECD:	Organisation for Economic Co-operation and Development
OXFAM:	Oxford Committee for Famine Relief
PNUD:	Programa de las Naciones Unidas para el Desarrollo (United Nations Development Programme)
RFA:	Rainforest Alliance
SAFS:	Sustainable Agriculture Farming System Project
SAN:	Sustainable Agricultural Network
SHB:	Strictly Hard Bean
SIK:	Swedish Institute for Food and Biotechnology
SMBC:	Smithsonian Migratory Bird Center
SPNE:	Sub-game perfect Nash Equilibrium
TDH:	Two double hectolitres
UNAN:	Universidad Nacional Autónoma de Nicaragua (National University of Nicaragua)
UNCTAD:	United Nations Conference on Trade and Development
US:	United States
USDA:	United States Department of Agriculture
WTO:	World Trade Organisation

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Introduction

1.1 Purpose, problem and research questions

> *"There is a harsh reality for the farmer. He is requested not to use chemical inputs; however, the alternative inputs are more expensive and less productive. Also, when using the alternative inputs, the final product often looks bad, and the market does not compensate these additional costs; on the contrary, it punishes the farmer through the refusal of his product or by paying lower prices"* (Sicajá, 2004. Small scale snow peas farmer, Patsún, Guatemala).

The purpose of this research is to study the benefits of cooperation in the use of environmentally friendly techniques to improve small producer income along global agri-food chains. Recent case studies have shown that smallholders earn only a very minor part of the income generated in these chains (for the Guatemalan snow peas case see Espindola, 2006; and Hartley, *et al* 2009, Pelupessy, 2007, FAO, 2004 and Talbot 2004, for the coffee case, among others). The analysis of potential benefits and constraints of the use of environmentally friendly technologies for product differentiation is especially important in a world of market imperfections, unequal distribution of power, strategic linkages, and strategic behaviour.

The main innovation of this research is the explicit consideration of the consequences of imperfect markets and the relationship between the complexity of global agri-food chains and the use of environmentally friendly technologies to upgrade small producers in these chains.

Analysis of globalisation has been recently approached in the literature on the study of international trade and production networks. The purpose has been to understand "the ways in which people, places and processes are linked to each other in the global economy" (Bair, 2009: 1). The analysis of potential benefits and constraints of environmentally friendly technologies as tools for product differentiation requires study of the global commodity chain, which implies consideration of the whole range of activities involved in the design, production and marketing of a product (Gereffi, 1999: 38). A global agri-food chain (GAFC) is a particular type of global commodity chain; it refers to the production, transformation and commercialization of agri-food products. In the dynamics of the international trade of tropical agri-food products, commodities usually go from developing countries to developed ones, following a traditional North – South trade pattern. Keeping the global commodity chain in mind, developing countries in this pattern usually control the cultivation and first-processing stages, while developed countries control international commercialization and transport, final transformation (if any) and consumption. Thus firms in developing countries function as raw material suppliers.

Products are traded through specific markets along the whole chain: for fresh produce, processed goods (when there is some transformation), and final products. Usually these markets are imperfect (oligopoly, oligopsony or monopolistic competition), which is explained mainly by the operation of lead firms or a governance force that control the entire chain. Most global agri-food chains are considered demand-driven[1]. Lead firms are frequently located in developed countries, close to consumers, where markets are more profitable and entrance barriers are higher because of specific knowledge or investment requirements. Direct primary producers have little influence on prices and therefore have little influence on revenue distribution along the chain (Díaz, 2003: 40). This results in market power concentration and the existence of unequal economic gains in favour of agents located in developed countries.

The governance force of the chain also influences the technology used by local producers in developing countries, because it determines the quality requirements of raw materials from upstream segments[2] of the chain. These technologies have caused significant negative environmental impacts all along the chains, and these impacts are unequally distributed as well. Impacts from cultivation and the earliest agro-processing stages are among the most evident in this sense (Díaz, 2003; Flysjö and Ohlsson, 2006), and these stages are frequently located in developing countries.

Therefore, considering both the economic gains and the environmental impacts from the international production and trade of agri-food products, we find an unequal distribution of effects among countries and agents along the whole chain. Economic gains favour those firms situated closer to consumers because of their market power and value creation capacity, while negative environmental impacts are mainly felt in segments located in developing countries. We will address this issue in detail in chapters 2 and 3.

Solutions to environmental problems associated with international agri-food chains in developing countries should not be restricted to specific stages in an isolated manner; they require influence over the behaviour of local firms and consideration of the constraints and opportunities that the global chain governance structure provides.

Increasing environmental quality in the cultivation and first processing stages may give access to higher prices or new markets, but it may also imply transition costs or higher direct production costs due to the use of new types of inputs, as in the case of our farmer from Patsún, Guatemala. Both access to new markets and the higher costs of technological change are difficult issues for individual producers. Additionally, the quality of the final product - including environmental quality - is a direct result of

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[1] According to Gereffi (1999b: 41-44), there are two distinct types of international economic networks: ‘producer-driven’ and ‘buyer-driven’ commodity chains. Producer-driven commodity chains are those in which large transnational manufacturers play major roles in coordinating production networks (including backward and forward linkages); this is usually the case for capital and technology intensive industries. Buyer-driven commodity chains refer to those industries in which large retailers, branded marketers, and branded manufacturers play the pivotal roles in setting up decentralized production networks in a variety of exporting countries, typically located in the Third World. This pattern of trade-led industrialization has become common in labour-intensive, consumer goods industries. More recently, Gereffi, *et al* (2005) argue that the producer-driven versus buyer-driven dichotomy does not encompass newer forms of network governance. We will come back to this issue in Chapter 3.

[2] The agricultural stage and the initial processing of raw material are upstream processes, while downstream processes include international commercialization and final transformation (Díaz, 2003: 41).

actions taken by several agents in the same or in different segments of the chain. Therefore, coordination by firms in developing countries is needed to improve environmental quality and create higher added value along the chain.

Assessing the impact that environmentally friendly strategies can have on the upgrading of primary commodity producers in agri-food chains takes on special interest. Environmental cooperation can contribute not only to the solution of local environmental problems associated with production processes but may also lead to increased market power through the vertical differentiation that can be achieved by producing and selling a better quality product[3].

According to the previous argument, we present the research problem of this thesis as follows: how can local producers cooperate in the application of environmentally friendly technologies to improve their competitive position in global agri-food chains?

It will be demonstrated that the strategic application of environmentally friendly technologies to improve the competitiveness of local producers must consider the complexity of the chains and the degree of market concentration. Agri-food chains have different degrees of complexity, and this complexity can be determined in terms of product transformation, which denotes the distance from cultivator to final consumer. Also, market structure may influence the environmental behaviour of firms; cooperation may differ with the degree of market concentration.

Until now, little research has been done on the relationships between market structure and environmental behaviour in agri-food chains; the economic literature usually considers firms competing in homogeneous final markets. Application to international agri-food chains should model the strategic behaviour of firms, not only horizontally (among the same type of agents), but also vertically (between buyers and sellers), where both agents operate in different segments of the chain and neither necessarily sells to final consumers.

In order to discuss the use of environmentally friendly techniques to improve the economic position of developing countries' agri-food producers, the following research questions arise:

i. What is the role that environmental issues play as a source of or restriction on competitiveness in global agri-food chains?
ii. Are the complexity of the chain and degree of market concentration important for cooperation to increase environmental quality in production and trade processes?
iii. How could differentiation through environmental quality become a strategic tool for local producers to increase their revenues?
iv. When could market interventions or other types of public policies stimulate environmentally friendly strategic behaviour in global agri-food chains?

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[3] Considering the raw material composition of most developing countries' agro-exports, vertical product differentiation means quality differentiation in *raw materials* –intermediate markets- and not in *final goods*.

1.2 Objectives

General objective

To assess the conditions for the use of environmental improvements as strategic tools to upgrade developing countries' small producers in global agri-food chains.

Specific objectives

1. To identify opportunities and constraints that different types of global agri-food chains present for the improvement of competitiveness of small-scale farmers in developing countries. Special relevance is given to environmental quality in the cultivation and first processing stages as a source of competitiveness.
2. To characterize the relationship between the degree of market concentration and the ease (or difficulty) of cooperation to improve environmental quality in the cultivation and first processing stages of an agri-food chain.
3. To identify the role that strategic environmental behaviour can play as a tool for quality differentiation and upgrading of primary commodity producers
4. To propose policy recommendations to upgrade local firms in developing countries through environmental improvements. We will take into account the empirical validation of the assessment method of strategic cooperation.

1.3 Theoretical approach

The Global Commodity Chain approach (GCC) is an appropriate methodological framework for the study of the dynamics of agri-food production, transformation, and commercialization in developing countries[4]. As a global approach, GCC conceptualises a sequence of markets, taking into consideration that there is no direct linkage between raw material producers and final consumers. The objects of study are the firms that create value in the chain, as well as their strategies that include variables other than quantity, price, or investment. This approach also explicitly considers governance structure and distributional aspects along the whole chain and is not limited to the analysis of supply and demand in a specific and isolated market.

In line with these arguments, the theoretical framework of this thesis includes strategic coordination for improved environmental quality in agri-food chains. The strategic variable is environmental quality, and the goal is to improve local firms' incomes in a world of market imperfections and asymmetric chain power structures.

1.3.1 Imperfect markets

Recalling Gereffi, *et al* (1994: 3), Global Commodity Chains (GCC) are international value-creating networks of producers and merchants. They include primary production, processing, commercialization, and final-use stages. In most agri-food chains, the

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[4] The terms Commodity Chains, Global Commodity Chains and Global Value Chains have been "often used interchangeably to describe the sequence of processes by which goods and services are conceived, produced, and brought to market", although each of these chain constructs has its own particularities (Bair, 2009: 2). In this thesis, we adopt the term Global Commodity Chain.

sequence of economic and environmental input-output systems is: cultivation, processsing, packaging, transportation, distribution, transformation and final consumption (Pelupessy, 2003a: 5).

The linkages between chain segments (nodes) are mostly imperfect markets (Pelupessy: 2003a: 4). In local markets for agricultural products, oligopsonistic structures are common (Rogers and Sexton, 1994), where agreements appear in the form of contract farming systems (Sáenz, 2006). In the export market for processed product, which for most developing countries is effectively raw material, prices are determined mainly by the market power of buyers (oligopsony). Closer to final consumers, markets for intermediate goods are also controlled by few agents; in some cases we see a type of bilateral oligopoly, while in others we see typical oligopoly structures with monopolistic competition characteristics due to product differentiations.

The most important market for developing countries is the raw materials export market (after processing and packaging), and the *local key-agent* for these countries is the first processor[5] that finishes the national segment of the chain. This is the agent who transforms and packages the product for the raw materials export market. According to the market sequence mentioned above, this agent deals with suppliers of agricultural products (upstream) and buyers of the processed products (downstream). In both cases, this agent holds differing degrees of market power that reflect different competitive and cooperative relationships.

The organization of global agri-food chains, including the operation of a governance force that controls the whole chain and the existence of imperfect markets, presents at least three additional implications for the global chain. Firstly, markets along global agri-food chains are not independent from one another; quality standards, certifications, transportation and storage regulations, and the involvement or exclusion of certain agricultural providers are often decided by lead firms, which may be multinational traders, final transformers or supermarket conglomerates (Pelupessy, 2003a: 4). Secondly, it is common that, in this sequence of imperfect markets, neither information of consumer preferences nor corresponding gains will be properly transmitted to primary producers. Finally, as stated before, environmental costs and income may be unequally distributed among the different segments of the chain.

In this context, the study of market imperfections along agri-food chains is of great importance to the understanding of the asymmetric distribution of income, as well as the unequal environmental effects among different agents and countries in the chain.

1.3.2 Strategic coordination

In presence of market imperfections, neoclassical theory "based on the concept of a single product firm, operating in a perfectly competitive market with large number of competing firms all producing the same product under the same cost conditions and all facing the same market demand curve" (Hobbs, 1996: 15-16) is not the most appropriate theoretical framework for the analysis of pricing and other behaviours of

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[5] This agent usually handles transformation and packaging. In some cases, depending on the characteristics of the product and the complexity of the chain, it may handle only packaging. In general terms, we will refer to this agent as *the first processor*.

market parties involved in global chains (see also FAO, 2007). At the international level, traditional trade theories based on comparative advantages are also limited in their capacity to analyse the dynamics of the international agri-food trade path. The limitations are mainly determined by their own basic assumptions: that countries trade final goods and developing countries produce and export homogeneous products (Díaz, 2003: 47-48).

International production and trade analyses based on price competition should be complemented by analyses based on quality and other types of non-price variables (Pelupessy, 2003a: 4; Pelupessy, 2007). Different types of vertical and horizontal coordination mechanisms must be considered; horizontal coordination takes place among players at the same stage of a chain, while vertical coordination happens among players at different stages (Poulton *et al*, 2004: 521). This requires consideration of theories based on strategic behaviour in situations of high market power concentration and game theory, keeping in mind the implications of participation in a global chain.

In this context, the non-cooperative game theory approach is of great applicability, where the main objective is the study of multiparty situations with strategic interdependence and mutual dependency of pay-offs. A player's optimal choice will depend on his or her expectations of the choice of others playing the same 'game' (Church and Ware, 2000: 214). The approach will be used in this thesis to study the strategic behaviour of developing countries' firms in the choice of environmentally friendly technologies to improve incomes of small producers. In the application of global agri-food chains, players act either in the same market or in different segments of the chain.

The game theory framework also allows us to study the individual behaviour of firms, even if there are no formal agreements or contracts among them. The institutional framework defines the rules of the game and may be changed by the government, which does not intervene within the game itself. Once rules are defined however, they are given for all players. Policy recommendations can also be made to improve the institutional framework.

1.3.3 The environment as an integral component of product quality

The quality of a specific product includes intrinsic and extrinsic characteristics (Jongen, 2000: 265). The intrinsic characteristics refer to its physical properties, such as texture, appearance, and nutritional properties, while the extrinsic characteristics are those related to externalities of the production process, such as contamination from pesticides used during cultivation or water pollution from processing (see also Ponte and Gibbon, 2005: 2). In this thesis, we will focus on the environmental impact of the production and trade processes.

Negative environmental effects from cultivation and first agro-processing have been significant in global agri-food chains and these activities are mostly located in developing countries. These impacts are a direct consequence of the quantity and quality of the inputs or technological package used in the production processes.

Within a global chain, the quality of final products is the result of a complex set of local and international agents' actions along different stages. Although (local) farmers and processors make decisions about their technological package, they are strongly influenced by the international dynamics in the chain. Finally, markets for environmentally sound products may be associated with price premiums (Kremen *et al*, 2002: 6, 10), which represent good opportunities for local farmers and first processors to differentiate their product through environmental quality. This means that coordination among agents of the agri-food chains located in developing countries is strategically important to improve environmental quality, by differentiating the product and creating higher value-added.

1.3.4 Environmental technology for strategic coordination

Environmental quality is affected by the applied technological package or combination of inputs. In the cultivation stage for instance, relevant inputs are the quantity of agrochemicals and shade cover used; in this case, a specific technological package will be associated with higher environmental quality as agro-chemicals are reduced and shade cover is increased. In the first processing stage, the relevant variables may be water use, energy consumption, and the management and disposal of solid and liquid wastes. A specific technological package would result in a higher environmental quality when water and energy consumption from non-renewable sources are low, and solid and liquid wastes are properly managed.

When we define technology as the relationship between environmental quality and the applied technological package, we will have as many technology options as we have alternatives for the intensity of use of these relevant variables. If this intensity changes in a continuous manner, the environmental impact (or environmental quality) will change in a continuous manner as well. Thus we may say that, in terms of environmental quality, technology is continuous.

However, we may also consider the corresponding markets in our definition because they are important for the determination of prices, which are expected to rise as environmental quality increases. Prices may increase in a continuous manner with respect to environmental quality, when technology is considered to be *continuous*. Prices may also rise in a non-continuous manner with respect to environmental quality, which implies the existence of specific environmental conditions required to access a small number of specific markets. If that is the case, the technology is considered to be *discrete*, meaning that environmental quality will “jump” from one discrete situation to another, while moving from one specific market to another (market niches).

The coordination of actions to improve environmental quality in the cultivation and processing stages of the chain may be of strategic concern. Taking conventional technology as the point of departure, both farmers and first processors must switch technology to differentiate their product through environmental quality. This implies trying to obtain higher prices or trying to reduce the risk of being excluded from current markets. If a threshold number of producers adopt the sustainable technology, a positive “country or region image effect” may arise and a price premium is more likely to be obtained. We will address this issue in detail with the case studies of this thesis.

With regard to costs, switching towards environmentally sound technology usually requires high investment and withdrawal costs (Wilson and Tisdell, 2001). Nevertheless, acting strategically does present certain advantages related to the positive externalities that may appear when most firms move towards environmentally sound technology. Innovation in cleaner technologies requires links and cooperation that facilitate economies of scale; therefore, a threshold number of followers are required for these positive externalities to appear. For instance, at the grower level, pest control will be more effective if a minimum number of farms apply it. If a threshold number of first processors take actions against water pollution, then cleaner rivers will reduce the costs of water purification. The strategy also demands and promotes institutional arrangements that will not work properly when only a few firms (lower than the threshold level) participate.

Differentiation strategies may be based on the improvement of environmental quality. When this is the case, the more environmentally sound product may obtain a premium that offsets the investment and withdrawal costs of the technology change. To access these benefits, however, a threshold number of producers must make the decision to change technology, meaning that the pay-off for a particular farm does not depend only on its own actions.

1.4 Methodological framework

To reach each of the objectives of this thesis, we present the following methodological steps.

Objective 1: On the study of environmental quality as a source of competitiveness in different types of global agri-food chains.

A characterization and typology of agri-food chains is made in terms of complexity, where this is defined as the degree of product transformation indicating the "distance" from cultivator to final consumer. The potential for product differentiation (in contrast to selling the product as generic), the type of technology chosen (considering both environmental quality and markets involved, as defined in the theoretical framework), and the potential for coordination among agents are all related to the complexity of the chain. The main motivation of the research at this phase is to study the role of environmental quality as an opportunity for innovation and upgrading for growers and first processors in chains of different complexities. An empirical application of the research is done for two illustrative cases: the Guatemalan snow peas chain (simple chain) and the Costa Rican coffee chain (complex chain).

Objective 2: On the relationship between market structure and the willingness to cooperate for environmental quality.

This relationship is studied for the cultivation and first processing stages of the local markets of agricultural produce for the two cases. These markets are characterized by oligopsony structures and are important because they are the space where local producers can behave strategically to improve environmental quality and differentiate their product in international export markets.

The point of departure is the existence of market imperfections, where market structure can be characterized according to its proximity to one of two extreme situations: spot market transactions (full competition) or complete integration (full cooperation).

For the development of coordination mechanisms, non-price variables, such as quality, play an important role. Once we have characterized the structure, we will relate it to the decisions of technology choice and corresponding environmental quality.

For the snow peas case, the organizational structure of the chain is outlined, based on field and secondary data. Special attention is paid to competitive and cooperative relationships between growers and first processors through the local markets for the famers' output; in light of this structure, possible cooperative behaviour in favour of the environment is assessed.

In the case of coffee, we analyse in detail the role that price and non-price variables play in cultivators' decisions regarding the choice of technology and buyers of their coffee berries; mills develop price and non-price strategies to attract raw materials from farmers. An econometric model using panel data is applied to estimate the degree of sensitivity of the amount of coffee received by each mill as a response to variations in the prices offered to cultivators. The elasticity coefficient gives an indication of the power of each mill in their respective market segments. Also, we study the market structure and degree of competition or cooperation by considering the number of firms in the market and their competitive strategies. The influence of non-price variables in the producers' decision-making is evaluated through workshops with selected cultivators (experts' opinions). Among the non-price variables, we emphasize those related to environmental issues. Once the influence of price and non-price variables in the decision-making of the producer is determined, we evaluate the relationship between the market structure and cooperative behaviour in favour of the environment.

Objective 3: On the role that strategic environmental behaviour can play as a tool for quality differentiation and upgrading of primary commodity producers in agri-food chains.

At this stage, fieldwork data are used to study the opportunities for upgrading by strategically improving the environmental quality of producers. The game theory approach is applied and the strategic variable is the choice of technology and corresponding environmental quality.

In the analysis of both case studies, we focus on vertical coordination between farms and processing firms, in the respective global chains of different complexity. The different cases allow us to compare a short and simple chain that applies discrete technologies with a long and complex chain with continuous technologies.

Objective 4: On the development of policy recommendations

In order to infer general conclusions for the global agri-food chains, we compare the main differences and similarities between the two case studies, considering their different complexities and available technology options. However, regardless of the degree of complexity of each chain, we perceive that coordination among farmers and first processers favours a sustainable equilibrium in the adoption of clean technologies. Within this framework, policy recommendations are needed to support the application of sustainable technologies.

1.5 Thesis structure

This thesis has seven chapters. In Chapter 2, we characterize agri-food chains and present a chain typology according to degrees of complexity. In Chapter 3, we develop the theoretical framework of the research and present strategic coordination for the improvement of environmental quality in cultivation and first processing stages as a way for small producers along global agri-food chains to increase revenues. In Chapter 4, we present the empirical study of the relationship between market concentration and the willingness to cooperate in favour of the environment for the two case studies: the Guatemalan snow peas and the Costa Rican coffee chains.

In the following two chapters, we use game theory to analyse opportunities and constraints for the upgrading of primary producers and first processors for the Guatemalan snow peas chain (Chapter 5) and the Costa Rican coffee chain (Chapter 6). We conclude with Chapter 7, with a discussion of the main findings, general conclusions and policy recommendations to promote the move from conventional to more environmentally friendly solutions.

2

Chains of differing complexity: towards a global agri-food chain typology

2.1 Introduction

The consideration of environmentally friendly technologies for improving small producers' income along global agri-food chains requires a clear understanding of the different types of developing country chains. Global agri-food chains are international networks of value-adding production, transformation and international commercialization of agri-food products; these networks encompass all product stages, from cultivation to final consumption. The linkages of individual firms with these networks increasingly affect the competitiveness of the firms.

In these international networks, most tradable agri-food goods from developing tropical countries are raw materials. For these products, the export market is not the final stage, meaning that a significant number of post-export, value-creating chain segments exists (Pelupessy, 2003a: 2). A generic agri-food chain usually includes agricultural production, one or more industrial transformations and final consumption (Carranza and Díaz, 2005: 3); when considering the degree of product transformation, these chains present different levels of complexity. The complexity of the chain is associated with the technology used, and presents different implications for the possibilities of product differentiation and the potential for coordination. Therefore, a general agri-food chain typology will be of great help in the characterisation of distinct chain types.

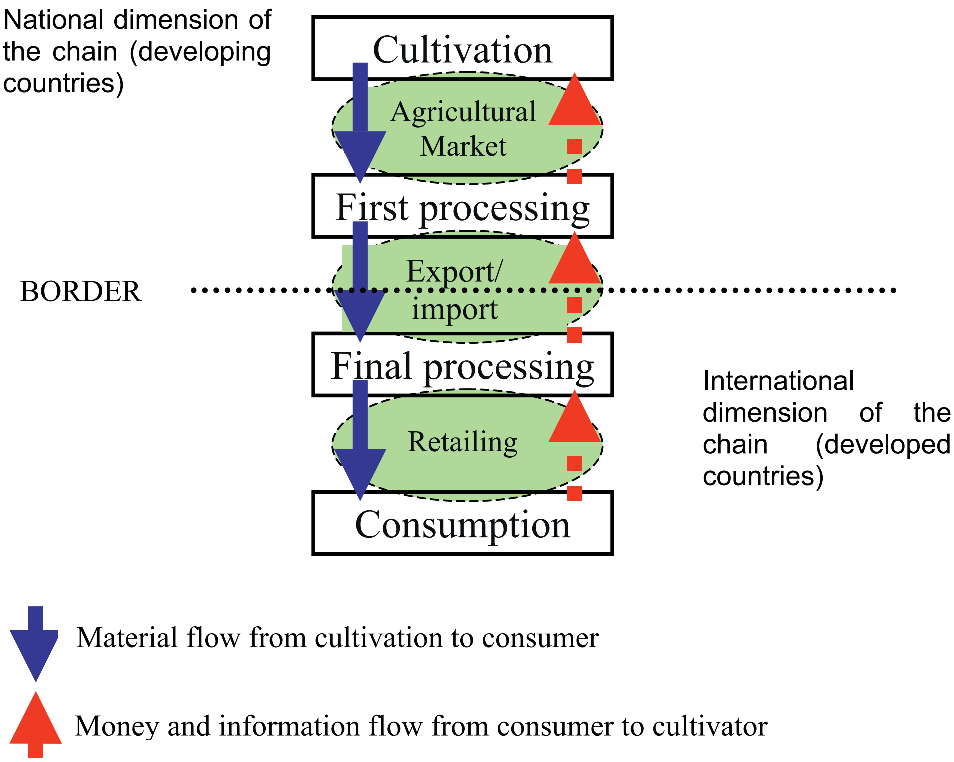
In this chapter we will create a global agri-food chain typology to identify opportunities for innovation and upgrading options for growers and first-processors in these chains. We propose three types of chains, according to their complexity: simple chains, as in the case of fruits and vegetables, intermediate chains for nuts and seeds, and complex chains for products such as coffee.

The chapter is structured into seven sections. After this introduction, in Section 2.2, we provide a general description of the main elements of the agri-food typology. Then, in sections 2.3, 2.4 and 2.5, we apply these elements to structure a general agri-food chain typology. We offer examples of each of the three chain types: fruits and vegetables in a simple chain (Section 2.3), nuts and seeds in an intermediate chain (Section 2.4), and coffee in a complex chain (Section 2.5). In Section 2.6, we characterize final markets for the two chains found in the case studies of this thesis: snow peas (simple) and coffee (complex). The purpose of this last step is to determine if final market dynamics differ with chain complexity. We close in Section 2.7 with conclusions of the chapter and elements for further analysis.

2.2 Relevant variables for an agri-food chain typology

A generic agri-food chain usually covers three types of activities: production (including any kind of transformation), distribution (commercialization and transport), and final consumption; the most common sequence is cultivation, local commercialization of agricultural produce, first-processing or transformation (including packaging), international distribution (export, import, and international transportation), final processing or transformation (if any), retailing, and consumption. We illustrate this sequence in Figure 2.1.

Figure 2.1: Material, income and information flows in a generic Global Agri-food Chain.



Economic input-output processes (cultivation and processing) as well as commercialisation (markets) activities characterize a typical agri-food chain. The downward arrows show material flows in the stages of production and transformation, from cultivation to consumption. However, in a second approach we may consider the consumer as the starting point for analysis of the process in which consumers' perception and preferences translate into product characteristics. This is called the chain reversal approach (Jongen, 2000: 264), shown in the figure by the upward arrows representing information and cash flows from consumers to cultivators. The dotted line of the upward arrows shows that information and economic gains are not always efficiently transmitted from consumers to cultivators due to unequal power distribution among agents participating in the chain. This characteristic is mostly present in the more complex chains, as we will see in Section 2.6 of this chapter.

Markets connect the stages of production and transformation along the chain, and they are usually imperfect, meaning that a small group of agents (buyers or sellers) control the dynamic of the specific markets. Imperfect markets and unequal power distribution among actors in the chain are effects of the chain governance structure, where lead firms located closer to consumers control the dynamics of the entire chain. Because these lead firms are located downstream, where activities tend to become more profitable, most agri-food chains are considered demand-driven (Pelupessy, 2003a: 3).

In global agri-food chains, the first stages of cultivation and first-processing are usually located in developing countries. The main actors in these activities are cultivators, first-processors, packers, and exporters. The export stage is usually closely linked to the first-processors, who do not interact directly with the final consumer (Carranza and Díaz, 2005). The downstream stages (international trade and transport, final transformation, retailing and consumption), are usually located in developed countries (Díaz, 2003). Activities closer to agricultural producers are labour intensive, while activities closer to consumers are capital and knowledge intensive. Because of the knowledge and capital intensive nature of the downstream stages, the actors involved in the initial stages cannot advance into the more sophisticated segments of the chain. This explains why developed countries concentrate the largest share of value-added produced along the whole chain. The division of activities among developing and developed countries is represented in Figure 2.1 by the horizontal dotted line.

In spite of this generic characterization, these segments do not always exist or operate in the same way in all agri-food chains. In some cases, final goods ready for consumption remain very close to their raw material form (fresh fruits and vegetables, for example), while in others the product requires some degree of transformation (as is the case with nuts and seeds). Sometimes the production and transformation process are longer and more complex, as in the case of coffee, and this complexity increases with the possibilities of blending. In the case of complex blends that may result in the chains of highly transformed products, the source of the original raw material may even be lost.

The degree of transformation in the chain is reflected in the distance between the agricultural raw material and the final product, or in other words, the difference between the grower's output and the final product. It is also a good indicator of the size of the chain, which has important implications for related markets and agents involved along the whole chain, as well as for transportation.

In this sense, we require a general typology of agri-food chains to understand the dynamic of developing countries' agri-food production and international trade. To elaborate the agri-food chain typology, our principle criterion for chain complexity is the degree of product transformation; this, in turn, is closely related to the technology applied along the chain. We will use this typology to analyse the role of product differentiation and coordination among developing countries' producers in the upgrading of these agents.

Before ending this section, we will explain in general terms the expected relationship among the following factors: chain complexity, the particular technology applied, product differentiation and coordination among agents.

As the reader will note later in Chapter 3 of this thesis, we define technology to include the quality and quantity of inputs (the technology package) used by producers and processors to achieve a specific product output. Our view of technology also considers the market involved, given that demand strongly influences the technology package used. By considering the markets involved, we take into account the quality requirements of consumers, competition and government regulation, among other elements. Both input-output systems and capacity for creation of value and profit may vary with different technologies (Pelupessy, 2003a: 4). Also, the technology chosen depends on production scale and has important implications for environmental quality. Short and simple chains are expected to offer a reduced and fixed number of technology options, while long and complex chains may offer a larger number of options along a continuous range. Intermediate chains are expected to move between these two extremes, depending on their similarities with simple or complex chains, as we will see later in this thesis. In Chapter 3 of this thesis, we will discuss in detail the issue of technology options, and in Chapters 4, 5 and 6 we will apply the concepts to a simple chain (snow peas) and a complex chain (coffee).

Based on the intrinsic characteristics of quality (Jongen, 2000), the feasibility for product differentiation is related to the degree of product transformation that occurs in the chain. In long and complex chains where the final product is a blend, usually only a small part of the product is considered main component. This part must fulfil special characteristics in terms of flavour, odour and texture, for example, and in many cases these characteristics are related to place of origin. The raw materials that fulfil these characteristics can be differentiated in the marketplace, and may obtain better prices than generic products. Additionally, differentiation helps meet the demand for environmentally and socially responsible products. We expect this type of differentiation based on the extrinsic characteristics of the product to depend on the complexity of the chain.

We consider that coordination is a key element that can positively affect incomes of local agents in a specific chain. We understand coordination to mean efforts or measures designed to make players within a market system act in similar or complementary ways, or work toward a common goal (Poulton *et al*, 2004). Horizontal coordination occurs among the same type of agents while vertical coordination is found among different types of agents in the market system. We are especially interested in the potential for coordination to improve the environmental quality of production processes along the chain. In this chapter, we will analyse the potential for coordination between growers and first-processors.

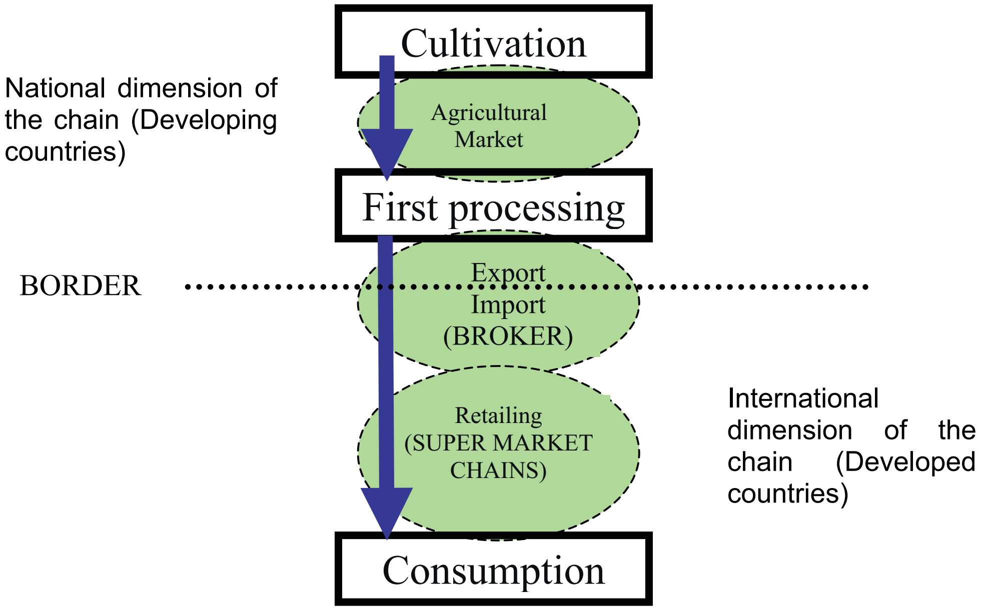
Based on previous considerations, in sections 2.4, 2.5 and 2.6 we will present an empirical agri-food chain typology. The typology characterises three types of chains according to their level of complexity: simple (fruits and vegetables), intermediate (nuts and seeds) and complex (coffee and other complex agro-industrial products).

2.3 Short and simple chains: fruits and vegetables[6]

2.3.1 Size and complexity of the chain

We characterise chains of fruits and vegetables as short and simple. This is because the final product (ready for consumption) does not undergo significant transformations from the original raw material produced at the cultivation stage. In Figure 2.2 we present the main segments of a general fruits and vegetables chain. Considering only on the materials flow from producers to consumers, we identify the chain segments as follows: cultivation, first processing, international commercialisation, local commercialization (retail), and consumption. The final product possesses the same characteristics as the original cultivated product, thus first processing consists only of washing, classification and packing.

Figure 2.2: Short and simple chains: materials flow and markets



Generally speaking, international brokers handle commercialization in this scenario; however, some initiatives exist to market the product directly, as we see in the Guatemalan snow peas case, where exports to the European market present shorter channel distance between first-processors/exporters and supermarkets (FUNCAFE, 2006: 21).

Fruit and vegetable chains are demand-oriented. The governance force of the chain is exercised by international brokers, who control international commercialization of the

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[6] The characterization of simple chains is based on the studies made for melon in Costa Rica (Sandí, 2004; Valenciano, 2004), snow peas in Guatemala (FUNCAFE, 2006; Jiménez and Pelupessy, 2006) and chayote in Costa Rica (Sáenz, 2006; Valenciano, 2004).

produce in strict cooperation with supermarket chains. These brokers buy the product from exporters, usually agents in developing countries, and distribute it to supermarkets. Brokers generally determine international prices, which then serve as reference prices for local agents (exporters, first processors and growers). Also, international brokers, in coordination with supermarket chains, pass quality requirements backwards to the cultivation and first-processing stages by defining standards, such as type, size, packing aspects, and certification requirements, if any. They also define the characteristics of the final product destined for consumers. The strength of these firms comes from the quality of the information they manage, especially in relation to consumer behaviour; this gives international traders a privileged position in the chain, because they not only monitor trends in the consumer market, but also can create future consumer preferences.

2.3.2 Type of technology and technology package

The technology package in a simple agri-food chain depends on the level of labour and land-intensity in the cultivation stage. In order to produce an attractive product, agents at this stage usually rely heavily on chemical inputs. This is especially relevant in the case of the Costa Rican chayote chain, where new pests have appeared (Valenciano, 2004: 85), or in the case of Guatemalan snow peas, where the crop is not originally from the tropics (Flysjö and Ohlsson, 2006).

In the first-processing stages, the main activities are selection, washing, packing and cooling; these activities imply the use of large amounts of water and energy. Labour also plays a very important role, while sophisticated transformation is not required.

Production scale can determine the capital intensity of the technology package used. For example, in the case of the Costa Rican melon chain, large scale producers are more capital intensive and more efficient, in terms of reduced unit costs of production. Scale also allows these enterprises to research improvements in their technology package or, for example, develop new varieties (Sandí, 2004: 30). Given the strict demand in export markets for fresh products, technology improvements are constantly required; large-scale producers are better able to handle this opportunity, as they often integrate cultivation, first-processing and export stages.

2.3.3 Product differentiation

In a short and simple demand-oriented chain, product differentiation is difficult to achieve at the export stage for two main reasons. First, the product does not undergo significant transformations from cultivation through consumption stages. Second, the international broker, in strict coordination with the supermarket chains, determines specific characteristics of the product and its presentation, thereby establishing cultivation conditions as well as processing and packing characteristics.

The case of chayote is particularly relevant. Even though this chain is demand driven, Costa Rican cultivators are trying to differentiate their product in the international market with respect to exporters from Mexico and Guatemala through quality and physical characteristics, such as shape and colour (Valenciano 2004: 68).

In spite of the difficulties in the differentiation of products found in some cases, we identify two general types of product differentiation. The first is promoted by international brokers to respond to specific consumer needs in distinct specific markets. In this case, brokers demand that first-processors/exporters meet specific product and packaging conditions.

The second opportunity for product differentiation arises from the environmental quality of production processes, both in the cultivation and in processing/packing stages. Processors can take advantage of new trends in environmental regulations, usually associated with higher prices. This is the case of the Guatemalan snow peas chain (Jiménez and Pelupessy, 2006).

2.3.4 Potential for coordination for the upgrading of primary producers

As mentioned before, the potential for coordination affects the identification of elements and strategies to increase income (positioning) of local agents (cultivators and first processors) in a specific chain. Current relationships that exist between growers and first-processors/exporters may limit this potential for coordination at this stage. For fruit and vegetable chains, market mechanisms determine the relationships between independent farmers and first-processors, where large processors - usually vertically integrated – exercise oligopsonic power in the market for fresh produce; farmers must simply respond to this reality. In the case of Costa Rican melon, for example, large transnational enterprises control the local market for fresh product and define the general dynamics of the cultivation stage. They control the cultivation, first-processing and exporting steps of the chain (Valenciano, 2004: 29), in what we have defined as vertical integration; small and medium exporters play a complementary role in this structure.

In the case of chayote, exporters exercise the highest possible market power in the local market. They are not only direct exporters but are also vertically integrated, so they produce most of their own supply. However, their role as buyers of fresh produce from other local agents gives them oligopsonic power which can impact local prices. According to Valenciano (2004: 72), exporters usually transfer low prices to local, non-exporting growers.

In the case of the Guatemala snow peas chain, the relationship between cultivators and first processors/exporters depends on the final destination of the snow peas in the international market. Most of the snow peas sent to the United States are grown by small-scale producers who do not export the product themselves. Usually local traders facilitate the relationship between the grower and the first-processor; they generally buy the fresh product at night markets and sell it to the first-processor. In the case of snow peas sent to the European Union, exporters/first-processors are more vertically integrated toward control of the cultivation stage. They also source part of their supply with independent farmers, sometimes through formal contracts; local traders do not play an important role in this case (Jiménez and Pelupessy, 2006).

Through this coordination mechanism, first-processors provide an impulse for local producer upgrading[7] through improved environmental quality as a source for product differentiation in the international markets. In effect, if first-processors make the

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[7] *Upgrading* is considered as a *shift* which firms or groups of firms might undertake to face competitive pressures or to improve their competitive position in global value chains (Humphrey and Schmitz, 2000).

decision to shift technology toward better environmental quality, we can expect cultivators to follow.

2.4 Chains of intermediate degree of complexity: nuts and seeds[8]

2.4.1 Size and complexity of the chain

We find that nut and seed chains generally present an intermediate degree of complexity. The produce is not consumed in its original state, but rather undergoes one or two intermediate processes of transformation. The first transformation process takes place in the country of origin and consists of sun drying, steaming, cooling and peeling, as in the case of cashew nuts (Flysjö and Olhsson, 2006: 68, 77), or shelling in the case of sesame seeds (Avendaño, 2006: 51). Both products are consumable after the first transformation, but they may also be consumed in a more elaborated form; this second processing stage is not usually performed in the country of origin. For example, in the case of the Salvadorian cashew nut chain, 90% of exported product is in its natural form as raw material for other products that require a higher degree of transformation. Among these products we find flavoured, roasted or baked nuts, and other by-products such as butter or paste. In this chain, the second transformation process usually takes place in India (Martínez, 2006:12), and the more elaborated product is re-exported directly to consumer markets such as the European Union (Martínez, 2006).

In the case of the Nicaraguan sesame seed chain, the international market for this product generally demands natural or peeled seeds, which are then partially transformed in the developed country into oil for human consumption (ESECA, 2006: 10; Avendaño, 2006: 51). Even though Nicaragua has the technology to process the product, this does not usually occur in the country, meaning that most of the production is exported as natural or shelled seeds (Avendaño, 2006: 51). According to ESECA (2006), from a total of 6,637 metric tons of sesame seeds produced during the 1997-98 harvest, 2,522 metric tons (38%) were exported after peeling or shelling, and the rest (62%) was exported in its natural form. No exports of oil or flour were recorded.

Taking into account the higher complexity of the processing stages, we find that nut and seed chains are longer in comparison to fruit and vegetable chains; Figure 2.3 presents the general structure of nut and seed chains. It is clear that the general structure differs from the fresh fruit and vegetable chain type shown in Figure 2.2, specifically in the longer and more sophisticated processing stage. This stage is not only more complex, as it implies more than just washing, classification and packing, but is also longer, especially in those cases where a second transformation process occurs.

In figure 2.3, we identify three main channels of production, transformation and commercialisation, from cultivation to consumption. The first channel, depicted with dark solid arrows, represents the case where the produce is consumed in its natural or peeled form and therefore does not require a second transformation process. The second channel is used when the produce requires a second transformation stage, but this takes place in the consumer country; we represent this channel with dotted arrows in the

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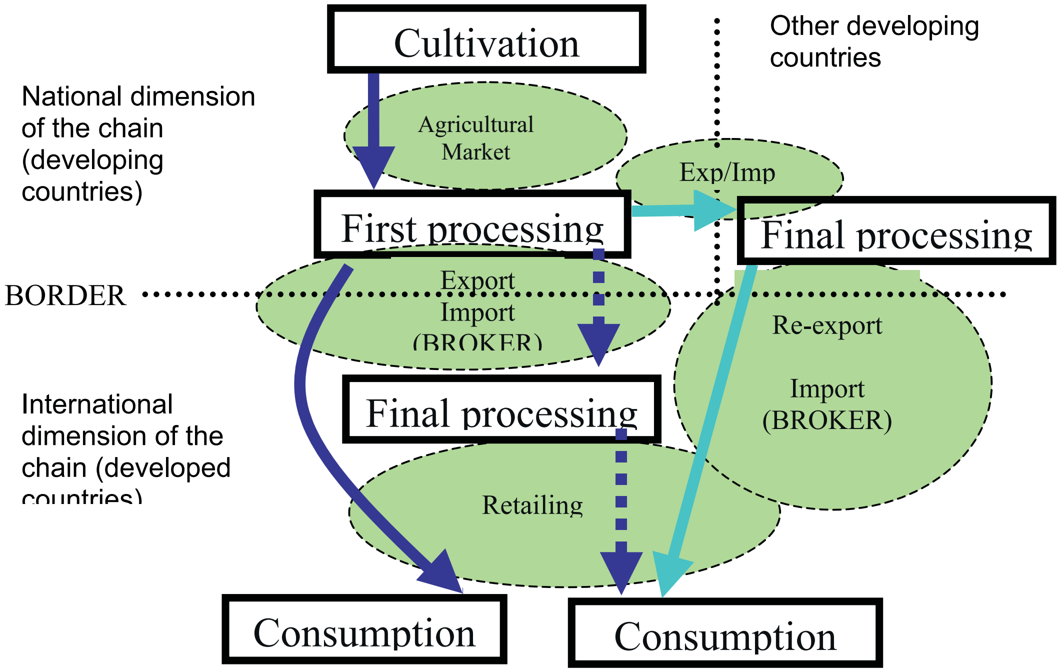
[8] The characterization of the chains of intermediate degree of complexity is based on the cashew nut chain in El Salvador (Flysjö and Ohlsson, 2006; Martínez, 2006), the cashew nut chain in Guatemala (Flysjö and Ohlsson, 2006) and the Nicaraguan sesame seed chain (Avendaño, 2006; ESECA, 2006).

figure. This is the case when sesame seeds are processed for oil or flour. Finally, the third channel, shown by the lighter tone arrows, represents produce that undergoes a second transformation stage in another developing country, as in the case of cashew nuts explained before.

Figure 2.3: Chains of intermediate degree of complexity: materials flow and markets



Nut and seed chains are demand oriented. In the case of the Salvadorian cashew chain, international traders located in the United States and Europe control the upstream commercialization process (from suppliers) as well as the downstream stages before final product reaches the consumer. These enterprises are large corporations that control a large share of the whole nut market (not only cashews) in the principle consumer markets such as the United States and Europe. Their market power arises from access to market information, as well as capacity to invest and innovate. Given the market power of these large firms, small agents located in producer countries face tremendous difficulties in accessing directly their final markets. In this case, local producers should attempt to develop vertical coordination with those trader agents located forward in the chain, in order to guarantee better payment for their product (Martínez, 2006: 54, 56-57).

In the Nicaraguan sesame seed chain, international traders also control the chain. According to ESECA (2006: 16), the mechanism of price transmission is:

International-traders → exporters → local-traders/first-processors → growers

Variations in world supply of sesame seeds directly affect this mechanism of price transmission.

2.4.2 Type of technology and technology package

In the cultivation stage, growers can produce nuts and seeds both conventionally and organically. In the Salvadorian cashew case, organic produce is the main export class. Organic plantations require organic fertilizers and inputs, as well as additional labour. Conventional plantations, on the other hand, do not require the extensive use of agro-chemical inputs; some of these are even managed in an uncultivated form, or combined with other agri-food activities, such as livestock or basic grains (Martínez, 2006: 9).

Nuts and seeds, such as cashew and sesame, do not require the use of sophisticated technology in the processing stage; in El Salvador, nut processing is performed with industrial, semi-industrial or traditional systems. In the organic case, which is the main type of cashew exported, the transformation process is considered semi-industrial (Martínez, 2006: 31).

The cultivation of sesame seeds in Nicaragua has existed since ancient times (ESECA, 2006: 6). Small and medium-scale producers and cooperatives cultivate this product using traditional, animal traction-based technology, or a combination of animal and mechanical traction. Producers do not use high quantities of agro-chemical inputs, and the seed is usually native (Avendaño, 2006: 48-49). Recently, sesame seeds have also been produced organically (Avendaño, 2006: 45).

2.4.3 Product differentiation

Environmentally friendly technologies have served as the source of product differentiation for nuts and seeds. Most of the Salvadorian cashew crop is organic, and the principle final markets are specialty stores located in Europe, the United States and Canada. In these markets, consumers are willing to pay price premiums of between 20% and 30% above commercial prices (Martínez, 2006: 13; Flysjö and Ohlsson, 2006: 66).

Sesame seeds produced in Nicaragua are very well known in the international markets; due to a high level of oil and protein, the quality and appearance generally exceeds international standards. This has generated opportunities for product differentiation and price premiums (ESECA, 2006: 26). However, even though the price for organic products usually exceeds the price of conventionally grown produce (ESECA, 2006: 24; Avendaño, 2006: 46), organic production of sesame seeds in Nicaragua is not significant in relation to conventional production (ESECA, 2006: 22).

2.4.4 Potential for coordination for the upgrading of primary producers

The majority of cashew plantations in El Salvador (64%) claim organic status, although they are generally not certified as such. Most of these plantations belong to cooperatives and are vertically integrated from cultivation to export. Individual, small scale producers have low participation in the cultivation segment, and the only channel available to their product is through intermediaries (Martínez, 2006: 9, 21)[9]. In the case

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[9] According to Martínez, 2006, conventionally grown nuts are consumed mainly in the local market. Plantations are managed conventionally, and sometimes even in uncultivated fashion. They belong to small scale producers who do not depend exclusively on the cashew activity; producers combine this activity with other agri-food activities such as livestock and basic grains. Plantations are spread along the Pacific coast of the country, where the climate is optimum. Due to this dispersion of

of Nicaraguan sesame seeds, local commercialization of the product occurs mainly through cooperatives (ESECA, 2006: 7).

In the case of the intermediate chains studied, the cooperative structure appears to play a very important role; therefore the potential for coordination is high. However, improvements in processing must occur (new technology options must be developed) in both chains for agents to take advantage of additional value creating activities. Also, local agents in developing countries must achieve better coordination with leading agents located closer to consumers.

Growers and marketers must capitalize on new trends towards environmentally and socially responsible products as an opportunity for product differentiation. This trend represents a growing market, especially in the European Union (Martínez, 2006: 40).

2.5 A long and complex chain: coffee

2.5.1 Size and complexity of the chain

The global coffee chain is long and complex; the final product, once ready to consume, has undergone a long process of transformation. The product the consumer obtains is very different from the harvested product at the farmer's gate. Apart from the transformation process, end-point coffee is usually sold as complex blends produced by large roasting companies.

Five segments can be identified in this chain: a) cultivation, b) milling or first-processing, c) international commercialization of green coffee, d) roasting and packing, and e) final consumption.

The first stage of the chain is agricultural production. Because of the agro-ecological conditions required by the coffee plant, cultivation is limited to tropical regions and warm climates. The raw material resulting from the agricultural stage is the coffee berry, the fruit of the coffee plant, which is delivered by producers to the milling plants.

The second stage is milling or first-processing. Mills receive the coffee grain or berry, and produce an end product known as green coffee. The berries are processed through one of two methods – the dry or the wet method (UNCTAD/WTO; 2002: 243). With the dry process, the grain is entirely dried and the green coffee product is mechanically obtained. The wet or washed process is divided into two phases: humid and dry. In the humid phase, the pulp is removed from the fresh berry as it is washed and dried. This must be carried out immediately after harvest to avoid loss of quality. The dry phase includes a process of grain selection after shelling. The grains are separated by characteristics such as weight, colour and size (Chaves, 2001: 32).

Milling or first-processing determines the quality of the coffee as much as the zone of origin and the altitude of plantations. The milling stage must preserve the quality of the grain, so if the process is deficient, product quality, acceptance and price may all be impacted (Villegas, 1999: 26). The intermediate product of the milling stage is green

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producers, they cannot organize, and the only way to reach the market is through intermediaries. Formal contracts or other types of long term relations between cultivators and traders are not common.

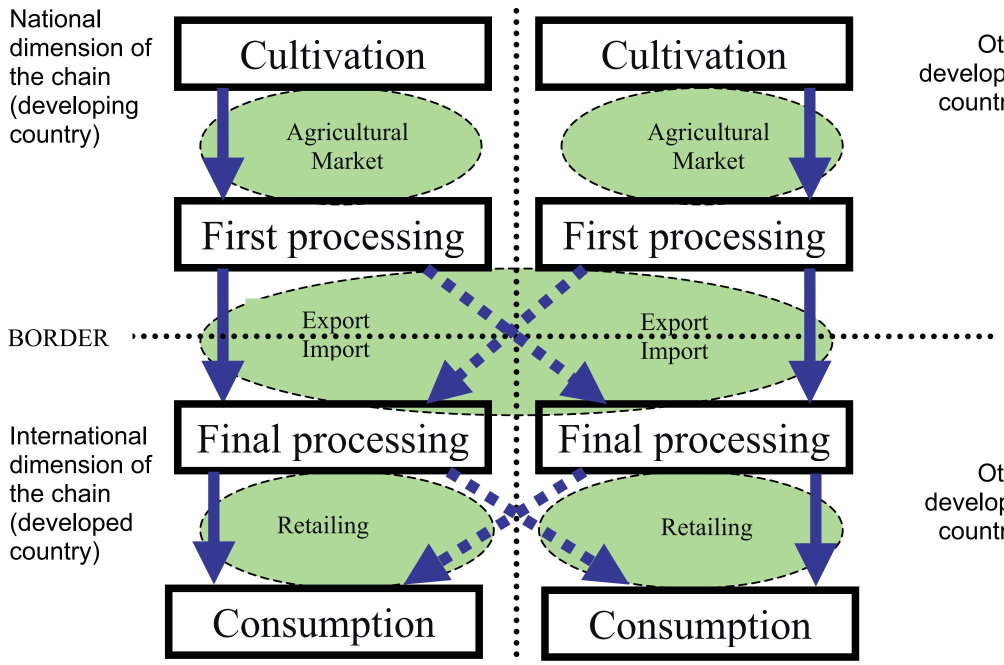
coffee, which is stored according to the exporter's requirements or sent directly to the roaster, in the case of national consumption.

The third stage is international commercialisation, both the export and import stages. Export is usually a volume-oriented process of concentration of bulk grain from several mills by one or more exporters. The green coffee is sold to the importer or directly to the roasters (Villegas, 1999: 26). The importer (or the roaster) buys coffee from several countries in order to obtain a broad range of types and qualities of coffee. This blending is a determinant factor later in the coffee chain at the consumer stage.

The following stage is roasting, which is the process of transformation from green coffee to roasted beans; the beans may also be ground at this stage. In the grinding phase, blends of different origins and qualities reduce dependency on a particular supplier and thereby reduce costs while catering to consumer preferences. In these blends, the so-called *suaves colombianos* (Colombian milds) are the primary beans used for flavour; proportionally, they are the smallest, and most expensive component of the blend, and they define flavour and aroma (Pelupessy 1998).

The last stage is final consumption, at home and other locations such as cafeterias and restaurants. Figure 2.4 presents the global structure of the international coffee chain and shows the different segments of the coffee chain and dimensions of the international trade..

Figure 2.4: Coffee as a long and complex chain: materials flow and markets



The intermediate product is the coffee berry, while the output in the first-processing stage is the product known as green coffee, which, after final processing becomes ground or whole bean roasted coffee. It is in this last stage where coffee can be mixed with other varieties from countries around the world; this is represented by the dotted diagonal arrows between the first and final processing stages. Once coffee is ready for consumption, it can be sold in the same country where it was processed, or elsewhere; this reflects the intra-industry coffee trade among developed countries (Díaz, 2003: 50).

2.5.2 Type of technology and technology package

Traditional technology in the agricultural stage prioritizes the extensive use of land. This technology is related to negative environmental impact, since in the growing stage the use of agro-chemicals such as pesticides, herbicides, nematicides and fungicides is necessary for control of diseases and pests that can affect the crop. In spite of this, the use of technology packages associated with the use of smaller quantities of chemical inputs is also common, and those cases are associated with environmental friendly markets (see Chapter 6 of this thesis).

In relation to the milling stage, as we explained earlier, industrial processing of coffee offers two distinct methods: the dry and the wet methods. The main difference between these methods is the use of water as a resource to transport and classify grain coffee, remove mucilage, and classify washed coffee (see UNCTAD/WTO, 2002: 243-44). In Costa Rica, the wet process is used because it generates very good cup quality, eliminating bitter flavours from the finished product. Nevertheless, this process generates two main by-products, pulp and waste water (Hernández, 2002: 48), with highly polluting consequences for the environment.

2.5.3 Product differentiation

From the perspective of primary producers, Costa Rican coffee presents important opportunities for product differentiation through quality; this has been recognized by high prices and premiums at the New York Board of Trade (ICAFE, 2007). Even though differentiation is an option for national agents of the chain (growers and millers), roasting companies have even more possibilities for product differentiation through the development of processes that add value to the primary product, or green coffee. Among these processes we find roasting, blending and packing, as well as branding, marketing, publicity and retail sales strategies.

Nevertheless, the consolidation of market niches for specialty coffee has generated opportunities to add value to the primary product. From the supplier side, this provides the opportunity to develop new forms of differentiation, such as differentiation through quality. For example, in the agricultural stage, altitude and location of origin suggest possibilities for denomination of origin, which can be a source of differentiation and higher prices in specialty markets. However, these differences may be lost in the following stages of the process (milling, transport and roasting) (Carranza and Díaz, 2005). In addition to differentiation through cup quality, differentiation based on environmental quality in the cultivation and milling processes can also be developed. The market now recognizes this differentiation through price premiums in the denominated markets of sustainable grown coffees: organic, fair trade and bird friendly (see Chapter 6 of this thesis).

2.5.4 Potential for coordination for the upgrading of primary producers

Mills perform first-processing in order to transform the berry into green coffee. For the Costa Rican case, growers choose the mill to which they deliver their coffee, and this is an opportunity to develop coordination mechanisms. Producers deliver their produce and receive advance payment, but the final price is determined some months later, when the mill sells the entire harvest and can report the final price received for its green coffee (see Chapter 4 of this thesis). The producer needs not sign a contract in order to deliver product to the mill, and his choice of mills is based on his own interests.

Considering this specific payment method for the coffee berries, we can identify three main channels between growers and first processors. In the first channel, cultivators deliver their crop directly to independent mills, most of them linked to exporters. Independent mills usually pay higher advance prices, so this channel is mainly used by those growers whose immediate interest is cash flow. Therefore, in this channel no strong coordination mechanisms are required and transactions are mainly determined by spot conditions.

The second channel relates to the cooperative system. Growers affiliate with cooperatives, creating important long term commitments. The growers who use this channel prefer more stable prices and are willing to maintain long term commitments; coordination mechanisms are necessary in this channel. Finally, the third channel is vertically integrated, where cultivators process their own crop in micro-mills. Although this channel currently handles a very small proportion of the total coffee harvested, its importance is increasing[10].

Within these schemes, mill decisions determine the potential coordination for environmental quality improvement. Coffee presents great potential in this sense, especially because environmental friendly markets for this product have emerged recently. Efforts must continue to increase quality and to market coffee as a differentiated product, not only through cup quality but also through higher environmental quality. Environmental innovations should be developed not only to obtain higher prices, but also to preserve local resources and maintain current positioning in the global chain.

Cultivators and mill operators should pursue innovations with the global chain as a reference, and not only the immediate buyer of the product. Greater knowledge of final and intermediate demands can help guide producers to increased power in the chain. The organization of the international coffee chain should reinforce the establishment of strategic coordination mechanisms in order to guarantee good quality of the final product, including environmental aspects.

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[10] From the harvest year 1999-2000 to the harvest year 2003-2004, the number of micro-mills has increased from 13 to 24, and for the harvest year 2006-2007 the number of plants was 53. In terms of the total harvest processed, all mills processed 0.26% of the total berry production in the harvest year 1995-1996, while in the harvest year 2006-2007 the proportion increased to 2.6% (ICAFE, 2007).

2.6 Final markets for snow peas and coffee: different dynamics for chains of different complexity.

In the chain reversal approach, when considering the need to translate consumer perception and preferences into product characteristics (Jongen, 2000), an analysis of final markets is of great relevance. However, final markets may differ with the complexity of the chain. In this section, we characterise final markets for two selected chains: snow peas (simple chain) and coffee (complex chain), in order to identify if market dynamics (quality management, product differentiation and availability of markets themselves) differ with the complexity of the chain.

2.6.1 Final markets for snow peas

According to data from FAO (2009), the total world imports of *green peas*[11] for the year 2006 were 243,817 metric tons, equivalent to more than US $267 million. The European Union imported 52.3% o the total, while the United States and Canada together imported 15.5%. At the country level, the main importer was Belgium (28.3%), followed by the United States (11.6%), Cuba (9.3%) and the Netherlands (8.6%).

The European Union market for green peas is very dynamic. Some countries play an important role as importers as well as exporters, meaning that re-export activity is relevant in this market. For example, The Netherlands and the United Kingdom imported 16.5% and 12%, respectively, of the total volume of green peas entering the European Union in the year 2006; however, at the same time, they were the responsible for more than 23% (13% for Netherlands and 10% for United Kingdom) of the total exports of this product to the region in the same year (FAO, 2009). These two countries thus are important distributers (re-exporters) of the product to the rest of Europe (MAGA, 2007: 19). In the case of the Netherlands, imports of this crop represented almost 50% of the local consumption of the country, while in the case of the United Kingdom this figure reached only 5%. This shows that the relative importance of local production to supply national consumption is different in these two countries. The case of France requires special consideration. This country is a very important producer of the crop; it imports only 5.4% of the total coming to the European Union while it exports around 27% of the regional total.

Outside the European Union, the most important suppliers of green peas to this market are Kenya (33.3%), Guatemala (10.8%) and Zimbabwe (4%) (Linares; 2009: 2; using data from FAO for the year 2005). According to Benjert (2008; personal fieldwork interview), there are no significant quality differences among these sources, so availability and trust are the main criteria used to justify source country for a purchase of this product. Also, when supply is sufficient, price may pay an important role as well (Van Poortvfliet, 2008; personal fieldwork interview).

Several facts explain the importance of availability of the product from diverse sources around the world. Importers and the processing industry require product all year. Given that the product must reach the final stage of the chain in its fresh form –it cannot be

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[11] We are using the figures of *green peas* because it is not possible to obtain aggregate data on *snow peas*.

stored for long periods of time- and also considering the crop's seasonal nature, importers buy the produce where it is available in any given month of the year.

The global availability of snow peas is presented in Table 2.1. We see that seasonality gives a natural advantage to countries because world production is distributed throughout the year; this is also advantageous for the buyers.

Table 2.1*:* Yearly availability of snow peas for the European Union

Country	***OCT***	***NOV***	***DEC***	***JAN***	***FEB***	***MAR***	***APR***	***MAY***	***JUN***	***JUL***	***AUG***	***SEP***
Peru	X	X	X									
Guatemala		X	X	X	X	X	X	X				
Kenya	X	X	X	X			X	X	X	X	X	X
Zimbabwe	X							X	X	X	X	X
Zambia								X	X	X	X	X
Morocco				X	X	X	X	X				
Egypt				X	X	X						

Source: Benjert, 2008. Personal fieldwork interview.

In spite of the availability of the product, in those months when the product is supplied by several countries at the same time, costs take on more importance. Where this is the case, Guatemala and, especially, Peru have disadvantages with respect to the African countries not only because of the distance –which affects transport costs- but also because labour costs are lower in these African countries (Santizo, 2008; personal fieldwork interview). This is important since two of the main variables in final export price are production and transportation costs (Benjert, 2008; personal fieldwork interviews)[12]. Moreover, most African countries receive tariff preferences in the European Union market (MAGA, 2007: 19); this clearly reduces the competiveness of Latin American countries.

Regarding the issue of specific suppliers from whom to buy, the main criteria considered by importers is trust based on long-term relationships and mutual commitments, according to Benjert (2008). Importers become accustomed to working with the same growers/exporters, and growers usually export only to the same importing company. This type of relationship does not require formal agreements among the parties (Benjert, 2008; personal fieldwork interview).

Companies usually market snow peas as part of a broader supply of fruits and vegetables, and all of these products follow more or less the same distribution channel. For the European Union, this channel is depicted in Figure 2.5.

Producers supply the market themselves, or through an exporter[13] or other intermediaries (wholesalers). Most of the produce is packed in the country of origin. Brokers and importers supply the processing industry and other re-exporters. As we saw previously, re-exporting is very common in the distribution channel to the European Union, and sometimes the processing plant also does the re-export activity.

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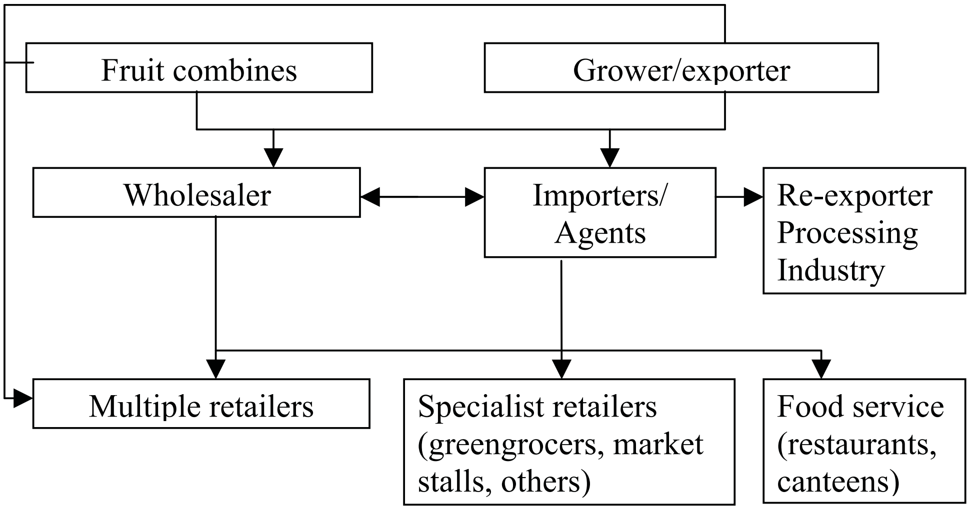
[12] According to Benjert (2008; personal fieldwork interview), final export prices are usually determined by mutual agreement, based on long term relationships between exporters and importers. Production and transport costs are a reference, but prices are adjusted to market conditions at the moment of the transaction.

[13] Chapter 4 of this thesis will address in detail the local stages of the Guatemalan snow peas chain.

Figure 2.5: European Union. Fruit and vegetable distribution channels



Source: CBI (2009: 19)

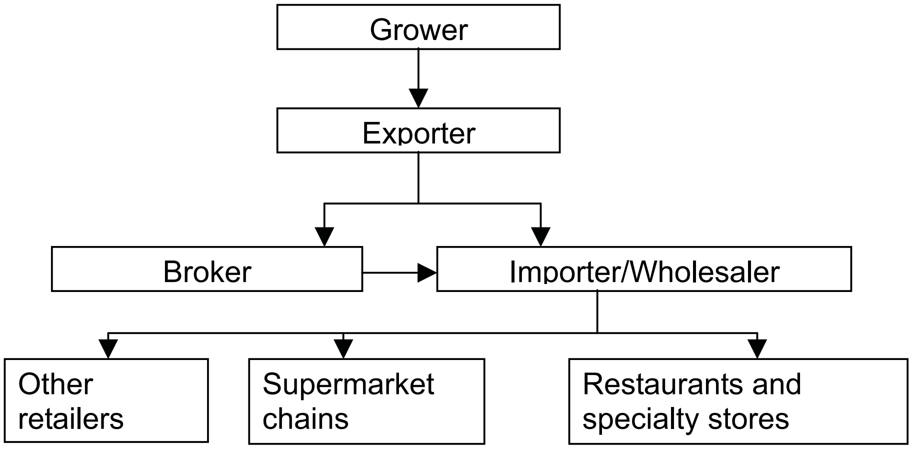
Wholesalers and importers also supply retailers as well as other specialized sales outlets: supermarket chains for example, or, even closer to consumers, restaurants and other food service points. According to Benjert (2008), in the case of the European Union, most produce moves through direct importers, not brokers; these importers usually distribute the product with certain exclusivity to a retailer or a supermarket chain. Processing activities are not significant since most of the produce is packed at the source of origin.

The United States is the second most important global market for snow peas, and the most important for the Latin American countries. The main providers for the United States market for *green peas* are Guatemala, Peru and Mexico, which supplied 64%, 20% and 15% respectively of the total green peas imported by the country in 2005 (data from FAO, 2009). The United States also supplies a very important proportion of the demand for snow peas with domestically grown produce. Domestic production is mainly located in California and supplies local consumption especially between May and September. According to AGEXPRONT (2004: 3), local production supplied approximately 40% of internal demand between 1995 and 1999. Exports represented 13% of the green pea imports of the country in the year 2005 (FAO, 2009). Considering the relative importance of local production, we should not expect re-exports to be significant.

Quality criteria are less strict in the United States market than in the European Union. According to Polanco (2008; personal fieldwork interview), the European market requires very high quality, for which consumers are willing to pay, while the United States has not maintained a high standard in this regard. Quality is also more relative to availability for the United States market than for the European Union (Santizo, 2008; personal fieldwork interview). If the supply of snow peas in any market is not sufficient to satisfy the demand, quality standards are reduced in order to maintain a certain volume; this is more likely to happen in the United States than in the European Union.

As in the case of the European Union, the commercialisation channel to the United States market follows the same distribution channel of other fruits and vegetables. The United States' case is depicted in Figure 2.6.

Figure 2.6: United States market.
Fruit and vegetable distribution channels



Source: Based on AGEXPRONT (2004) and personal fieldwork interviews to Guatemalan exporters.

As explained in Chapter 4 of this thesis (Subsection 4.2.2), snow peas growers move produce to the exporter mainly through an open market channel largely controlled by local brokers (called *coyotes*). The relationship between producer and exporter is not as close as it is in the European Union channel. The exporter, who sometimes also produces some of the commodity to be exported, sends the product directly to an importer or to an international broker. According to Santizo (2008; personal fieldwork interview), most of the produce that goes to the United States market goes through a broker, who receives a commission for the transaction without facing significant risks. At the last stage of the chain, the importer distributes the produce to supermarket chains and other retailers, as well as to restaurants and specialty stores. Re-exports are not considered an important activity in the snow peas market in the United States, as is the case for the European Union market.

The internal demand for this product in the United States market increased over the last 20 years. While in the past the Chinese community dominated local consumption, in recent years use of the product has increased in restaurants, salad bars and supermarkets, where the product is offered in different forms, such as frozen, fresh and pre-cooked (AGEXPRONT, 2004: 9).

What can be said about the income distribution along the snow peas chain? We have not found sufficient information on costs at any stage of the chain to calculate the value added distribution along all segments. However, for the Guatemalan case, Espindola

(2006: 36-37) calculates mark-up at each stage as a percentage of the consumer price. The figures are different for the European Union and the United States channels. While in the European Union channel the exporter receives the highest share (68%), in the United States channel the highest share is received by the retailer (41%). Even when costs are higher for those who export to Europe, the margin after subtracting costs is also higher: US$ 1.14 for those who export to the United States and US$ 2.71 for those who export to the European Union (figures does not include transport costs, which are higher in the European Union market). Farmers and exporters to the European Union channel obtain a larger share of the consumer price while importers and retailers in the United States channel obtain the larger share.

2.6.2 Final markets for coffee

Coffee is one of the most popular beverages in the world. Global consumption for the 2005/06 harvest is estimated in 119 million bags of 60 kg each, equivalent to a daily average of nearly 20 million kilograms. 26% of global consumption originates in the producing countries, whereas 74% originates in the importing countries. World per-capita consumption after year 2000 has increased from 4.43 kg in the year 2000 to 4.47 in 2005 (FAS-USDA, 2006: 2); where 4.6 kg/year has been the average for the Western markets and only 0.7 kg/year in coffee producing countries (Pelupessy, 2007). Finland and Denmark are currently the most important per capita consumers, with 12.7 and 9 kg respectively for the year 2005, followed by Sweden and Belgium-Luxembourg with an average consumption of 7.71 and 7.21 kg for the same year (FAS-USDA, 2006: 19). For exporting countries, it is important to stress the case of Brazil and Costa Rica, where per capita consumption is similar to that of importing countries, and even slightly higher than the United States and Japan (Pelupessy, 2007).

The yearly rate of increase of world coffee consumption is estimated to be around 2% from the 1994-95 crop to 2007-08, with a slightly higher increase of 2.8% in the last harvest with respect to 2006-07 (ICAFE, 2008: 15). According to the International Coffee Organisation (quoted by ICAFE, 2008: 15), the source of this trend is the increasing consumption in emerging economies and exporting countries. Since the early 1980s, the most spectacular growth has been experienced by Japan, with average yearly growth in consumption of more than 3.5% (UNCTAD/WTO, 2002: 12). However, the most important market is still the United States, with an average share of total world consumption of 17.4% during the period 2002-2007 (ICAFE, 2008: 16). Nevertheless, United States consumption has remained virtually unchanged since the early 1980s (UNCTAD/WTO; 2002: 12). As a block, the European Union is the most important market with 42% of the total world consumption in the first decade of this century (Pelupessy, 2007).

It is generally accepted that the best possibility for growth is to increase the number of coffee drinkers (Pelupessy, 2007; ICAFE, 2008), since the most important consumer markets are already saturated in terms of the number of daily cups per consumer.

As mentioned before (Section 2.5 of this chapter), the coffee chain is characterized by its extended length and complexity, meaning that from plantation to cup numerous segments exist and various activities take place, and the product undergoes significant transformation. Multiple agents perform these processes of production and transformation along the chain: producers, millers and roasters; the interactions among these agents are expressed through market transactions. Apart from producers and mills, additional agents enter the chain: exporters, importers and other types of intermediaries. Therefore, apart from the final market at the end of the chain, several intermediate markets are also important: the berry, green coffee and roasted markets. All these markets are imperfect (Pelupessy, 2007) and highly concentrated, as we will see in more detail here, in the case of markets for green and roasted coffee[14].

Most internationally coffee is traded in its green form. According to UNCTAD/WTO (2002: 31), green coffee accounted for 82% of gross coffee imports in 2001, while roasted and soluble coffee represented 6.6% and 10.7%, respectively. Even as imports of roasted coffee have increased in the last years, a very small proportion of this total comes from producing countries.

It is estimated that 77% of coffee consumed globally is ground roasted, while the remaining 23% is instant. Roasting is a highly controlled activity in importing countries. Around 90% of the coffee consumed in importing countries is roasted in those countries (UNCTAND/WTO; 2002: 32), and the market for this product is dominated by large multinationals; Phillip Morris, Sara Lee/DE and Nestlé controlled 45% of the market in 2001 (FAO; 2004). Blending is another important characteristic of this market. Most of the coffee consumed in importing countries is blended, which is a technique used by roasters to maximize flavour and fragrance. At the same time, blending evens out the finished product and reduces roaster dependence on one source of supply. The exact composition of blends is proprietary information, and this constitutes an important entry barrier (Pelupessy, 2007).

As mentioned before, 23% of the ready-for-consumption world coffee market is instant or soluble, and the balance ground roasted. It is estimated that 83% of soluble coffee is processed in the importing countries. As in the case of roasted and ground coffee, the instant coffee market is also highly concentrated; Nestle and Kraft Foods account for around 75% of the world market, while Nestle alone supplies more than 50% of the world demand (UNCTAND/WTO; 2002: 34).

Roasters market their coffee to two distinct market segments: the retail (grocery) and the institutional (catering) markets. Most retail sales are channelled through supermarket chains owned by the roasters themselves; however, this is not always the case. Nevertheless, supermarket own-brands now account for a large proportion of retail coffee sales, while the number of small independent food outlets is diminishing (UNCTAD/WTO; 2002: 29). According to FAO (2004), 30 agents accounted for 33% of retail sales in the year 2001.

Moving backward in the coffee chain, roasters generally buy their coffee from international trading companies, who in turn buy from producing country exporters. As mentioned before, most internationally traded coffee is green coffee, which makes this a primary market for producing countries. This market is also very concentrated: four international trading companies accounted for 39% of the international coffee trade in the year 2001 (FAO; 2004). These companies act as oligopsonists when buying green coffee from producing country exporters, but act as oligopolists when selling to roasting

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[14] We present an analysis of the market structure for berry coffee in Chapter 4 of this thesis, in a case study from Costa Rica.

companies. In the last case, however, the market presents a situation that we denominate bilateral oligopoly because, as shown before, the roasting industry is highly concentrated as well; thus, a reduced number of companies concentrate a high proportion of purchases of the grain for industrialization (oligopsonic).

Intrinsic characteristics of coffee such as body, acidity and aroma are determined by a combination of the botanical variety, topographical conditions (including geographical location and altitude), weather conditions and the care taken at each step of the chain from cultivation to consumption: growing, harvesting, storage, export preparation and transport (UNCTAD/WTO; 2002: 245; Pelupessy; 2007). Taking into account botanical variety and topographical conditions, the International Coffee Organisation classifies coffee into four groups: Colombian mild Arabicas, other mild Arabicas, Brazilian and other natural Arabicas, and Robustas. South and Central American countries produce over 80% of Colombian and other mild Arabicas, while Brazilian and other natural Arabicas are dominated by Brazil, with a low participation by some African countries; Asia and Africa dominate in Robusta (Díaz, 2003: 88). Consideration of origin is very important for blending, and becomes a source of product differentiation. Traders may place premiums on certain lots of grain coffee for their flavour characteristics and exclusivity.

We consider extrinsic characteristics a second source of product differentiation for coffee, and these characteristics relate to sustainability of production and transformation processes. Among the most important sustainable coffees are organic, Fair Trade, Utz Kapeh, Rain Forest Alliance and shade grown certifications. These coffees held a share of 1.5% of global coffee export volume in 2003; however, their share increased slightly to 2.6% for 2005 (Pelupessy, 2007: 23).

The market sequence of the global coffee chain is presented in Figure 2.7. We find that the shape of the figure originates from the different levels of market power and the number of actors, as explained earlier[15]. The high concentration of international commercialization and roasting segments in the hands of large transnational enterprises, located in importing countries, allows these companies to drive quality criteria and product types required by the market. Even when big supermarket chains compete with the roasters, the supermarkets specify the type of coffee they want by establishing specific blends and maintaining their own-brands (UNCTAD/WTO; 2002: 30; Pelupessy, 2007). Through this mechanism, they exert influence on prices and other conditions, and thereby constitute the governance force of the global chain jointly with big roasting companies (Pelupessy, 2007).

The low market leverage exerted by coffee producing countries as well as the concentration of high value-added activities (roasting) in importing countries imply an unequal transmission of prices paid by final consumers to local agents in producing

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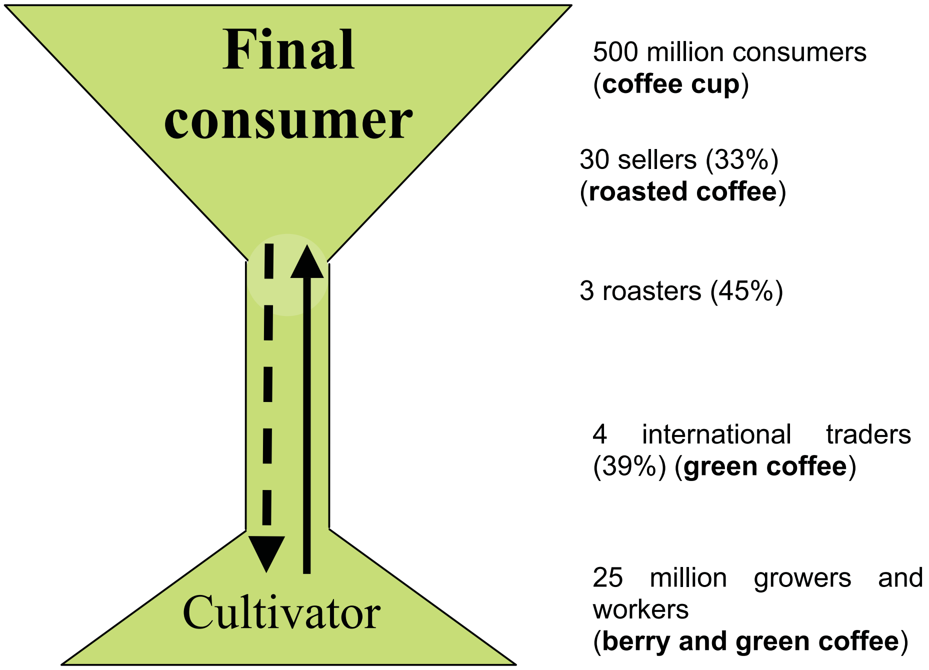
[15] For illustrative purposes, we have added to the figure the approximate number of actors for each segment of the chain, as well as the percentages of the total value traded in each segment that is controlled by the number of actors indicated. For example, in the segment of international commercialization, four international traders control 35% of the total green coffee market. However, it is important to clarify that a reduced number of actors does not necessarily imply increased market leverage. Market leverage is determined by the existing horizontal and vertical competitive relationships among agents. For instance, during many years Brazil and Colombia controlled more than 50% of the global coffee market, but this fact did not award market leverage in the same proportion (see Karp and Perloff, 1993).

countries (Pelupessy, 1998: 11). Moreover, the existence of highly concentrated markets does not allow the transmission of price reductions from export markets to consumers (see Morales and Berggren, 2002; and Bettendorf and Verboven, 2000 for an analysis of the unequal price transmission in coffee from the export market to consumer, for the Swedish and the Dutch case respectively). This unequal price transmission from consumer to producer is illustrated in Figure 2.7 by the downward arrow, which is presented as a dotted line to reinforce the incomplete nature of this information flow. The evidence shows that while consumer prices have remained stable, green coffee prices have shown large fluctuations (Pelupessy, 2007).

Figure 2.7: Sequence of markets in the international coffee chain



The absolute values represent the number of actors in each segment of the chain, and the figure in brackets represents the respective percentages of the total value traded in each segment that is controlled by the indicated number of actors.
Source: Pelupessy, (2007). Figures of the number of actors are for the year 2001, taken from FAO (2004).

Concentration of market power along the global coffee chain explains the unequal distribution of economic benefits. According to FAO (2004: 33), in the global chain structure for the year 2001, the agricultural segment obtained the lowest proportion of final sales generated by the commercialization and consumption of coffee, at 10%. Furthermore, approximately 25 million producers and workers shared in this 10% portion. Meanwhile, roasting and retailing generate 29% and 22% respectively of sales, while the number of actors is relatively small in these segments. Other studies roughly confirm this situation (Pelupessy, 1993; 1998; 2001; Ponte, 2001; 2002; Talbot, 1997; 2004. See also Hartley, *et al* (2009) for an application to the Costa Rican coffee chain[16]). Talbot (1997) studies not only the distribution of income, but also the distribution of surplus between producing and importing countries along the global coffee chain. After explaining the difficulty in obtaining accurate data on costs and profits among producing and importing countries, he concludes that before the 1980s, roughly half of the total financial benefit generated along the entire chain stayed in producing countries. However, the situation changed dramatically after 1986 when a massive shift of benefit from producing countries to transnational enterprises located in importing/consuming (core) countries took place. The main explanation for this shift is the elimination of the International Coffee Agreements and the liberalization of the market, which provided an opportunity for transnational enterprises to exert their market power and control prices in both directions: backward (green coffee) and forward in the chain (processed coffee for final consumption).

Environmental costs may also be unequally distributed along the coffee chain. By partially applying the Life Cycle Assessment technique (LCA), using the Life Cycle Inventory (LCI) of environmental impacts, Díaz (2003) concludes that the agricultural stage seems to be the source stage for most of the classified environmental impacts present in the Costa Rican coffee chain, even when important impacts can be found in the first processing segment (developing countries) and the final consumption segment (developed countries) (Díaz; 2003: 145-146; 289-90). Considering that coffee is a demand driven chain, the technology packages used in the cultivation and first processing stages have been in line with the requirements of international buyers, and these technology packages have caused considerable environmental impact in the developing countries segments of the coffee chain. Also, if roasters change their environmental requirements, we could expect some growers to be excluded from the market if they do not meet these new requirements.

2.6.3 Conclusions on the relative importance of final markets in agri-food chains of different complexity

From the specific analysis of final markets for the two chains of different complexity, we can draw the following conclusions:

1. Both chains are demand-driven, and retailers, especially big supermarket chains, define the characteristics of the product they want. The mechanism for this, however, varies for each type of chain. In the simple chain, there are no special quality requirements because the product does not undergo significant transformation. In this case, the criterion is more related to availability. However, in the complex chain, given the product transformation performed and the opportunity to create a product of specific quality through blending, quality management plays a very important role and the origin of the product becomes highly relevant.

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[16] In a more specific study, Hartley, *et al* (2009) estimate the income distribution along the Costa Rican coffee chain for the year 2004. They differentiate between two different coffee chains for the Los Santos region in Costa Rica: the conventional and the organic. In both cases, they conclude that the retailer in the consumer country captures the highest percentage of total revenues generated. For the conventional chain, retailers obtain 79%, while local growers obtain 9%, local mill 6%, importer 2%, and roaster 5%. For the organic chain, the income distribution changes slightly, revealing a better position for local growers; they obtain 14% of revenues, while mills obtain 3.5%, importers 1%, roasters 4.5% and retailers 77%.

As a result, based on the intrinsic characteristics of the product, product differentiation is more likely in the complex chain, and at the same time we can find a broader range of available markets.

2. Unequal distribution of incomes is evident among the different agents in the chain, although we cannot draw conclusions on the distribution of value-added due to the lack of information on costs in some segments of the chain. In all the studies consulted (Espindola, 2006 for snow peas; FAO, 2004 and Hartley *et al*, 2009 for coffee) the segments located in the importing and consumer countries (importers and retailers in the simple chain and roasters and retailer in the complex chain) obtain the largest percentage of total chain incomes. The exception to this is found in the chain of snow peas exported to the European Union, where the exporter obtains the largest share of revenue. However, when comparing two distinct scenarios (a conventional and a more sustainable one), growers obtain a higher proportion of incomes in the more sustainable scenarios (see Hartley *et al*, 2009, and Espindola, 2006, for the coffee and snow peas cases, respectively). We recommend studies on the real distribution of value- added, not only incomes, among all segments of the chain to refine these conclusions.
3. According to the interviews done in The Netherlands to characterize local markets for the two products studied, we can infer that unequal transmission of information from consumer to cultivator is more difficult in the complex chain than in the simple one. Relationships between growers/exporters and importers/distributors are less complex in the simple chain: agents have a type of exclusivity agreement through the mechanisms of vertical coordination. However, the complex chain has several providers and the mechanism is more market oriented[17]. Thus, information management constitutes a more important entrance barrier in complex chains.
4. As mentioned before, a larger variety of markets is available in the complex chain, and product differentiation based on intrinsic characteristics is more likely. Considering the sustainable markets, differentiation based on the extrinsic characteristic can also be possible, and the availability of markets is higher in the complex chain. We will address this issue in more detail in the following chapters by defining technology as a combination of the environmental quality and the markets involved. In this case, complex chains will be related to more technology options.

2.7 Concluding remarks

In this chapter, we have proposed a global agri-food chain typology. For this typology, consideration is made of both the size and complexity of the chain (the degree of transformation), its relation to technology used, implications for product differentiation and the potential for coordination in order to improve the environmental quality of the production processes along the chains. According to complexity, we can classify chains into three types: simple (as for example fruits and vegetables), intermediate (nuts and seeds for instance), and long and complex (coffee).

The degree of product transformation reflects the distance between grower and final consumer, demonstrating the degree of difference in the finished product compared to

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[17] In order to characterize the final markets for coffee and snow peas in The Netherlands, the researcher visited that country during October 2008. Some interviews were made for the snow peas case, but none for coffee. From the companies contacted in the coffee sector, only one small roaster was willing to attend the interview, which unfortunately was not possible to carry out due to logistical issues.

the product at the grower stage. In a dynamic perspective, some chains may even change their complexity, which depends mainly on the degree of elaboration of the product to be consumed. For example, nuts, such as peanuts and cashews, can be consumed directly after a simple process (intermediate chains), but the extraction of oil or butter from these nuts makes the chain longer and more complex; potatoes can be consumed without any additional transformation (simple chain) but fried potatoes require a more complex transformation process (intermediate chain).

We adopt a broad definition of technology, and include more than just the technology package, which is the quantity and quality of inputs used in the production and transformation processes; we also consider the markets involved. The reason for this is the consideration of the influence of demand-side markets on the technology package chosen on the production side. Then, in demand driven chains, as is the case of agri-food ones, the technology package is chosen in order to fulfil the demand side requirements, including environmental requirements. In this sense, when growers and first-processors choose the technology package for their processes, they are at the same time choosing the end market destination of the produce as well as the environmental quality of the production process. Simple chains, which do not include any important product transformation, are associated with a discrete number of technology options, while long and complex chains are associated with a high and continuous range of technology options.

The possibility of product differentiation is related to the degree of product transformation when referring to intrinsic characteristics of the product. Generic raw materials, as in the case of simple chains, offer few possibilities for product differentiation; meanwhile, in complex chains such as coffee, special raw materials can be differentiated if they constitute an important component of a blend. Product differentiation can be achieved even at intermediate markets. Based on the extrinsic characteristics of the product (environmental quality of the production processes) the complexity of the chain is also expected to play important roles.

We analyse the potential for coordination by identifying elements and strategies that positively affect positioning of local agents in the chain. If environmental quality is considered the strategic variable, coordination among growers and first processors must be present in order to obtain a final export product that fulfils specific environmental quality requirements and reaches the corresponding markets. Given the actual coordination mechanisms, the first processor must promote the change, given this agent's relatively high degree of market power. Market mechanisms alone are not sufficient to promote the change. In the short and simple chains studied, coordination mechanisms are mainly based on market relationships while in intermediate chains the cooperative systems seems to be of great importance. The coffee chain presents both types of coordination mechanisms. In studying the potential coordination mechanisms for the upgrading of local producers, institutional arrangements and public policies play the important role of promoting and encouraging technology change.

From the analysis of final markets for these chains, we have shown how final market behaviour differ according to the complexity of the chain, and how this complexity has implications for the availability of markets, quality management, coordination mechanisms and information transmission from consumers to cultivators.

As a conclusion of the chapter, the analysis of environmentally friendly technologies as instruments for improving incomes (positioning) of small producers along global agri-food chains must consider the different types of agri-food chains. This thesis will focus on a simple chain (the Guatemalan snow peas) and a complex one (the Costa Rican coffee chain).

3

Theoretical framework: environmentally friendly strategic behaviour in global agri-food chains

3.1 Introduction

In this chapter, we develop the theoretical framework of the thesis, presenting strategic coordination as a way to improve environmental quality in the cultivation and first-processing stages of global agri-food chains. The strategic variable is environmental quality and the goal is improvement of local firms' incomes (positioning) in the chain, in a world of market imperfections and unequal distribution of power in the global chain structure. We structure the theoretical framework using the Global Commodity Chains approach (GCC) combined with theories of industrial organization, especially for the consideration of market imperfections and strategic behaviour, which we analyse using game theory. We also consider theories of environmental management and innovation.

We commence with a discussion of market imperfections in global agri-food chains and a characterization of chain governance (Section 3.2), where non-price coordination mechanisms serve as the principal means of interaction among agents. In Section 3.3 we present the advantages of analysing strategic coordination among firms using key concepts of game theory, and in Section 3.4 we discuss the concept of environmental quality, an integral part of product quality, and the advantages of coordination among firms in order to improve this element.

Section 3.5 offers a broad discussion of the concept of technology; environmental quality is considered part of the concept, as are potential markets for the product in question. Here, we differentiate between discrete and continuous technologies. If prices increase steadily as a result of improvements in environmental quality, we consider that technology is continuous, while if prices increase in a non-continuous manner, then the technology is considered to be discrete. In Section 3.6 we study the importance of horizontal and vertical coordination mechanisms to improve environmental quality in global agri-food chains, and in Section 3.7 we conclude this analysis.

3.2 Global Agri-food chains and market imperfections

In the last two decades, conceptualization and analysis of globalisation has been described in the literature on the study of international trade and production networks with the purpose of understanding "the ways in which people, places and processes are linked to each other in the global economy" (Bair, 2009: 1). According to this conceptualization, the terms Commodity Chains, Global Commodity Chains and Global Value Chains have been "often used interchangeably to describe the sequence of processes by which goods and services are conceived, produced, and brought to market", although each of these chain constructs has its own particularities (Bair, 2009:2)[18].

In this thesis we use the Global Commodity Chain approach (GCC). The main purpose of the study of GCCs is the analysis of value-creating input-output activities oriented towards the production and consumption of a finished product. More specifically, global commodity chains are international networks of producers, merchants and service providers linked by processes of value creation, which include primary production, processing, commercialisation and end use (Gereffi, *et al*, 1994: 3).

Global Agri-food chains (GAFC) are specific types of Global Commodity Chains related to the production and international commercialization of agri-food products (see Chapter 2 of this thesis). The linkages between chain segments or nodes are mostly imperfect markets (Pelupessy: 2003a: 4). For instance, in local markets for fresh produce, where the seller is the farmer and the buyer is the first-processor, contract farming systems (Sáenz, 2006) combined with oligopsonic structures are quite common (Rogers and Sexton, 1994). In the export market for first-processed produce, considered raw material for trade purposes, buyers generally set prices (oligopsony). However, agents may pursue options for product differentiation to increase their market power, and this may generate conditions of monopolistic competition (see Pelupessy, 2001, for a detailed analysis of the international coffee chain).

Closer to final consumers we find markets of successively transformed intermediate goods and, further downstream, the chain ends with wholesale and retail markets of final goods (Pelupessy, 2003a: 4); these markets are also controlled by few agents. In some cases we find a type of bilateral oligopoly, while in others we see typical oligopoly structures combined with characteristics of monopolistic competition, this due to product differentiation.

For developing tropical countries, frequently the local *key-agent* is the first-processor[19], the actor that prepares the product for export to the international raw materials markets. The first-processor deals upstream with suppliers of the agricultural produce and downstream, with buyers of the first-processed product. This agent has different degrees of market power; for instance, in the upstream market for agricultural produce, the first-processor usually holds oligopsonic influence; however, in the downstream, traditional raw materials export markets, this agent usually holds less power because oligopsonic buyers in developed countries generally control price. Sometimes this agent does have the opportunity to increase market power by applying product differentiation strategies, as mentioned earlier.

The presence of imperfect markets along global agri-food chains is explained by the operation of a driving force that controls the chain. This force or control structure appears when an actor or actors, such as a company or group of companies, coordinate to control the extension, nature and flow of the chain's resources (Pelupessy, 2001: 7).

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[18] Bair (2009) makes a deep description of the genealogy, origin, contradictions and complementarities among the terms used to describe the global chain constructs.

[19] First-processing includes some transformation and packing. For products such as fresh fruits and vegetables, this stage may include only packing. In some cases the processor is also in charge of export.

Where the retail and processing sectors are imperfectly competitive, successive market power may be exercised at each stage of the food chain (FAO, 2007). High barriers to entry, mainly related to access to capital, contribute to perpetuate this structure. In these highly concentrated segments of the chain, profitability is high (Gereffi, 1999: 43). Global agri-food chains are frequently demand-driven and oriented by consumer preferences from developed countries far from the primary producer, often located in developing countries (Pelupessy and Van Kempen, 2005: 367-70).

The organization of global agri-food chains and the existence of imperfect markets present at least four additional implications for the global chain. First, markets along these chains are not independent from one another; quality standards, certifications, transport and storage regulations, as well as the involvement or exclusion of certain agricultural providers, are often decided by lead firms, such as multinational traders, final processors or supermarket conglomerates (Pelupessy, 2003a: 4).

Second, in this sequence of imperfect markets, data regarding consumer preferences often inefficiently transmits to primary producers; this also takes place with income and other information from final consumers to farmers. This inefficiency arises from the effect of unequal power structures along the chain, which give a small number of agents control of production flows from producer to consumer, as well as control of the flow of information and incomes from consumer to primary producer. Also, price reductions in export markets do not always pass directly to consumers, due to the concentration of power in those markets (see Morales and Berggren, 2002; and Bettendorf and Verboven, 2000 for an analysis of unequal price transmission from the export coffee market to consumer). From the unequal distribution of market power and profits, we can conclude that a low proportion of income stays in producer countries[20]. In this sense, agents in developing countries (cultivators, first processors, exporters) should develop better ways to create higher value-added.

Third, environmental costs may also be unequally distributed among the different segments of the chain. Empirical studies have shown the concentration of environmental impacts in stages located in developing countries: agricultural and first processing, for example. Díaz (2003) applied a Life Cycle Inventory (LCI) of environmental impacts for three agri-food chains in Costa Rica (coffee, cheese and baby vegetables) from cultivation to consumption; for the coffee chain Díaz located the key environmental issues for the agriculture and first-processing segments in developing countries, as well as in the final consumption stage in the importing countries. In the case of cheese, the main environmental effects are found in processing, while in the case of baby vegetables, cultivation generates the principal environmental impacts (Díaz, 2003: 289-90). Flysjö and Ohlsson (2006), whose report within the context of the Improved Sustainability of Agro-food Chains in Central America[21] project, use the Life Cycle

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[20] See Chapter 2 of this thesis (Section 2.6) for an illustration to the snow peas and coffee cases.

[21] The project *Improved Sustainability of Agri-food Chains in Central America: a Techno Managerial Approach*, was financed by the INCO DEV Programme from the European Union. It was run by a Research Consortium with the participation of Tilburg University (Coordinator) and Wageningen University (The Netherlands), the Swedish Institute for Food and Biotechnology (SIK) from Sweden and a network of Central American research institutions constituted by the Agricultural Economics School of the National University of Nicaragua (UNAN), the Foundation for Development (FUNDE) from El Salvador, the Foundation for Rural Development (FUNRURAL) from Guatemala and the International

Assessment Method (LCA) to compare the environmental impacts of eight different country chains and five different products in Central America[22]. They also conclude that, in most cases, the main impact for all categories was found at the cultivation phase, largely due to the use of pesticides; this was especially the case for short and simple chains (snow peas and melon) and coffee. In spite of these studies, we recommend a detailed look at other important environmental impacts in all categories in different chains to draw more general conclusions.

The fourth implication of the type of global agri-food organization and the presence of imperfect markets is the need for coordination. In the specific case of agri-food chains, final product quality results from the actions of all agents involved in the various stages of the global chain. In this sense, to reach a specific quality level, some coordination among agents is required. Coordination along the chain can be one of two types: horizontal, among agents of the same segment, or vertical, among agents of different segments. Coordination among agents of different segments is especially important when considering that final quality is not only determined by physical properties of the product, but also by process quality, which includes aspects related to the environmental quality of the production, transformation and commercialization processes (see Jongen, 2000: 265).

In this context, neoclassical theory is not the most appropriate theoretical framework to analyze pricing and other behaviours of agents involved in global chains; this theory relies on the concept of a single-product firm operating in a perfectly competitive market, with large number of competing firms all producing the same product under the same cost conditions and the same market demand curve (see Hobbs, 1996: 15-16). In contrast, the Global Commodity Chain approach (GCC) seems to offer more to the study of international agri-food production and commercialization. We can mention the following reasons in favour of this argument:

a. The GCC is a global approach for the study of internationally distributed production and trade processes, in which small and medium scale growers operate far from distributors and consumers.
b. This approach considers a sequence of markets, because for most tradable goods no direct relationship exists between raw material producers and final consumers.
c. Firms and other value-creating agents in the chain are the objects of study, as are their strategies, which include non-price competition. Accords, contracts and other cooperation strategies are also analysed.
d. The GCC approach explicitly considers the governance or power structure of the chain, and its distributional aspects along the whole chain, and does not restrict its scope to the analysis of demand and supply in specific and isolated markets.

These arguments contrast with traditional International Trade Theories based on the comparative advantages approach. Although these theories provide tools to predict the pattern of international trade and shed some light on the resulting income distribution,

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Centre of Economic Policy for Sustainable Development (CINPE) and the Regional Institute for Toxic Substances (IRET) from the National University (UNA) of Costa Rica.

[22] The products considered were coffee (Costa Rica, Guatemala and El Salvador), melon (Costa Rica), cashew (Guatemala and El Salvador), chayote (Costa Rica) and snow peas (Guatemala). The impact categories considered were: primary energy use, global warming potential, eutrophication, acidification, pesticide use and use of land and water.

they offer little for sectoral analysis in developing countries that participate in the chains (Díaz, 2003: 47-48). These limits are mainly generated by the basic assumption of the theories, which are: i) the countries trade, ii) the objects of trade are final goods and iii) developing countries produce and export homogeneous products. According to our previous arguments, this is not the case with global agri-food dynamics in developing countries.

Given these limitations, we recommend the substitution of analysis based on price competition by analysis of quality and other non-price variables (Pelupessy, 2003a: 4; Pelupessy, 2007). Markets do not only respond to changes in relative prices of goods and productive factors; they also respond to stimuli from the institutional framework, such as available information, definitions of property rights, or the possibilities to sign contracts (Ayala, 2003: 89). Arm's length market relations work well for standard products because they are easily described and valued (Gereffi, *et al*, 2005: 80), but this is not the case for most international agri-food chains, where the product must undergo several stages of transformation and the links between these stages are not free market transactions.

Therefore, to analyze the price system in markets along global agri-food chains, horizontal as well as vertical coordination mechanisms must be considered (Muradian and Pelupessy, 2005). According to Muradian and Pelupessy (2005: 2031), coordination represents the exchange of non-market information, capabilities and activities between two segments of the commodity chain that are not linked through ownership. Poulton, *et al* (2004) define coordination as efforts or measures designed to make players within a market system act in a concerted or complementary way, or toward a common goal. They distinguish between vertical and horizontal coordination mechanisms, sustaining that horizontal coordination takes place among players at the same stage of a market system, while vertical coordination functions with actors at different stages of the market system (Poulton, *et al*, 2004: 521). This last conclusion coincides with the analysis of Muradian and Pelupessy.

Coordination relates to the governance structure in the chain. Gibbon (2001), for instance, considers the coordination system as a source of power and reinforcement of "drivenness" along the chain. On one hand, coordination reinforces or enhances barriers to entry, but, and more importantly, it also permits driving agents to implement more efficient mechanisms (cost and risk reductions) to obtain the required supply, allowing higher profits even for subordinate agents in the chain. On the other hand, northern countries usually control chain co-ordination, since it is typically associated with links (or "nodes") that have particularly high barriers to entry, and because international income distribution remains extremely uneven (Gibbon, 2001: 346). In line with Gereffi, *et al* (2005: 81), Gibbon (2001: 346) also considers coordination to be more important than direct ownership for the control of global scale production systems.

Ponte and Gibbon (2005), recurring to convention theory, refine the understanding of the governance of global value chains through the analysis of quality and its relationship with the mechanisms of coordination. We may frame the management of quality as a question of competition and cooperation between actors in the same value chain, each one having only partial access to (and control of) information regarding product and related production and process methods. However, these authors distinguish forms of coordination from the modes of governance of global value chains. Governance is the process of organizing activities to achieve a functional division of labour along the chain, resulting in specific allocations of resources and distribution of gains. Governance defines the rules and conditions of participation, and these are translated into different forms of coordination. This implies that a relatively coherent mode of overall governance may generate different forms of coordination. Although we may easily conclude that, as quality becomes more complex, firms would move towards 'hands-on' forms of coordination (closer to vertical integration), the authors argue that this is not necessarily the case. Firms may operate with more 'hands-off' forms of coordination (closer to arm's length relations) if they are able to embed complex information about quality in standards, labels, certification, and codification procedures (Ponte and Gibbon, 2005: 2-3).

Gereffi, *et al* (2005) argue that the producer-driven versus buyer-driven dichotomy does not encompass newer forms of network governance. Therefore, they elaborate a typology of five governance structures ranging from market to hierarchy, with three different types of network governance between these two extremes: modular, relational and captive value chains. However, according to Talbot (2009), these types of governance structures do not characterize larger segments of the chain; rather, they seem to apply primarily to one transaction linking two successive nodes in the chain.

In general terms, global value chain analysis has focused more on 'vertical' relationships between buyers and suppliers, with less emphasis on coordination and competition among actors operating in the same function or segment of a particular market (Ponte and Gibbon, 2005: 4)[23]. However, horizontal coordination usually helps to reduce free-ride behaviour. One of the few authors that explicitly consider the issue of horizontal coordination is Poulton, *et al* (2004). Here we see two examples where this type of coordination may reduce free riding by other chain agents. The first relates to German manufacturing. To reduce free riding by firms on training investments, agents negotiated industry-wide wage settlements for standard skill grades, thus minimizing incentives for employees to switch firms after completing training. The second example refers to the African cotton industry. Mills provide loans to producers, thus exposing themselves to free-riding by cotton-buying competitors. One way to address this problem is through horizontal coordination, where firms seek mechanisms to restrict competitors directly; however, another option is to provide incentives to producers through vertical coordination (Poulton, *et al*, 2004: 522).

Vertical coordination may take the form of agreements between producers, traders, processors and buyers about what and how much to produce, time of delivery, quality and safety conditions, and price (Van der Meer, 2006: 11). Behaviour may range from open spot-market transactions to full vertical integration measures; between these two extremes we find strategic alliances and contract options (Hobbs, 1996: 19-20; Hobbs and Young, 2000; Van der Meer, 2006: 11).

Poulton, *et al* (2004) differentiate among formal and relational coordination. Formal or impersonal coordination refers to rules and regulations from formal institutions, in the context of procurement by state institutions or formal collective organizations (i.e. industry associations) with decision-making powers, where coordination is provided by

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[23] This corresponds with the narrow scope of the analysis of horizontal coordination cases in the literature.

private agents. Relational coordination is defined as informal agreements enforced by consensus or private consent, and major players make decisions informally amongst themselves (Poulton, *et al*, 2004: 522-23). According to the authors, relational coordination may be the most effective option for many cash crop systems in Africa; however, they consider that this type of coordination suffers from two main drawbacks, both related to market power asymmetry. First, few counterbalances exist to the dominant players; second, this coordination relies on private enforcement of rules, usually by the dominant players, allowing these players to exercise power over smaller rivals (Poulton, *et al*, 2004: 523).

To summarize, we have shown that in a world of global chains, where the links between the chain segments are imperfect markets, we should substitute neoclassical theory based on price competition with analysis of the different types of non-price competition and coordination mechanisms among firms, taking into consideration that they are value-creating agents in the chain and their decisions are based on rational self-interest.

However, given the existence of unequal power distribution, in most situations the best choice available to an agent, as well as the final payoff, depends on actions taken by other players – assuming a normal situation of mutual dependence of payoffs. This is the main pillar of game theory (Church and Ware, 2000: 212; Mas-Colell *et al*, 1995: 217. See also Wilson and Tisdell, 2001; Carraro and Topa, 1995; Heide and Miner, 1992; among others, for concrete applications).

3.3 Strategic coordination in agri-food chains

In a situation of mutual payoff dependence, firms must act strategically to maximize their revenues. They must consider not only their own actions, but also the possible actions of other firms, especially in situations of high power concentration, such as oligopoly/oligopsony - the common market structure in global chains.

In this context, the non-cooperative game theory approach in the study of multiparty situations with strategic interdependence seems to apply. "Non-cooperative game theory is a set of tools used to model the behaviour or choices of players (individuals, firms) when the payoff (profit) of a choice depends on the choice of other individuals (i.e., other players). Recognized payoff interdependency gives rise to interdependent decision making. The optimal choice of a player will depend on expectations regarding the choice of others playing in the same 'game'" (Church and Ware, 2000: 214).

The game theory framework allows us to study the individual behaviour of firms even if no formal agreements or contracts exist among them. The institutional framework defines and enforces the rules of the game, which, according to Poulton, *et al* (2004), are impersonal coordination mechanisms. Government does not intervene in the game itself, but it can change the institutional framework for the players; however, once rules are defined, all players must take them as given.

Games are usually classified according to timing of the moves and uncertainty about the payoffs of rivals (see Church and Ware, 2000: 215, among others). According to the timing of the moves, we can classify games as static or dynamic. In static games, each player moves once without knowing rivals' movements at the time of moving. In dynamic games, players move sequentially, having an idea, perhaps imperfect, of the actions taken by the others to that point. The dynamic game type applies when the game is repeated over time, as retaliation by rivals can take place in future movements. Therefore, players must consider the payoff of developing credibility before every move.

Related to the uncertainty about the payoffs of rivals, the theory divides games into complete or incomplete information games. In a complete information game, players know not only their own payoffs, but also the payoffs of all other players. If the game works with incomplete information, players know their own payoffs, but there are some players who do not know the payoffs of some of the other players (Church and Ware, 2000: 215).

The non-cooperative game theory approach to multiparty situations with strategic interdependence seems to apply to markets along global agri-food chains. The GCC approach allows us to analyse the strategic behaviour of agents, whether they are located in the same or in different segments of the chain. For instance, in the first stage of the chain, most agricultural markets are characterized by the presence of oligopsonic agents, meaning that buyers have high market power (Rogers and Sexton, 1994; FAO, 2007). Other markets along the chain also reveal power concentration among a few agents (Pelupessy, 2003a; FAO, 2007), either through market transactions or through some type of horizontal or vertical coordination. Situations of payoff interdependency (game theory) are evident, where an individual's pay-offs depends not only on personal action but also on actions taken by others.

We can point to analyses of market transactions and coordination situations applied to global agri-food chains from the literature; the global coffee chain is especially illustrative. According to Muradian and Pelupessy (2005), the most common structure of the coffee chain is characterized by "market transactions" between roasters/traders and growers/processors in the "mass" segment and generally stronger coordination in the specialty segment, where coordination is a key tool for managing quality along the chain. In market transactions, high levels of power asymmetry may be present in the case of oligopoly or monopsony, even though no coordination exists (Muradian and Pelupessy, 2005: 2031). In a more general context, Ponte and Gibbon (2005) argue that global value chains are becoming increasingly 'buyer driven', although they are characterized by 'hands-off' forms of coordination between 'lead firms' and their immediate suppliers. This is because lead firms have embedded complex quality information into widely accepted standards and codification and certification procedures (Ponte and Gibbon, 2005). None of these studies are game theory applications.

We also find applications of the non-cooperative game theory framework to the sectoral level (agriculture or industry) in the literature. Considering horizontal strategic behaviour, Karp and Perloff (1993) apply a linear-quadratic dynamic feedback oligopoly model to estimate the degree of competition and the adjustment path of Brazil and Colombia, as the two main coffee exporters. They found that these countries behave relatively competitively, meaning that their behaviour is closer to price taking than to collusion. This is a horizontal game, because it studies the strategic behaviour of the parties involved when they play the same role in the market, and the final result depends only on their behaviour. Other variables are considered as given, including the behaviour of buyers on the other side of the market.

A good example of a vertical game is the iterated games framework developed by Heide and Miner (1992). They examine cooperation between 136 industrial buyers and suppliers by identifying four domains of potential cooperation (flexibility, information exchange, shared problem solving, and restraint in the use of power) for repetitive games. The study supports the potential value of interactive perspectives on inter-organizational cooperation in particular, and on inter-organizational relationships in general. In this model, the time framework of a relationship may affect cooperation. According to the authors, observers of industrial relations in the United States, for example, have suggested that both firms and unions are much more likely to adopt cooperative strategies when they assume that they will likely interact during an indeterminate future (Heide and Miner, 1992: 268).

Combining horizontal and vertical coordination mechanisms, Carraro and Topa (1995) develop a two-stage model on taxation and environmental innovation which is solved by applying backward induction. The first stage is an innovation game (horizontal coordination), where firms decide if and when to adopt a new and less polluting technology. The second stage is a policy game between polluting firms and the regulator (vertical coordination), where the latter chooses between a set of policy instruments to push firms to adopt the less polluting technology, as well as the optimal time frame for adoption.

While the previous examples show application of game theory at the sectoral level, they are not developed in the context of global agri-food chains; even though, examples can be found of cooperative and non-cooperative game theory applied to supply chain management. Nagarajan and Sosic (2006) discuss cooperative games, and emphasize profit allocation and stability in a theoretical and general application to supply chains. Also, Meca and Timmer (2008) have focused on the benefits of inventory centralization for retailers and gains in efficiency from collaborative actions between the supplier and the retailers. We also find non-cooperative applications. For example, Purwaningrum, *et al* (2010) study a principal-agent problem between farmers and government in the cotton industry in Uzbekistan, and Radhakrishnan and Srinidhi (2005) analyze the benefits of information exchange in a value chain. Faße, *et al* (2009) give an overview of different methodologies related to value chain analysis in the context of environment and trade research, including game theory applications; however, they emphasize potential methodologies with no concrete applications.

Our research focuses on applications of non-cooperative game theory in global agri-food chains, considering environmental quality as the strategic variable, with special emphasis on the relationship among farmers and between farmers and first-processors. None of the studies reviewed are similar in this respect.

3.4 The environment as an integral component of the final quality of the product

Negative environmental impacts are clearly important in the context of global agri-food chains. These negative impacts usually relate to soil erosion and depletion in the cultivation stage, water and soil pollution by agrochemicals, and liquid and solid waste production. In the first agro-processing stage, impacts are mainly tied to water and energy consumption as well as air pollution, waste water contamination, inadequate solid waste disposal, and odour generation. In the stage of transformation and packing, environmental outputs are associated with air and water pollution and solid waste, while distribution and transport cause air, water and soil pollution as well as solid waste (see Pelupessy, 2003b: 103-107, for the characterization of negative environmental impacts in the coffee chain). Effects from cultivation and first agro-processing stages are among the most relevant (Díaz, 2003; Flysjö and Ohlsson, 2006), and, because these stages are mostly located in developing countries, the main environmental impacts are produced in those countries[24].

Impacts on the environment determine the environmental quality of the production process along the different stages of the chain, and these impacts result from the technology package used. The impacts can be negative or positive. For example, in the cultivation stage, a technology package based on the use of pesticides will generate soil, water and air pollution (the greater the use of pesticides, the higher the negative impact on the environment), while a technology package based on the use of organic inputs and shade cover (as in the case of coffee, for example) will generate water source preservation, carbon capture and biodiversity protection, among other benefits.

We must consider environmental quality as an integral component of final product quality (Muradian and Pelupessy, 2005), because the final quality of a specific product must include intrinsic and extrinsic characteristics (Jongen, 2000: 265). Intrinsic characteristics refer to physical properties of the product such us texture, appearance and nutritional properties, while extrinsic characteristics are related to the production process, such as the quantity of pesticides used during cultivation or the level of water pollution resulting from processing. Also, Ponte and Gibbon (2005) consider that quality standards communicate the attributes of a product, and the attributes "can pertain to the *product* itself (e.g. coffee appearance, taste, cleanliness, absence of taints) or *production and process methods*". These methods may include aspects related to authenticity of origin, safety, environmental and socio-economic conditions. Moreover, in the current situation, quality standards tend to focus (sometimes exclusively) on production and process rather than on the product itself (Ponte and Gibbon, 2005: 2).

The previous discussion demonstrates the importance of production and process in the definition of final product quality, through environmental quality in production processes. With a global chain perspective in mind, we must frame the final quality of an intermediate or end product in terms of three additional implications. First, final quality is the result of a complex set of local and international agent actions along all chain stages. One firm alone may not be able to attain a specific level of quality because it does not control all the phases involved. Second, while farmers and agro-processors make decisions about the technology package used, the international dynamics of the chain greatly influence these agents. In the value creation process, leading downstream firms decide on quality standards, including the environmental regulations that must be followed by developing country firms. As an implication of this power relationship, we suggest that attempts to solve environmental problems associated with agri-food production should not be restricted to specific cultivation and agro-processing stages of the chain in an isolated manner. On the contrary, constraints and opportunities provided

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[24] Additionally, public regulations are generally much stronger in developed countries, and this also helps to create bias in the location of environmental impacts.

by the chain governance structure must also be considered. In this sense, developing country firms usually must adjust their technologies to meet international environmental standards, as well as other requirements.

The third implication of the consideration of environmental quality in the final product is related to the demand side; markets for environmentally sound products may offer price premiums (Kremen, *et al*, 2002: 6, 10). Even if the size of the premium varies and the benefit may not be equally distributed among all agents involved in the chain due to asymmetric power distribution, price premiums represent good opportunities for local farmers and first processors to differentiate their produce based on associated environmental quality[25].

In this context, coordination among agents in agri-food chains located in developing countries may assume strategic importance in the improvement of environmental quality. Moreover, strategic coordination with agents located closer to final consumers may generate benefits if these actions imply the capture of a higher proportion of the surplus generated at the consumer stage (Pelupessy and Van Kempen, 2005: 374-5; for strategic alliances surrounding non-environmental attributes). Also, coordination with lead firms may be very important since these are the primary sources of material inputs, technology transfer and knowledge in the organizational networks (Gereffi, 1999: 38). Local agents should not pursue improvement of environmental quality only to reduce local environmental impacts, but also to increase their incomes.

The treatment of the environment in economics literature traditionally considers a perfectly competitive or oligopolistic structure, where firms compete in the same isolated and homogenous final goods markets. Negative environmental impact is seen as an externality, which can be internalised through pollution control instruments or bargaining solutions (Pearman, *et al*, 2003, among others). When considering a market structure of non-perfect competition, analysis usually considers the traditional scenario where firms compete in an oligopolistic final consumer market (see for example Carraro and Topa, 1995, for an application of an environmental innovation game). Application to international agri-food chains should model the strategic behaviour of firms, not only horizontally (among the same type of agents) but also vertically (among buyers and

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[25] The size of the premium varies, as can be seen in the following studies. An economic valuation of the Sustainable Agriculture Farming System Project (SAFS) at the University of California-Davis shows that price premiums exist for all organic crops grown in the project, although the size of the premiums has changed over time and fluctuates from year to year. From 1989 to 1999, processed organic tomatoes have averaged a 54% price premium above the conventional price, beans 41%, corn 29% and safflower 28% (Klonsky, 2000: 1). Andrew Barkley, a Professor and Coffman Distinguished Teaching Scholar at the Kansas State University, Department of Agricultural Economics, indicates that profitability of organic production depends on price premiums and mentions that organic vegetable prices in Kansas duplicate conventional vegetable prices; also, significant price premiums are available for grain and soybeans (www.kansassustainableag.org/organic/Barkley.pdf). Another study on price premiums for verified legal and sustainable timber in the United Kingdom market shows that this market pays a premium of between 8% and 15%, depending on the species, for United States certified hardwood; as well as a premium of between 2% and 5% for certified dark red meranti from West Malaysia. In this industry, if other countries start to demand this type of product, and there is no significant increase in supplies of alternative certified tropical hardwoods, then the price premium may rise in the future (Oliver, 2005: 4). Another study, the Green Gauge Report, a syndicated database of consumer attitudes and behaviours that focuses on the environment and environmental efforts in the United States, states that the overall shift away from a mindset conducive to the green market has resulted in a declining willingness to spend extra money on green products. The average eco-premium people are willing to pay has dropped from 6.6% in 1990 to 4.5% in 1996 (Tibbet, 1997: 4); it is, however, still positive.

sellers), where agents may operate in different segments of the chain, and none of them necessarily sells to final consumers. Additionally, we should also consider the influence of chain governance on a specific market.

3.5 Environmental technology: continuous or discrete? A broad interpretation

In the previous section, we referred to *technology package* as the way inputs are combined to produce a specific product. Also, we identified the relationship between technology package and environmental quality, where a broad range of technology packages generate different impacts on the environment, according to the types and quantities of inputs used in each. Therefore, when any producer chooses a specific package, this agent is choosing a specific contribution to environmental quality. In this section, we establish the difference between *technology package* and a broader concept of *technology*.

Focusing on environmental quality in the cultivation and first processing stages, we can identify some relevant variables that characterize the relationship between the technology package and environmental quality. In the cultivation stage, for example, we take as relevant variables the quantity of agrochemical inputs and shade cover. In the first processing stage, the relevant variables could be water and energy consumption, and solid and liquid waste management. Accordingly, in the cultivation stage, a specific technology package would represent higher environmental quality when the use of agrochemicals is lower and shade cover is higher. In the first-processing stage, a specific package would represent higher environmental quality when water consumption is low, energy use from non-renewable sources is low, solid waste is reduced and adequately stored, reused or transformed into a useful input (organic fertiliser, for instance), and liquid residuals are reduced and properly treated.

We will classify technologies according to environmental quality. In our definition, the first component of technology is the relationship between the technology package and environmental quality. We also want to discuss the continuity or non-continuity of this concept; we have as many technology options (both in the cultivation and first processing states) as we have options for the intensity of use of the relevant variables. If the intensity of use of relevant variables can change in a continuous manner, then the environmental impact (or environmental quality) will change in a continuous manner as well. If this is the case, we say that in terms of environmental quality (the first component of our definition of technology), technology is continuous[26].

The technology package is chosen by the agent at any stage of the chain. Focusing on cultivation and first processing stages, the cultivator and the first-processor choose the

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[26] To be even more specific, let us develop an example for the cultivation stage. We have said that environmental quality in this stage rises as the use of chemical inputs is reduced and shade cover is increased. Both variables can vary in a continuous manner: chemical inputs can range from zero (organic) to high quantities, and those quantities can be measured in a continuous manner (kilograms, litres, etc); also, shade cover can be measured as the percent of the total area covered by shade, also a continuous variable. Given the relationship of intensity in the use of these variables and environmental quality, we can argue that environmental quality varies in a continuous manner as well, leading to the characterization of technology as continuous.

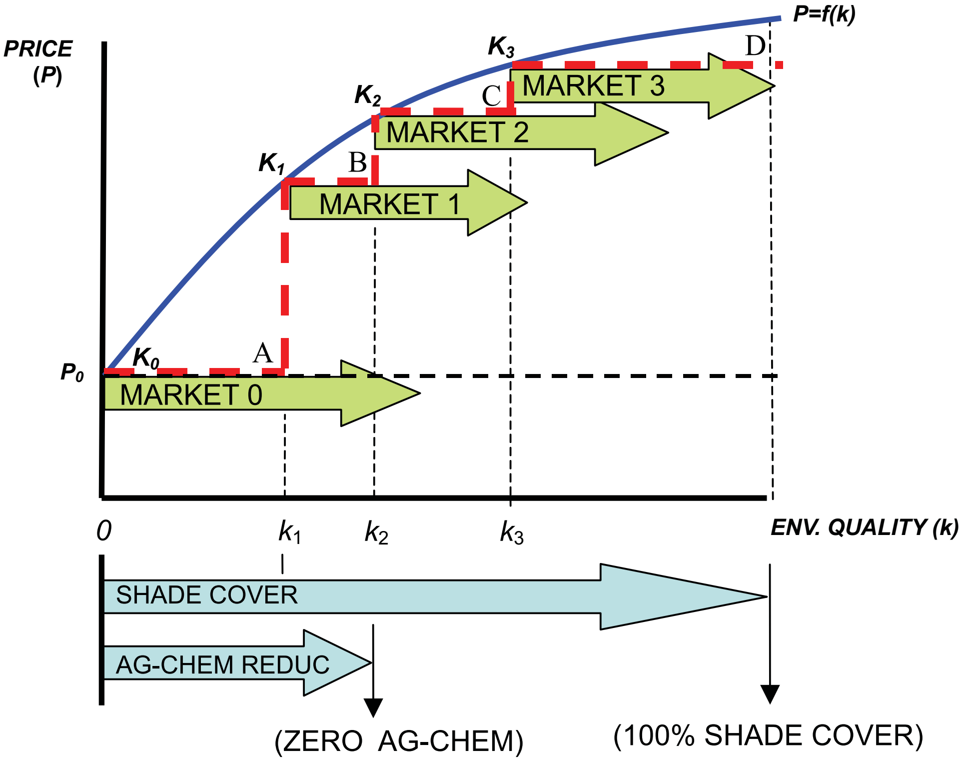
corresponding technology package. However, as mentioned before, international dynamics along the chain strongly influence this decision, because leading downstream firms usually determine the quality standards of the product, including environmental standards; this has important implications for all stages of the chain.

In this sense, a broader definition of technology should consider not only the relationship between the technology package and environmental quality, but also the markets involved that impose demand-side conditions. In order to consider conditions from the demand side, we take into account the relevant available markets, as stated before. In markets for environmentally sound products, we expect prices to rise as technology moves from the most polluting option to that of the highest environmental quality. However, prices could rise in either a continuous or a non-continuous manner in relation to environmental quality. The former would be the case where any small change in the intensity of use of the relevant variables (to increase environmental quality) is recognized in the market in the form of higher prices; while the later would be the case when access to special markets depends on the fulfilment of specific and discrete environmental standards: environmental certification programmes, for example. Therefore, by additionally considering the relevant markets, technology can be denominated continuous or discrete, and the continuity or non-continuity of price behaviour becomes a function of environmental quality and market requirements.

In summary, we have defined technology in terms of i) environmental quality of the cultivation and first processing stages and ii) the relevant markets involved. Environmental quality is a function of the intensity of use of relevant input variables: chemicals and shade cover for the agricultural stage, for example, and use of water and energy from non-renewable sources, and solid and liquid waste disposal, for the first-processing stage. Considering only the environmental quality of the production processes, technology will be continuous if the intensity of use of the relevant variables can change in a continuous manner. However, considering the available markets as well, technology can be either continuous or discrete. If prices increase in a continuous manner with respect to improvements in the environmental quality, then we consider technology to be *continuous*. However, if prices increase in a non-continuous manner with respect to environmental quality, implying the existence of limited specific markets, then we consider technology to be *discrete*. In the latter case, environmental quality “jumps” from one discrete situation to another to facilitate movement from market to market.

The relationships among the intensity of relevant variables, the environmental quality of the technology package used and the potential markets are depicted in figures 3.1 and 3.2 for the cultivation and the transformation processes, respectively. The bottom half of figure 3.1 shows the relationship between the level of environmental quality and the intensity of use of the relevant variables: shade cover and reduction of agro-chemical inputs. Environmental quality increases when moving from the current or most polluting technology package (*0*) to the highest environmental quality option (100% shade cover). The upper half of the figure represents the relationship between prices and environmental quality, which is a market relationship. The line P_0P represents the relationship between prices and environmental quality where prices increase in a continuous manner with respect to environmental quality. If this is the case, continuous technology is shown by the set of ordered pairs (k, P) along the line P_0P.

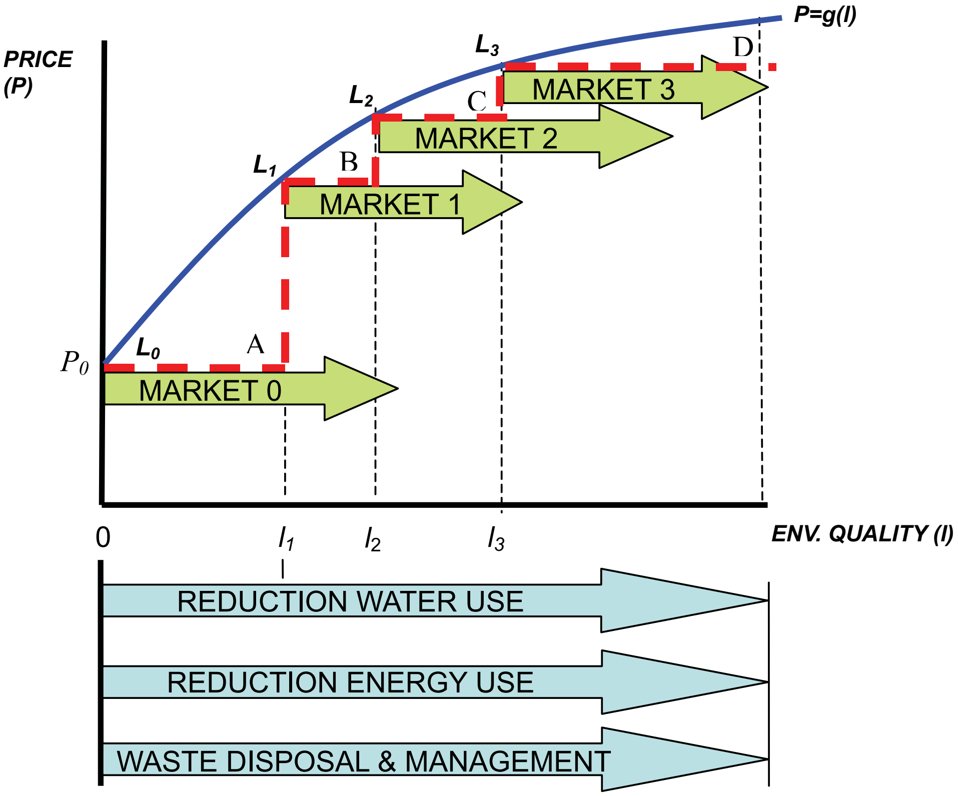
Figure 3.1:
Continuous and discrete technology, markets and relevant variables.
Cultivation stage



If access to special markets depends on compliance with specific environmental standards (minimum environmental quality requirements), and the corresponding markets are the only options for sale of the product, then we have a set of discrete technology options determined by the number of available markets. We present this case in the upper half of the figure, with the dotted line $P_0AK_1BK_2CK_3D$. Different markets are simulated, and each of them relates to different environmental standards. For example, we see that Market 2 is organic as access requires zero agro-chemical use; Market 3 is organic and still more demanding in terms of the intensity of shade cover. In this simulation, we have four technology options (K_0, K_1, K_2 and K_3), each of them related to a particular market, where access to each market depends on the fulfilment of a minimum environmental quality, and environmental quality is determined by the intensity of shade and the use of agro-chemical inputs. Points k_1, k_2 and k_3 are the minimum environmental quality standards to access Market 1, Market 2 and Market 3, respectively; and P_0 corresponds to the price obtained when environmental quality is between the lowest value (0) and k_1.

Figure 3.2 presents the case for the first processing stage. In the bottom half of the figure we find the relevant variables that determine environmental quality. As seen in the agricultural case, if prices increase continuously with environmental quality due to the technology package used, then we have continuous technology given by the whole set of ordered pairs along the line P_0P. However, we may have a set of discrete technologies as well (L_0, L_1, L_2 and L_3) if prices increase along a non-continuous path, since the only way to sell the product is by accessing specific markets after fulfilling environmental quality requirements. The non-continuous line $P_0AL_1BL_2CL_3D$ represents the case of discrete technologies.

Figure 3.2:
Continuous and discrete technology, markets and relevant variables.
First-processing stage



As mentioned before, the purpose of this thesis is to study the benefits of environmentally friendly techniques to increase the incomes of developing country agents (growers and first processors/exporters) along global agri-food chains. In this case, technology is the strategic tool of choice for these agents. By choosing their technology, growers choose both the environmental quality level and the specific market. Whether technology is continuous or discrete is relevant in terms of available options; we should expect differences according to the complexity of the chains as defined in Chapter 2 of this thesis.

Even if improving environmental quality allows access to higher prices or new markets, technology shifts may imply transition costs or higher production costs due to the use of new types of inputs. Both access to new markets and the related higher costs are difficult for individual producers to face; once again, the need for strategic coordination is evident. In the next section we will see the role that strategic behaviour can play in improving environmental quality and incomes of local producers in developing countries. We will focus on strategic coordination among local agents in developing countries; we have noted earlier that strategic coordination with other agents located in chain segments closer to final consumers can also be beneficial.

3.6 Environmental quality as a strategic tool in global agri-food chains: the importance of horizontal and vertical coordination.

As mentioned before, increasing environmental quality may allow access to higher prices or new markets and may be a requirement imposed by external buyers as a condition for remaining in the market. Farmers and first-processors must switch technology if they want to access these advantages, considering at the same time that their costs will likely increase. How then can the technology shift be facilitated? Do firms have incentives to move or on the contrary will they prefer to stay locked into the current technology? What would be the best strategic choice of technologies to improve environmental behaviour and income positions of the firms in the chain? What would be the most profitable technology option for farmers and first-processors, and how would this affect final environmental quality? Can solitary farmers and first-processors accomplish the technology shift, or are a minimum number of agents required to facilitate the shift?

We will try to answer these questions with the support of Figure 3.3. Let us assume the existence of two discrete technology options: the traditional polluting option, and the alternative, sustainable option. We assume producers use traditional technology (point of departure) and we offer alternative technology as one of the available sustainable options. The decision problem for the producer is whether to stay in the polluting technology or to move to the higher environmental quality package. We can apply this analysis to both the cultivation and first processing stages. The figure depicts the dynamic relationship between revenues at the firm or farm level as a function of time for both the traditional (polluting) and the alternative (sustainable) technologies.

Line ABC represents the returns of the traditional, unsustainable technology. Returns initially grow, but after a certain point they may fall and eventually become negative; this occurs because, at the beginning, environmental damage only produces *external* negative effects, which are not considered in costs and price calculations by an individual agent. This technology may offer competitiveness in the short and medium term, because at the initial stages consumers do not punish the use of dirty technology. However, at some point, external costs may increase internal costs for the firm[27], and buyers[28] may become more environmentally conscious and punish the use of dirty technology. In such a situation, not only total revenue is affected, but the cost of

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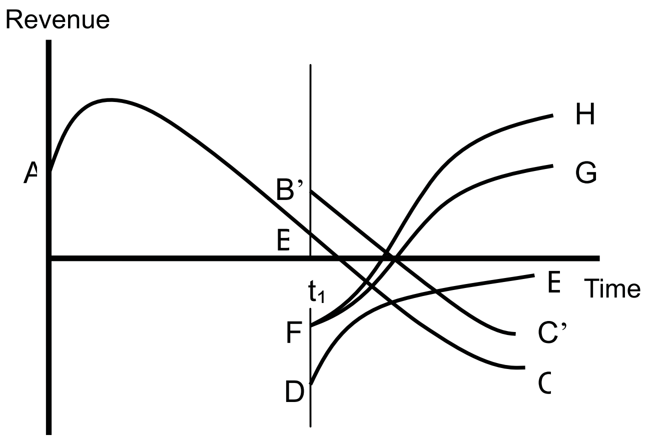
[27] For example, at the farm level, additional health costs due to worker exposure to pesticides may arise, as well as "crop losses due to proliferation of pests and effects on agricultural soils from pesticide pollution" (Wilson and Tisdell, 2001). Measures may be required to reduce environmental impact and mitigate local pressure, and these costs are not necessarily offset by higher prices.

[28] In agri-food chains, for developing countries' exports, buyers are not final consumers. However, they normally take into account consumer trends towards more environmentally sound products.

production will also increase, generating a “bottleneck” for competitiveness (Wilson and Tisdell, 2001; See also Ajayi, 2000: 9).

Figure 3.3: Expected economic returns of traditional and sustainable technology



Source: Adapted from Wilson and Tisdell (2001).

We may even see options where line BC moves upward (B’C’), due to innovation processes within the unsustainable technology package. This may postpone negative returns, but in the medium term, the trend is the same (downwards). Within this context, increasing the environmental quality of production processes becomes more and more obligatory in order to maintain market position.

At time t_1, the firm has a decision problem; it must consider a shift in technology, but its decision can be affected by others’ actions. A shift to sustainable technology may imply high withdrawal and direct production costs. At the agricultural production stage, for example, these costs come from the use of new types of inputs, sometimes with higher prices, lower productivity, or negative effects on product quality; for example, the reduction of chemical inputs may negatively affect product appearance, which increases the probability of rejection in the final destination market. For processors, higher costs of shifting technology are associated with quality controls that may even be external to the plant; for example, to guarantee specific environmental quality in raw material from the cultivation stage, processors require technicians to directly advise farmers. Also, if processors advance seeds or other inputs, they face the corresponding financial costs. These withdrawal and higher direct production costs must be neutralized, at least at the beginning of the change process. Moreover, even if cleaner produce obtain premium prices, this only occurs some time after implementation of the technology change.

Given these withdrawal costs, an individual farmer will not likely achieve adequate returns from shifting technology if others do not follow. From the cost side, negative externalities from neighbouring firms may offset positive effects of the shift of an individual firm, or even make this shift economically infeasible. For example, at the farm level, pest control costs are higher if the firm acts alone in the shift, because of the negative externalities of pesticides used by neighbours. At the first-processing stage, the lack of effectiveness of an individual firm’s actions to change technology would be seen in the use of water that has been polluted by other processors, for example. From the income side, access to premium prices for environmentally sound products will usually require a minimum number of agents to shift technology in order to reach a threshold volume. This implies that in the short run, if firms act in isolation, they will be locked into the unsustainable technology (Wilson and Tisdell, 2001). In this case, the path followed is BDE, which does not provide economic justification for the shift.

Some economically feasible options for the technology shift may exist, but they imply some kind of cooperation among firms. We will first analyse what may be called *horizontal strategic interaction*. Some positive externalities may appear - or a reduction of negatives - if most producer or agro-processing firms in the same chain segment make the change; this could in effect reduce the individual costs of the technology shift (see Wilson and Tisdell, 2001). Innovation in cleaner technologies requires links and cooperation that facilitate economies of scale; therefore, a threshold number of firms must switch for these positive externalities to appear. For example, at the farmer level, pest control will be more effective if a threshold number of farms apply the sustainable technology. In the first-processing stage, a shift to higher environmental quality technologies will be more effective and less costly if all members of the industry make the shift; for example, if pollution from waste water disposal generally decreases, cleaner rivers will reduce the costs of water purification for all.

On the other hand, on the demand side, a cleaner product may generate a premium price as a reward for the shift to sustainable technology. If a threshold number of firms adopts the sustainable technology, a positive “country or region image effect” may arise, possibly associated to a denomination of origin, and the premium is more likely obtained. This price premium may justify efforts to improve environmental quality in production and processing stages.

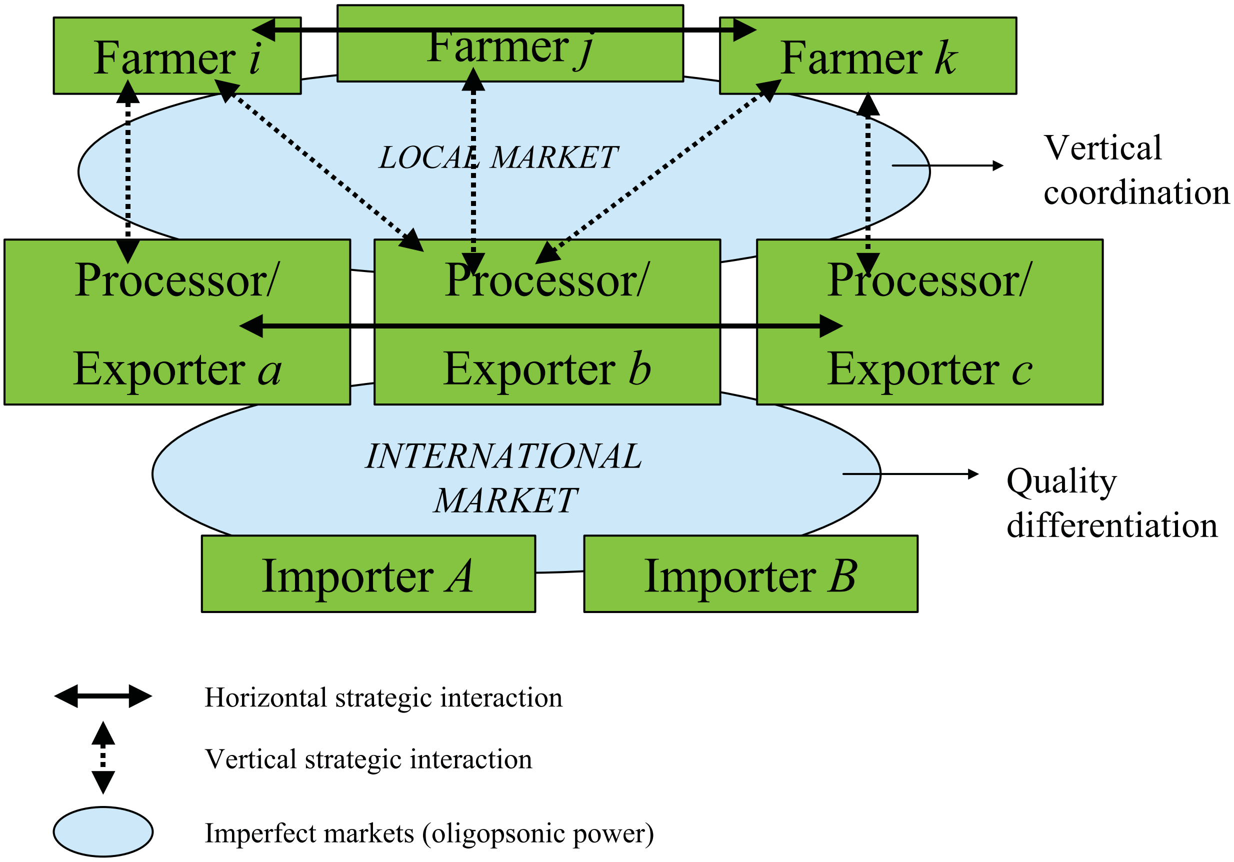
The generation of positive and the reduction of negative externalities that permit reduction of the individual costs of technological change, as well as the construction of a country or regional image that permits premium pricing, require that a minimum number of producers make the change. This threshold number represents a minimum production scale for the country or for the region. In both cases, institutional arrangements will be demanded and promoted, and they will not work properly if only a few firms participate - lower than the threshold level. If that threshold number of producers is reached, the path followed is BFG, where positive externalities, reduction of negative externalities, or expected premiums will offset the withdrawal costs of the technology shift.

A second possibility for technology shift is tied to the vertical relationship between farmer and first-processor, which we have called *vertical strategic interaction*. A specific processor may agree with its grower-suppliers on a shift in technology in order to produce and export an environmentally sound product, which can be branded accordingly and marketed by the processor. This solution implies marketing strategies for that specific brand to take advantage of the particular characteristics of the product. Therefore, agents must develop differentiation strategies based on environmental quality. In other words, improving environmental quality both at the processor and the farmer level is a way to differentiate the product. If this is the case, the path will be BFH, where the environmentally sound product receives a premium that offsets the withdrawal costs of technology change.

The final position of lines FG or FH will depend on the final technology used as well as the threshold number of farmers shifted to the new technology required to access specific markets. This means that we may see a specific profit path for each available sustainable technology.

To summarize, the economically feasible options for shifts in technology require the explicit consideration of strategic interactions among firms. We see these options in Figure 3.4, considering chain segments located in developing countries. We identify possibilities for strategic interaction at the *horizontal* as well as the *vertical* level. The first case refers to coordination among the same type of agents, such as farmers, while the second refers to coordination among agents located in different segments of the chain; an example is coordination between farmers and a specific processor. The main difference between the first and the second case is that, in the first, a generalized situation (country or region) is needed to take advantage of the cost reductions through supply side economies of scale or price premiums for the new, environmentally sound product. In the second case, we have developed the analysis at the agro-processing step and specific differentiation strategies must be developed. This option may offer earlier and better results compared with the other, because it guarantees quality control along both segments of the chain.

Figure 3.4: Horizontal and vertical strategic interaction along global agri-food chains



The existence of continuous or discrete technologies will be important to the evaluation of available options and potential markets; this may affect the ease with which horizontal and vertical coordination can be developed in the chain, as we will see in the specific applications for the case studies of this thesis.

3.7 Concluding remarks

In this chapter we have identified the existence of market imperfections along global agri-food chains, where mechanisms of non-price competition such as accords, contracts and other kinds of cooperation strategies are the norm rather than the exception. Also, under the global chain perspective, a governance or power structure must be explicitly considered, meaning that we cannot restrict the analysis of value creation and distribution to the analysis of demand and supply in a specific and isolated market.

On the other hand, we have defined technology in terms of environmental quality and potential markets involved. Considering these aspects, we have stated that technology can be continuous or discrete. Environmental quality constitutes an integral component of the quality of the product, and as such has implications on price; we can expect prices to increase when environmental quality increases. If, as a result of successive environmental quality improvements, prices increase in a continuous manner, we say that technology is continuous; while if prices increase in a non-continuous manner, we say that technology is discrete. This last case suggests the existence of limited specific markets, for which access to each requires the fulfilment of a minimum environmental quality level.

While increases in environmental quality from the demand side (higher prices, continued market participation) offer potential benefits, technology shifts may imply higher costs, both in terms of transition and production costs. Also, access to new markets may require a minimum scale of production, and therefore a threshold number of producers. Both access to new markets and related higher costs are difficult to confront for particular producers on their own; thus coordination among agents of agri-food chains located in developing countries takes on strategic importance for improvements in environmental quality. Strategic use of technology is key, and the goal is to improve the firms' positioning in the global chains. Whether technology is continuous or discrete will affect the range of available options, and the existence of continuous technologies may facilitate coordination.

We can characterize strategic coordination along a global agri-food chain in two ways: horizontal and vertical. The first refers to coordination among agents located in the same segment of the chain, while the second refers to coordination among agents located in different segments. Constraints and opportunities of the global chain are especially relevant, especially in the case of vertical coordination.

Working method for the case studies

As mentioned before, our purpose in this research is to study the benefits of cooperation in the use of environmental friendly techniques, as instruments for the improvement of small producer income in global agri-food chains. To that end, we apply a four-step case study method. First, we construct a general typology of agri-food chains to identify chains of different complexity. Based on this characterisation, we study the simple chain of Guatemalan snow peas and the complex chain of Costa Rican coffee; the focus of analysis will be on the relationships between cultivators and first processors, keeping in mind constraints and opportunities presented by the chain dynamics. The second step is a discussion on the market structure of the two chains, in order to infer the influence that this has on willingness to cooperate in favour of improving environmental quality, in the cultivation and first-processing stages. We use both primary and secondary data, as well as workshop discussions with stake holders.

In the third stage, based on empirical characterisations of the selected chains, we apply game theory to each chain. The objective is to identify the opportunities for cooperation in favour of the environment. The actors (players) are growers and/or first processors, depending on the game, and the strategic variable is environmental quality. We emphasise the vertical relationships between cultivators and first processors, keeping in mind the global chain perspective. The different case studies will allow us to discuss the implications presented by chain complexity for cooperation if favour of the environment.

The fourth stage is the comparison of the main outcomes obtained from the two case studies. Of course, the case studies represent chains of different complexities and different technology options, but consideration of the global chain perspective will allow us to draw conclusions and offer policy recommendations in favour of clean technologies.

4

Market structure and cooperation to improve environmental quality

4.1 Introduction

In this chapter, we study the operation of specific markets in agri-food chains to identify the relationship between market structure and cooperation for improvement of environmental quality in the cultivation and first-processing stages. The local markets for the short and simple chain Guatemalan snow peas and the long and complex chain for Costa Rican coffee are taken as case studies. We define market structure in terms of the degree of horizontal and vertical coordination, from open market transactions (no explicit coordination-full competition) to full cooperation -total coordination- (Hobbs, 1996: 19-20; Hobbs and Young, 2000; Van der Meer, 2006: 11).

Local markets for agricultural products serve as the links between cultivators and first-processors. These markets usually present imperfect competition conditions with oligopsonistic characteristics, where i) the product is perishable, traded in large quantities, and growers are limited to selling their product to buyers close to production areas, ii) processors cannot substitute other inputs for the specific produce iii) high exit barriers exist for participating growers due to asset specificity and resulting low price elasticity of supply, and iv) grower cooperatives, associations and other institutions with high buyer power may be present (Rogers and Sexton, 1994).

Agricultural markets provide the space where cultivators and first-processors can coordinate to differentiate their product in the international export markets by improving environmental quality. In the local Guatemalan market for snow peas, agents negotiate mainly through open market transactions. These transactions are mostly controlled by local intermediaries, called *coyotes*, who buy produce from farmers – usually paying in cash - and sell to first-processors. However, other commercialisation channels also exist, with closer coordination between farmers and first-processors. Prices in these markets are affected by the oligopsonistic power of first-processors, who at the same time receive influence from international agents located downstream in the chain.

The Costa Rican coffee case is more complex. Here the market for coffee berries shows characteristics of oligopsony as presented by Rogers and Sexton (1994), but with a higher number of channels between farmers and first processors. Several variables affect pricing in Costa Rica; the most important of these is the international export price for processed product (Asamblea Legislativa de Costa Rica, 1961). Therefore, the degree of first-processor influence over producer price is limited; considering this, non-price based competition becomes important.

Given the differences between the two case studies, we apply distinct methodologies to study the relationship between market structure and cooperation for improvement of environmental quality. For the snow peas case, we identify the structure of the chain and give special attention to direct price competition and coordination relationships between growers and first-processors in local markets. The nature of these relationships will generally be either that of open spot markets or vertical integration, which justifies a qualitative analysis. Environmental aspects are studied for each market structure.

For the coffee chain case, we must analyze the influence of market structure on cooperation in favour of the environment by first considering the influence of price and non-price variables on the decisions of producers regarding technology and buyers for their produce. We identify the role of price in these decisions by estimating the degree of sensitivity (elasticity) of the quantity of coffee that each mill receives as a response to variations in its buying price. We evaluate the influence of non-price variables in grower decisions through working group discussions with these agents. Among the non-price variables, we give special attention to environmental aspects. When we have determined the importance of price and environmental concerns to farmer decisions, our focus turns to the relationship between these two variables. We apply this method to the market for coffee berries in the region of Los Santos, Costa Rica, considered to produce some of the best quality coffee in the country due to altitude and climate factors.

This chapter is structured into four sections. After the introduction, sections 4.2 and 4.3 present analysis of the case studies: the Guatemalan snow peas case (Section 4.2) and that of Costa Rican coffee (Section 4.3). Section 4.4 provides concluding remarks.

4.2 Market concentration and environmental cooperation in the Guatemalan snow peas chain

4.2.1 Guatemala in the international market for snow peas

Guatemala has produced snow peas since the late 1980's (OECD, 2002: 57). Currently, this product is cultivated mainly in the highlands, especially in the departments of Chimaltenago and Sacatepequez. From an environmental perspective, these areas are especially relevant as wetlands; from the socioeconomic perspective, they are areas of high population density under land-use pressure.

Snow peas have become increasingly important in Guatemala as a non-traditional export product (Julian, *et al*, 2000: 56). The country is ranked as the leading global exporter of the crop, followed by Mexico, Zimbabwe and Zambia (Salazar, 2003: 86). It is also the main foreign snow peas supplier to the United States, and one of the most important suppliers to Canada and Europe (see Chapter 2 –Section 2.6- of this thesis).

For cultural and socio-economic reasons, this product has no significant local consumer market. The local population associates the product with international markets and not domestic consumption; snow peas are virtually unknown in the Guatemalan diet, and several substitutes exist (*ejote*, for instance[29]). On the supply side, most growers prefer

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[29] This situation partially explains why a large proportion of non-exported snow peas is simply wasted; this also has implications on price. In some local markets of agricultural products in Guatemala

to sell to independent small traders (local middlemen commonly known as *coyotes*), who sell the product to processor/exporters; this is a very well developed marketing channel. *Coyotes* pay cash and usually buy a grower's entire harvest (from the beginning to the end of the season). This treatment is not guaranteed if the product is sold directly on local spot markets[30]. Other growers work with cooperatives or have special agreements with processor/exporters.

Table 4.1 shows the percentage distribution of Guatemalan snow peas exports; participation in the most important export markets (United States and Canada) has been declining over time. The percentage of national snow peas exports shipped to the combined North American market has decreased from 87.5% in 1995 to 77.7% in 2007; this is still the most important market for the product, however. The share of export volume going to just the United States market decreased considerably in the period 1995 to 2001, from 85.5% to 61%, then recovered in 2007, reaching 77.5%. Europe is the second most important market for the product at 10.2% of total in 1995 to 21.2% in 2007.

Table 4.1: Guatemala. FOB value of snow peas exports

By market of destination -Relative participation, in %-

Region	**1995**	**1998**	**2001**	**2004**	**2007**
USA/Canada	87.5	80.4	77.0	77.3	77.7
Europe	10.2	19.1	21.9	19.6	21.2
Others	2.3	0.5	1.1	3.1	1.1
Total	100.0	100.0	100.0	100.0	100.0

Source: Banco de Guatemala

The European market is more demanding in terms of quality. Exports to this market require more quality control, both at the cultivation and local commercialisation stages[31]; firms exporting to Europe work closely with farmers to meet requirements and avoid related risks. Higher prices compensate the stricter requirements of the European market. Table 4.2 shows that this market has paid higher average prices for Guatemalan snow peas and, with the exception of 2007, has shown larger periodic price increases than the North American market.

(Fieldwork, 25/7/2004), snow peas were found in very small quantities, as in the National Wholesale Centre (CENMA, or Centro Nacional de Mayoreo) and in the market of Chimaltenango. Prices per pound were: ejote Q3.00 (Sumpango), snow peas Q2.0-2.5 (Sumpango), and sugar snaps Q2.0 (CENMA) and Q1.5 (Chimaltenango). However, in contrast with the situation in local markets, lower quality snow peas were priced between Q4.6 and Q5.75 per pound in the local supermarket Hiperpaiz. The reason for this dynamic is clear when we consider that the price difference is paid by a wealthier sector of the population that buys in the supermarkets (1US$=Q7,72 at 22/7/2004). This also means that supermarkets in Guatemala are earning high margins on the product.

[30] Sometimes product that cannot be sold to traders is sold on the local market, but this product is second or third category in quality, so prices are lower and payment conditions worse than export conditions.

[31] It is estimated that about 12% of snow peas received by processing plants do not fulfil export quality requirements (Santizo, 2004; personal fieldwork interview). However, according to some plant managers, depending on the season of the year, the percentage of waste may be even larger – up to 40%.

Table 4.2: Guatemala.
Average prices of snow peas exports, by markets of destination.

		US$ per kilo			
Region	**1995**	**1998**	**2001**	**2004**	**2007**
USA/Canada	0.52	0.61	0.64	0.69	1.21
Europe	0.62	0.89	1.11	1.40	1.89
Others	0.32	0.38	0.39	1.01	1.08
Average	0.53	0.65	0.70	0.77	1.31

Source: Banco de Guatemala

Prices in the international snow peas trade are generally quite volatile, especially in the United States and Canada. These prices are lower in spring and especially summer, when the competing snow peas harvest takes place in California. In Canada, volatility is even higher than in the United States, while the European price is generally stable because distribution channels there maintain stable price bands (Ministry of Agriculture of Ecuador and Inter-American Institute for Cooperation on Agriculture, 2001: 6-7).

4.2.2 Structure of the Guatemalan snow peas chain

The Guatemalan snow peas chain is a good example of a simple and short chain. Final, ready-for-consumption product characteristics are very close to raw material form, implying little product transformation in the chain. In this case, post-harvest handling practices take on great relevance. The *local key-agent* in this case is the agro-processor/packer/exporter. As in the case of all fruit and vegetable chains, possibilities for product differentiation for local agents (cultivators and first processor/packers) in the snow peas chain are limited, implying that international buyers usually do not require particular product characteristics (see Section 2.6, Chapter 2 of this thesis). Moreover, they can easily source product from other countries, or even from the importing country - as in the case of the United States where large quantities of snow peas are harvested using cheap labour in California. The situation is similar in Europe, where snow peas originated.

To characterize the structure of the Guatemalan snow peas chain, we use both primary and secondary data. As a primary source, we did fieldwork through structured interviews with the following chain agents:

1. 33 farmers with an average of 0.25 hectares planted in snow peas, located in the departments of Chimaltenango and Sacatepéquez. These departments produced 90% of the total snow peas harvest in Guatemala in 2002-2003.
2. 8 representatives of processing and export plants. Three of these plants export mainly to the United States, and the remaining five to the European Union.
3. Representatives of two producer associations with strong links to processing plants exporting mainly to the European Union.

Interviews were performed in two different periods, to obtain information during both dry and rainy seasons: 23-30 July, 2004 and 25 February to 1 March, 2005. Despite the limited and not statistically representative sample size, with the information obtained we can characterize the market structures found along the Guatemalan snow peas chain.

The following activities occur along this chain: cultivation, local commercialisation, agro-processing and packing, international trade (including international transportation), wholesale and retail trade, and final consumption. The first three segments occur in Guatemala, the remaining segments in developed countries.

Cultivation consists of weeding, tying, spraying for pest control, and picking. *Agro-processing* comprises product reception, cleaning, drying, haze removal, classification, packing and cold storage. Processing and packing plants start the cold chain, to guarantee product preservation (Salazar, 2003; see also www.snopea.net/index.html).

Exporters control the agro-processing segment. They source produce through two main channels:

I. FARMER → LOCAL TRADER (COYOTE) → PROCESSOR/EXPORTER

A very common sourcing channel for the processor/exporter is the *night* or open spot market. These are local markets that usually work at night, where farmers sell the day's harvest[32] to local traders, or sometimes directly to processor/exporters. Local traders buy the product, usually paying in cash, and deliver it to the processor; they cover expenses associated with payments to farmers and transport. In some cases, between the farmer and the *coyote* intervene *smaller local brokers* who obtain produce directly at farms, on the street or even at farmers' houses; they then take the produce directly to the open markets. In this case, the channel between the farmer and the processor/exporter is:

Farmer→small local broker→ local trader → processor/exporter.

II. FARMER → PROCESSOR/EXPORTER

The other common channel to processor/exporter is direct from the farmer. We can characterize the three different forms of this channel as follows (Julian, *et al*, 2000: 58):

i. Vertical integration. One business group, sometimes a large farm or group of farms, produces 50% or more of the product that is processed and exported. These large producers are usually affiliates of multinational companies.
ii. Cooperative system. A group of producers form cooperatives, "organizations of small producers that pool their production to achieve an exportable volume".
iii. Contracts. Processor/exporters contract production with independent firms and agree mutually on terms and conditions of production and prices.

We illustrate the sequence of production, transformation and commercialisation activities in Figure 4.1. As in Chapter 2 of this thesis, the downward arrows are material flows in the different stages of production and transformation from cultivation to consumption.

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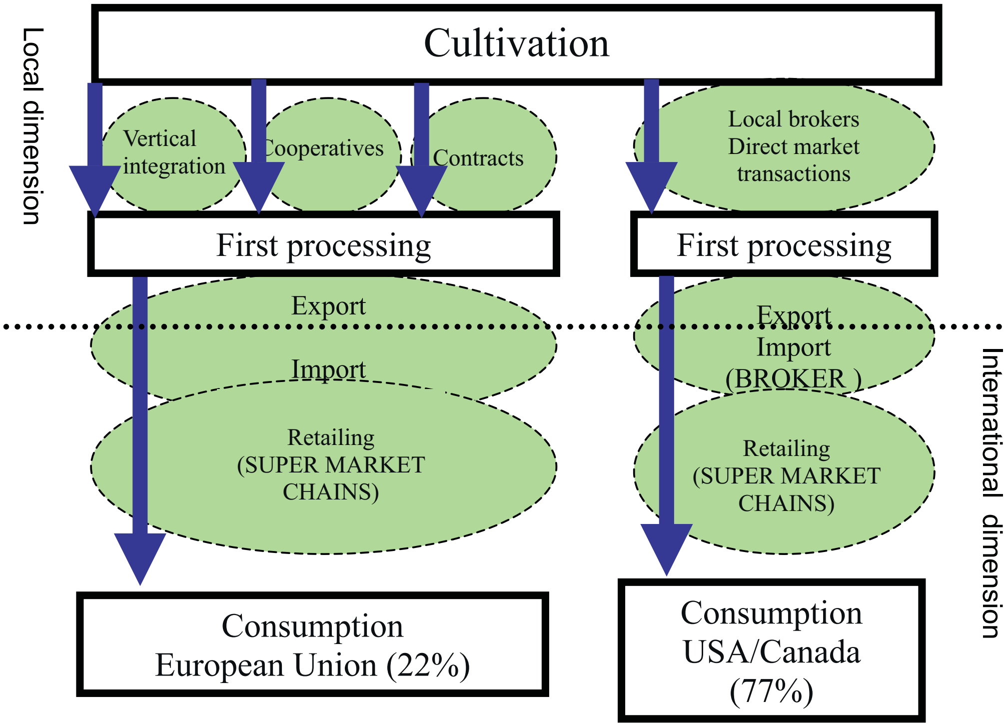
[32] Farmers harvest during the day, two or three days per week depending on the region and destination market. In the regions of Santa Polonia, Patzún y Patsicia, market days are Monday and Thursday, while in Sumpango, the market opens on Monday, Wednesday and Friday. Specific transaction hours vary in each market, but always occur at night for around five or six hours, depending on transaction volume.

We identify two main production and commercialisation channels for Guatemalan snow peas in Figure 4.1. The first, on the right side of the figure, refers to exports to Canada and the United States. Local commercialisation takes place through open or night markets, and exports move through international brokers. The second channel is oriented toward the European markets. Processor/exporters integrate with local farmers through agreements, and night markets do not play the key role found in the first channel.

Figure 4.1: Guatemalan snow peas chain: materials flow and markets



Source: Author, based on fieldwork and Julian et al, 2000.

The organization of the production and commercialization chain has important implications for final price in local markets, as well as for environmental impacts generated along the chain. In Subsection 4.2.3, we will see implications for local market pricing, while implications for selected technology and associated environmental impact are presented in Subsection 4.2.4.

4.2.3 Chain structure and farmer pricing[33]

The local night market is an important supply channel between farmer and processor/exporter, especially for produce exported to the United States and Canada. The suppliers are farmers selling produce harvested during the same day and *coyotes*, who collect produce from the streets or farmers' houses. The buyers are mostly local traders who then sell to processing plants; sometimes processor/exporters buy produce directly at night markets.

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[33] This section is based on results obtained from fieldwork described earlier.

At first glance, market structure appears to approach that of open competition. No one knows in advance what the final price will be, and, in the end, price is almost the same for all sellers. Before price is settled, there is time for bidding, and information flows smoothly between buyers and sellers. Moreover, final price is established without governmental or non-governmental intervention. However, taking a closer look at the dynamics of the entire chain, our field observations and interviews indicate that final price fluctuates around a reference price given by international brokers. This means that, even if not observed directly in market dynamics, the international broker exercises important influence on local prices. Local brokers usually earn a per-pound, fixed intermediation margin, so their earnings depend on volume rather than price strategies[34].

In the case of the production and commercialisation channel to Europe, agreements between farmers and processor/exporters play a key role. From analysis of the snow peas chain, we may identify three types of agreements (see Figure 4.1). The first occurs when a group of producers form a cooperative. The cooperative advances seeds, fertiliser and other chemical inputs; provides technical assistance to producers, and usually pays a higher price for the produce. Growers are required to sell to the cooperative and pay back advances when the crop is harvested. They are subject to control and supervision by the cooperative, but at the same time they receive reports on cooperative performance and activities. The price paid by the cooperative to affiliated farmers is usually higher than open market price[35]; however, producers do not know the final sale price when they deliver their produce. They must wait several days to receive payment.

The second type of agreement occurs between independent growers and processor/exporters. Support from the processor/exporters to farmers is basically the same in this case as in the cooperative system, but farmers do not participate in the firm's activities. Growers usually hold contracts that guarantee prices. This system works well for control of produce quality, and seems to be common with exporters who trade mostly in the European market.

We have identified a third type of agreement between farmers and local brokers. This is usually an informal contract that allows the farmer to guarantee the sale of an entire harvest during the production cycle. The local broker may advance seeds or other inputs, and provides technical support in the production process.

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[34] The price determination mechanism operates as follows (source: fieldwork observation and interviews):

a. Processor/exporters learn export price currently paid by international brokers.

b. With this price as a reference, exporter subtracts processing, packing, transport and other costs required for the product to reach broker. The resulting amount is the maximum price the processor/exporter is willing to pay local brokers. However, the resulting price can be lower than the reference price. The price paid to local brokers is often a fixed amount above the final price determined in the market. At the time of the fieldwork (July, 2004) this amount was Q 0.25 per pound. With the maximum price at-plant and local intermediation margin (Q 0.25, in this case) as a reference, local brokers go to market with an idea of possible buyers and reference prices.

c. With the previous restrictions in mind, end price is established. Clearly prices can go below the reference level, but they will never exceed the reference level, which means that the competitive mechanism operates for declining prices, but not when prices rise above the reference price.

[35] When farmers participate in a cooperative organization, they assess benefits other than the spot price, for example, stability and technical support. They may also prioritize higher final prices, regardless of the wait required. A farmer who prioritizes immediate cash flow will transact on the spot market, even when the final price is lower than that obtained through the cooperative system.

Contracts, especially those that define prices, are intended to reduce short-term competition and the power of the open market to determine final prices. However, the contract system does have some drawbacks. For example, the export firm sometimes does not respect the accorded price and refuses purchase, usually claiming quality issues. Also, exporter loans to farmers may have high interest rates, making payment difficult (Salazar, 2003: 87). On the other hand, from the *exporter perspective*, farmers also do not always respect the agreements. If market prices are higher than the contract price, farmers might break the contract and go straight to market; if contract prices exceed market prices, some producers that do not have contracts will try to sell product through farmers who do.

In addition, sufficient incentives do not exist for farmers to enter the contract system. Farmers prefer to sell their product to local brokers and not acquire obligations with processor/exporters or a cooperative, even when the broker price is lower. The reason for this behaviour may be that growers are driven by cash flow and not by concerns regarding the final destination of their product. Local traders pay cash, clearly very important to farmers considering their socio-economic conditions and their high discount of the future. If farmers are associated with a cooperative, they must wait to receive payment. If farmers are far away from markets, they may not have the means to transport their product, and harvest volume may not be sufficient to justify contracting third-party transportation. So they prefer to sell to the *small local broker*, even when the price is lower than the open market price. Also, some farmers prefer to avoid supervision by processor/exporters in the production and quality management processes.

Another factor against the contract system is the additional advantages that processor/exporters may find in buying from local brokers, even if they have to pay a higher price. With this channel, processor/exporters avoid the costs and risks of transporting product from market to plant, and they can apply stricter quality controls when buying produce directly at the plant.

These drawbacks of the contract system strengthen the role of the local broker or trader. Those farmers that do not have contracts or commitments must sell their product at market to the highest bidder. For these reasons, the open market assumes special relevance in defining short term prices.

Informal contracts between farmer and local broker are intended to reduce short-term price competition, as the farmer usually accepts the price set by the market; however, an implicit intermediate or long-term price competition exists among market participants. Depending on the loyalty that one party may hold toward the other, either retaliation or cooperative behaviour may appear in the future.

4.2.4 Implications of chain structure on technology choice, and associated environmental impact

As for many agricultural products, the use of pesticides increases productivity and assures adequate product appearance. Especially in the case of Guatemalan snow peas, pesticide use in the cultivation stage is important because the crop is not native to the tropics and therefore is subject to numerous pests and diseases controlled through chemical inputs (Linares, 2009; Hart and Reisman, 2003). Since the introduction of snow peas in Guatemala, cultivation of the crop has been characterized by the intensive use of pesticides in the cultivation stage (Hart and Reisman, 2003).

In addition to the benefits of pesticide use, negative environmental impacts also occur, and the risk exists that residues in the final product will exceed limits permitted by importing countries, as has occurred in recent years in the Guatemalan snow peas industry. Violations of environmental import standards of the United States market in recent years have negatively impacted this industry (Julian, *et al*, 2000: 56-57; Hart and Reisman, 2003: 4-5) and have caused refusal of product at the port of entry, as well as damage to product image and severe losses for Guatemalan exporters. Following Julian, *et al* (2000), we call this phenomenon market setback[36]/[37].

The two channels of production, transformation and commercialisation we have identified present different implications for the Guatemalan snow peas industry. When processors specify explicit coordination mechanisms with farmers, quality controls may then be established and enforced. On the other hand, where the open market dominates and the source farm of a specific supply of snow peas cannot be identified, controls are very difficult to establish.

Farmers who produce for the open market do not have incentives to apply ambitious quality criteria, such as reduced chemical inputs. They use a great variety and quantity of chemicals to obtain optimum product appearance. Sometimes the destination markets do not allow certain inputs used. In the words of a small scale farmer from the region of Patsún, Guatemala: *"There is a harsh reality for the farmer. He is requested not to use chemical inputs; however, the alternative inputs are more expensive and less productive. Also, when using the alternative inputs, the final product often looks bad, and the market does not compensate these additional costs; on the contrary, it punishes the farmer through the refusal of his product or by paying lower prices"* (Sicajá, 2004, fieldwork interview).

The existence of the open market channel for exports may reduce overall quality of the export supply (Julian, *et al*, 2000). These markets present great potential for environmental impact, because quality control processes are weak or absent. In order to meet demand, local traders may mix potentially contaminated open market snow peas

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[36] Responding to increasing worries about the effects of pesticide residues on public health, the USDA has begun stricter inspection and follow-up for all agricultural products. Guatemalan snow peas have been reported as the most important violator of permitted residues. For that reason, the United States has frequently suspended snow pea exports from Guatemala and ports have rejected shipments, resulting in important economic loses for Guatemalan producers and exporters (Hart and Reisman, 2003). Application of these measures became stricter in 1998, when the Animal and Plant Health Inspection Service (APHIS) published a specific guide for pesticide content assessment in snow peas (USDA, 1998). This guide details the main pests associated with snow pea cultivation, maximum permitted levels of chemical residues, and other related phytosanitary rules; excessive levels of Chlorothalonil (fungicide) and Methamidophos (insecticide) residue appear most frequently in Guatemalan snow peas (Hart and Reisman, 2003).

[37] In the application of the life cycle assessment to Guatemalan snow peas, Flysjö and Ohlsson (2006) found that cultivation was the phase with the highest environmental burden. This phase is the primary source of energy use, global warming impact, eutrophication and acidification. Those impacts are mainly explained by the extensive use of pesticides in the agricultural stage; in fact, snow peas produced for the European market have lower environmental impact compared to those produced for the United States market, due to the stipulated lower use of agro-chemical inputs in cultivation for the European market.

with produce from other channels, risking contamination of the entire lot. This dynamic implies that the environmental impact of snow peas cultivation and the possibility of market setbacks are concerns for all agents in the chain, not just buyers and sellers in the open market. Here we see the importance of coordination among agents in different stages of the chain for tighter quality control in cultivation.

Coordination mechanisms between farmers and first processors offer many advantages for both agents because they insure good product quality standards. Farmers receive technical assistance in advance, as well as seeds and other inputs, and financial support to start the production cycle.

Table 4.3: Guatemala - Technology typology of snow peas production and trade

Traditional Technology	***Sustainable Technology***
Main Characteristics	
• Mainly trade through local (night) open markets; local traders (*coyotes*) play a key role. • Influence of international spot markets in determining local price (international brokers as dominant chain agent). • Absence of quality controls, including environmental, in cultivation phase. • Small-scale, low-technology production.	• Use of agreements and contracts: processing firms provide technical assistance, quality control and guaranteed price; farmers accept processor recommendations and commit to deliver product according to contract. • International medium term price trend determines contract price. • Strict quality controls, including environmental, in cultivation phase. • Medium scale production (cooperatives). • Opportunities for farmer organisation and association. • Access to irrigation systems. • Production takes place mainly in summer, when waste and use of chemical inputs are lower.
Environmental impact	
• Pesticide treadmill (ongoing and increasing use of pesticides). • Contamination of water, soil and air. • Worker and consumer health risks.	• Regulated use of pesticides and other chemical inputs. • Reduction pollution risk for water, soil and air. • Reduction of worker and consumer health risks.
Economic implications	
• Environmental costs are social, not private. • Increasing social costs of pesticide treadmill. • Volatility generates lower average prices over time. • Risk of market setbacks and export rejection, with subsequent economic losses.	• Economies of scale. • Higher costs and average prices, with lower volatility. • Lower risks of market setbacks and export rejection.

These mechanisms may also include assistance in transporting the produce to processing plants. For processors, coordination with farmers represents a promise of good quality product, which may lead to higher prices and reduced risk of product rejection or other market setbacks. In this case, quality standards become an entrance barrier for farmers, but at the same time offer access to more exclusive markets.

Considering both environmental impact and the destination markets, we can relate the two types of production and commercialization channels identified earlier to different technology options, as defined in Chapter 3 of this thesis. In this sense, we can identify two technology options for the Guatemalan snow peas chain: a traditional option which tends to be unsustainable and an alternative or more sustainable option. Traditional technology includes the intensive use of chemical inputs, and is closely related to the production and trade system of the United States and Canadian markets. Sustainable technology mandates reduced chemical use through stricter environmental quality controls, and is closely related to the European market. We present the main characteristics and implications of both technologies in Table 4.3.

Despite the drawbacks of the contract system explained in Subsection 4.2.3, farmers and first-processors may find strategic value in the shift from traditional polluting technology, related to the North American market, to more sustainable technology in line with European requirements (Jiménez and Pelupessy, 2006). This shift has withdrawal costs, and leads to higher direct production costs. As a result, environmental quality becomes an entrance barrier for the European market. However, shifting technology will reduce the risks of market setbacks and may permit access to price premiums for both farmers and processors by differentiating the product through environmental quality.

The key agent in the technology shift process is the first-processor. However, public regulations are also important as they generate pressure for compliance with environmental standards in industry-wide production and post-harvest practices.

4.2.5 Concluding remarks on market concentration and environmental cooperation in the Guatemalan snow peas case

From the analysis of the structure of the Guatemalan snow peas chain, and considering both environmental impacts and the markets involved, we have identified two production and commercialisation channels with their respective technology options. These channels illustrate a clear relationship between market structure and cooperation for improved environmental quality in the cultivation and first-processing stages of the chain. In the market for agricultural produce, we found that as behaviour approaches the rules of open spot market transactions, conditions for cooperation in favour of the environment becomes less favourable, and negative environmental impacts are higher. On the other hand, where strong coordination mechanisms exist between farmers and processors (contracts, cooperatives, or vertical integration), conditions for cooperation in favour of increasing environmental quality are far more favourable.

The shift from polluting to sustainable technology should be of strategic concern for farmers and first-processors. Chapter 5 of this thesis will analyse the possibilities for strategic management of environmentally friendly technologies for the upgrading of farmers and first processors in the Guatemalan snow peas chain.

4.3 Market concentration and environmental cooperation in a price regulated oligopsony: the Costa Rican coffee case

The market for coffee berries in Costa Rica is not completely open. In each coffee region, a limited number of buyers exists, and the majority of these are regional processors or representatives of companies from outside of that particular region; growers decide freely to whom they sell their produce. Growers generally receive an advance payment upon delivery, and must wait several months before receiving the balance.

Farmers hope to receive the highest prices possible, but price is not the only factor they consider when deciding to whom they will sell their produce. Other non-price variables related to the institutional framework (Ayala, 2003: 88) are also relevant to this decision. These variables include the following: location (distance to delivery point), access to information, transaction costs, loyalty, trust, contractual agreements, tradition, and personal relationships. When growers choose a processor for their produce, an implicit election of technology is made, since each individual mill may have its own commercialisation channel and particular quality requirements, including environmental requirements.

In this section, we analyze the influence of price and non-price variables on the decisions of agricultural producers regarding technology and buyers for their produce. We focus on the coffee berry market in the Los Santos region in Costa Rica. The role of price in grower decision making is determined by the degree of sensitivity (elasticity) of the amount of coffee that each mill receives as a response to price variations. We evaluate the influence of non-price variables through workshop discussions with growers. Among non-price variables, we place special attention on environmental aspects. With this exercise, we obtain an indicator of the influence of market structure on the willingness to cooperate for improvement of environmental quality, at the cultivation stage of the chain.

4.3.1 The influence of prices on farmer decisions in the coffee berry market: a case study in the Los Santos region, Costa Rica

In this subsection, we are interested in the degree of sensitivity (elasticity) of the amount of coffee that each mill receives as a grower response to variations in price.

Mechanisms of price determination for coffee berries

As mentioned before, farmers receive advance payments when they deliver their coffee to the mill. Final price depends on the value of the processed product on the local and international market, and final payment is made with a lag of several months. For final grower price calculation, the mill subtracts the following costs from the total sale of the harvest: mill operating costs, commission on the sale, and the contribution to the Coffee Stabilization Fund (Fondo de Estabilización Cafetalera) (Asamblea Legislativa de Costa Rica, 1961). The minimum price that the mill must pay growers is calculated and enforced by ICAFE for each individual mill according to its specific conditions. In this sense, we can assess that the price for coffee berries is regulated, but the final price depends mostly on the international sale price and mill operating costs.

The mill can influence the final grower price by applying quality management and commercialization strategies to increase local and international prices of its processed product, as well as through reduction of operating costs.

Usually, farmers receive payment in instalments; that is, they receive partial payments between the initial advance and final payment. Nevertheless, some companies, especially those linked to trans-national exporters, offer larger advances in order to attract greater quantities of product from growers. This mechanism, very close in essence to spot selling (that is, only one payment), is especially relevant in those cases where vertical integration exists between first processors (mills) and other agents located forward in the chain[38]. This purchase method generates competition for coffee berry, especially in the Los Santos area, where a high quality coffee is produced.

Case study: the Los Santos region, Costa Rica

Costa Rican coffee is classified according to its region of origin. ICAFE identifies seven distinct coffee-producing regions. Each region has its own climate and soil characteristics, which are functions of altitude and location. These variables determine to a great extent the characteristics and cup quality of coffee.

High altitude cultivation produces Strictly Hard Bean (SHB) coffee quality; this type of coffee presents a closed fissure in the berry, high acidity, good body and bouquet in the cup (Díaz, 2003: 106). Los Santos is a high altitude coffee producing region, famous for the *Tarrazú* bean. Because of the quality of the grain produced in this region, Los Santos coffee receives relatively high prices in the international markets. As it can be seen in Table 4.4, average prices received by Los Santos farmers (final farmer prices, in line with export prices as mentioned earlier) are the highest in the country.

Table 4.4: Costa Rica. Final farmer prices for ripe coffee berry by region

	Harvests - Current US$		
Region	**2005/2006**	**2006/2007**	**2007/2008**
Pérez Zeledón	109.47	118.28	131.18
North Zone	114.84	124.40	135.00
Coto Brus	116.55	121.68	138.05
Turrialba	118.90	123.88	136.17
Central Valley	124.28	134.27	144.29
Occidental Valley	124.16	131.97	148.73
Los Santos	127.33	136.35	150.87

Source: ICAFE

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[38] For example, some mills are also exporters and subsidiaries of large transnational coffee enterprises. In Costa Rica, this is the case Beneficio F. J. Orlich and Comercializadora ECOM, part of CAFINTER S. A., which vertically integrates the phases of first processing (milling), export and international commercialization. Another example occurs with the *Palmichal* series of mills, where CECA, as exporting member of the Neumann Kaffee Grupe, represents the interests of that transnational company in Costa Rica.

Los Santos produced more than 30% of total national coffee production in 2006-2007, with approximately 22% of the total cultivated area allocated to coffee in the country (ICAFE, 2007); this indicates a higher than average yield[39].

Taking into account the number of buyers and sellers and the concentration of transactions in the market for coffee berry in this zone, we can conclude that this market approaches an oligopsonistic structure. For the crop year 2004-2005, 6671 producers sold to only 19 buyers. Most buyers process their coffee within the same region, but some process outside of the region. Coopetarrazu, the most important buyer, bought around 30% of the total coffee harvest, while the first and second most important buyers, Coopetarrazu and Coopedota, combined for 45%. If we consider the four largest buyers out of the total of 19, we add two transnational enterprises which do not process coffee within the region: Volcafe and F. J. Orlich. These two firms bought 23% of the total coffee produced in the region, meaning that the four most important buyers concentrated 68% of the total coffee sold during the indicated period (calculations are based on official data from ICAFE: www.icafe.go.cr). This concentration indicates oligopsonistic power in this market, even when we take into account that mills do not determine price through spot market transactions, as previously discussed.

The Los Santos area comprises the counties of Dota, Tarrazú and León Cortés; among these counties, differences exist in terms of the number of coffee buyers (competitors) and competitive conditions. In Dota, only three mills operate. The main actor in this county is Coopedota, which receives and processes more than 85% of the local harvest (in the past this figure was even higher)[40]. Competition is very limited; firms from outside of this area cannot establish receiving stations,[41] because this is not permitted by local law (Hernández, Ricardo; personal fieldwork interview, 2007). Considering that only two additional small mills (including one organic) operate in the area, Coopedota acts very much like a monopsonistic agent.

The second sub-region is Tarrazú. In this county, Coopetarrazu is the most important mill. According to Zúñiga (2008; personal fieldwork interview) this cooperative receives and processes 75% of the local harvest. However, a large number of local competitors do exist here, including affiliates of trans-national companies.

The third sub-region is León Cortés. This is the Los Santos area county with the largest number of buyers under the most competitive conditions. There is no local cooperative

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[39] Coffee is the most important crop in the Los Santos area. According to the National Institute of Statistics (INEC), for the year 2006, 63% of total area of the region was dedicated to coffee production, a very high percentage considering that 14% of land in the region is protected forest (INEC and ICAFE, 2007).

[40] We obtained this figure by considering the quantity of coffee received by Coopedota as a proportion of total coffee received by this cooperative and the other mill located in Dota, the Montañas del Diamante mill, during the last 5 years. In all cases, the figure was higher than 85%, with the exception of the 2005-2006 crop, which was 84%. The figure however, does not consider coffee that may be delivered to mills or points outside the county. Another very small, organic mill is also present in this county, but the volume processed by this plant is not significant as a proportion of the total coffee processed in the county.

[41] Receiving stations are branches of the mills located throughout the cultivated area. They are installed close to farms to facilitate the delivery of produce by local growers. In this sense, the receiving point is a tool for mills as they compete for produce. Many of these receiving points belong to mills located outside the zone, meaning that competition for the coffee berry goes beyond the mills existing within the region.

here[42], unlike Dota and Tarrazú. The influence of Coopetarrazu in this county, while important, is limited. Here this cooperative receives and processes around 17% of the coffee grown in the county (Zúñiga, Ricardo. 2008; personal fieldwork interview). Coffee growers do not trust the cooperative system, due to negative experiences in the past with a local cooperative (Coopeleco). This history explains why trans-national enterprises have important influence here, although, in recent years, some micro-mills managed directly by growers have appeared[43].

On the influence of price on farmer decisions in the market for coffee berry: an econometric model

As mentioned before, the market for coffee berries in Los Santos presents the initial characteristics of an oligopsonistic structure, as described by Rogers and Sexton (1994), even though the influence of first-processors over producer price is highly limited due to the partial price regulation in effect. However, since export price obtained by the mill is one of elements used to set grower price, mills can influence this price through strategies targeted at insuring export prices. The grower price is different for each mill, so farmers take price into account, among other variables, when deciding which technology to use and to which mill they will sell their harvest.[44] In this subsection, we will focus on the influence of price by holding other variables constant and will analyse the influence of other variables later.

In order to analyse the influence of price on farmer decisions, a panel data model is applied to estimate the elasticity of grower response to variations in mill prices. Grower sensitivity to price can be considered an approximation of the supply elasticity faced by each particular mill. Based on this calculation, we can generate some conclusions on the degree of market power. By considering the location of each mill, as well as the number of competitors in each county of the Los Santos region, we draw conclusions regarding market structure.

Model specifications

In line with economic theory, and considering that agricultural producers are price takers, we may expect that the quantity of coffee received by a specific mill is a direct function of the final price paid to growers by this specific mill in the previous period, since current prices are unknown when farmers deliver their coffee. The volume received by a mill in the current period is the dependent variable, while the final producer price from the previous period is the explanatory variable. Other variables are constant, as explained earlier.

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[42] There is a small cooperative in the district of Llano Bonito, named Coopellanobonito; however, although it is well recognized in the area, its actual zone of influence is very limited. According to Ortiz (2008, personal fieldwork interview), this cooperative only receives 20% of its volume from growers outside of the local community of Llano Bonito.

[43] As a very important indicator of the highly competitive conditions in this area, it can be mentioned that León Cortés produces less than 50% of the volume produced jointly by Tarrazú and León Cortés, but, during 2006-2007, this county had nearly 60% (97 out of 169) of the total receiving points located in these two counties (figures based on official data from ICAFE). The location of receiving points close to farms is one of the most important competitive strategies among mills.

[44] Prices play a role in grower decisions regarding technology, in the manner in which we defined technology in Chapter 3 of this thesis (Section 3.5). If producing coffee of a specific environmental quality assures an adequate price premium, farmers may have the incentive to switch technology.

Thus, we have:

$$q_{it} = f\left(P_{i,t-1}\right); \quad \frac{dq_{it}}{dP_{i,t-1}} > 0 \qquad (1)$$

Where:

q_{it}: quantity of coffee received by mill *i* in period *t*.

$P_{i,t-1}$: final farmer price paid by the coffee mill *i* in previous period, *t-1*.

Equation (1) provides the following functional form of the model:

$$q_{it} = \alpha + \beta_i P_{i,t-1} + \varepsilon_i \qquad (2)$$

A panel data model will be estimated, with each mill *i=1, ..., n* and *n* as the number of mills located in the region of study.

We expect that each coefficient (α, β_i) will be positive. As final price of a specific mill increases during a period, the quantity of coffee received in the next period will also increase $(\beta_i > 0)$. We also expect a positive influence from non-price variables $(\alpha > 0)$.

In order to obtain elasticity coefficients, we consider prices and quantities in their logarithmic form (percentage variations). In this case, the panel data model (2) is estimated as follows:

$$Log(q_{it}) = \alpha^* + \beta_i^* Log(P_{i,t-1}) + \varepsilon_i^* \qquad (3)$$

Here coefficient β_i^* indicates the percentage of change in the quantity of produce received by mill *i* as a reaction to a 1% change in price from the previous period.

Model estimation

We have mentioned previously that during 2004-2005, 19 buyers operated in the Los Santos region; however, some of these buyers are recent entries. Also, other buyers that played important roles in the recent past are no longer operating. For this reason, we estimate the panel data model (3) for an extended period - from 1990 to 2003. Using this period, we capture competitive behaviour of the most important mills in the region, including one (Beneficio La Meseta) that is no longer in operation, but was a strong competitor in the recent past[45]. The mills included in the model are listed in Table 4.5.

We use panel data for the analysis, consisting of observations of the same cross-sectional units over several time intervals. This allows us to identify interaction between firms and analyse the dynamics of these interactions (Greene, 1997: 613).

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[45] We have omitted another mill from the study. Coopellanobonito experienced severe instability during the period of study, although today it is a strong and healthy firm (Ortiz, 2008; personal fieldwork interview).

Table 4.5: Los Santos Region - relevant coffee mills, 1990-2003

Name	**Type of mill**
F.J. Orlich	Transnational from outside of region
Volcafe San Diego	Transnational from outside of region
Coopeunion	Cooperative from outside of region
Coopedota	Cooperative from the region
Coopetarrazu	Cooperative from the region
La Meseta Los Santos	Transnational branch from the region

We apply a fixed effect model, where the intersection for each of the model's equations is considered equal in all cases; that is, $\alpha_i^* = \alpha^*, \forall i = 1,...,n$. The same intercept for all mills allows us to understand the performance of the milling sector as a group, and compare the different equations by the differences in their slopes, which represent elasticity coefficients. The software program E-views is used for the econometric analysis.

The Costa Rican Coffee Institute (ICAFE) provided the data, and the variables were defined as follows:

- *Quantity of coffee received:* volume of coffee berry received by each mill in a particular year (*t*), in units of *two double hectolitres* (TDH) of produce[46].
- *Farmer price*: final price paid by mill *i* in previous period (*t-1*), after regulated pricing procedure, as indicated in the previous subsection. Units are Costa Rican *colones* per TDH.

We present the regression output in Annex 4.1. By analyzing the regression data and applying traditional criteria, we observe that all coefficients are positive, as expected, indicating a positive relationship between quantity of coffee berries received and final farmer price in the previous period. An $R^2 = 0.66$ and the probability of the F-stat = 0.0000 indicate that the overall model is significant.

The individual values of each variable also show positive results for the majority of mills, and the *t*-values show that final farmer price is significant, at more than 95% confidence level for all mills, with the exception of Coopeunion, whose coefficient is significant at 90% confidence level. The *t*-value also shows that intercept (α) is significant as well, which indicates that other variables besides final farmer price also influence the quantity of produce received by the mills.

A Durbin Watson statistic equal to 1.6 (with 6 explanatory variables and 78 observations) does not allow us to conclude a positive or negative serial autocorrelation; the calculated value lies within the indecision zone. However, an analysis of the disturbances from the model (ε_i) and of the individual correlations for each mill shows no evidence of serial autocorrelation.

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[46] On average, and considering normal efficiency conditions for the mill, a 46 kg bag of green coffee is obtained from the equivalent of *two double hectolitres* (400 litres) of coffee berry. In Costa Rica this measure is also called *fanega*.

To test for multicollinearity, we obtain the correlation matrix for the explanatory variables, and find no evidence of severe multicollinearity. In the correlation coefficient between Coopetarrazu and F.J. Orlich, we obtained a value higher than 0.8. The remaining coefficients are lower, in absolute values, than 0.6. The correlation matrix is presented in Annex 4.2.

Analysis of results

According to the functional form of this model, the coefficients measure sensitivity of the dependent variable (quantity of coffee received by mills) as a response to changes in the independent variable (final farmer price paid by given mill in the previous period). We can interpret the slopes as farmer price elasticity of the quantity received by a specific mill; we can further consider this as an approximation of the supply elasticity coefficient faced by a particular mill[47]. Table 4.6 is a summary of elasticity values obtained from the model for each mill.

Table 4.6: Costa Rica, Los Santos region

Elasticity coefficients per mill (1991-2003)

Mill	**Elasticity coefficient** β_i
Coopetarrazu	0.20
La Meseta Los Santos	0.16
Volcafe San Diego	0.14
Coopedota	0.10
F.J. Orlich	0.09
Coopeunion	0.06

Source: Annex 4.1

We can observe that, in all cases, elasticity is lower than 1.0, meaning that changes in the final price paid by a given mill provoke a proportionally smaller change in the volume of produce that this mill receives. According to our previous interpretation, this suggests that the supply of any particular mill is inelastic.

To analyze individual results, it is important to take into account the different competitive conditions among the three sub-regions. We start with Dota county, where Coopedota is the leading mill. As mentioned before, this cooperative currently receives and processes more than 85% of the coffee cultivated in Dota, implying that local competition is very limited; this is reflected in the relatively low elasticity coefficient of 0.10, reinforcing the notion that Coopedota acts as a monopsonistic agent.

In the sub-region of Tarrazú, Coopetarrazu is the most important mill. Although this cooperative receives and processes 75% of the total coffee produced in this county (Zúñiga, 2008; personal fieldwork interview), the presence of transnational companies generates significant price competition, suggesting that the cooperative must price carefully.

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[47] This elasticity coefficient is different from the price elasticity of the aggregate farmer supply.

This is reflected in the result obtained for the elasticity coefficient for Coopetarrazu (0.20), which is the highest among the mills studied, and twice that of Coopedota.

The third area studied, León Cortés, presents the largest number of buyers and the most competitive conditions; this is also the area with the most significant presence of transnational enterprises. The elasticity coefficient for Coopetarrazu (0.20) in this county also reflects the importance of price competition here. The relatively lower elasticity coefficients for La Meseta (0.16), Volcafé San Diego (0.14) and F.J. Orlich (0.09) may reflect price strategies used by these firms to capture supply; these firms usually make complete payments on delivery, therefore advance payment equals final price paid to farmers meaning that final price is not paid in instalments.

The Lerner index of oligopsony power

The Lerner Index of oligopsony power serves as an indicator of market concentration, the relative market power a particular agent can have in the market, and is inversely related with the elasticity coefficient of supply (Lopez and You, 1993; Bergman and Brännlund, 1995; and Weerahewa, 2003). In other words, the lower the supply elasticity coefficient, the higher the Lerner index and greater market power exerted[48]. Taking the individual elasticity coefficients calculated earlier for Coopedota and Coopetarrazu as an approximation of the supply elasticity faced by those mills, we may conclude that in the sub-region of Dota, market concentration is higher than in Tarrazu; or from another perspective, market conditions are more competitive in the sub-regions of Tarrazú and León Cortés, areas of influence of Coopetarrazu. Additionally, we could expect more mill competition in the county of León Cortés compared to Tarrazú, considering that the number of actors in León Cortés is higher and no large firm captures a high share of the market there.

Conclusions on the influence of price on farmer decisions

In conclusion, while in general we identify oligopsony structure in the market for coffee berries in Los Santos, we can also differentiate competitive conditions in the three sub-regions as follows:

- Dota: market structure close to monopsony with very limited competition. A cooperative (Coopedota) is leader.
- Tarrazú: higher competition compared to Dota. Price is an important factor in farmer decisions and should be considered carefully. A cooperative (Coopetarrazu) is leader.
- León Cortés: larger number of buyers and more competitive conditions. No local cooperative concentrates purchases and acts as leader in this county.

On the influence of non-price variables on farmer decisions

Returning to the model, we will now analyze the intercept, which indicates the influence of variables other than final farmer price on the quantity of produce received by each

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[48] We were interested in the calculation of Lerner Index coefficients for all mills; however, we were not able to calculate the corresponding conjectural elasticity for the mills with the available data. Therefore, we derive partial conclusions using estimations of the supply elasticity coefficients obtained from the model.

mill. As mentioned before, the *t*-value shows that the intercept (α^*) is statistically significant, indicating that other variables apart from final farmer price also influence the supply received by the mills. The influence of non-price variables on farmer decision making is the subject of the following subsection.

4.3.2 Influence of non-price variables in coffee grower decisions and the importance of environmental aspects

We have stated that variables other than price appear to influence selection of technology by farmers, as well as to which mill they sell their crop. In this subsection we study the influence of non-price variables on farmer decision making, with special attention on environmental regulations. Also, we will estimate the relative importance of non-price and price variables in farmer decisions.

We evaluate the influence of non-price variables on producer decisions through group workshop discussions with growers, with one workshop held in each of the sub-regions studied. In all discussions, coffee producers with extensive experience were invited in order to illustrate the situation of the whole coffee sector in the region, and not the situation of any specific grower[49].

In general terms, we identified the following non-price variables as the most important in farmer decisions:

i. Trust in the mill. This variable can be measured through the following mill actions: a) respects financial commitments, including, of course, payments to the farmers; b) supports growers by advancing inputs, providing financial support and advising them if needed during the production process; c) transmits information to growers; d) pursues innovation initiatives and is, for example, willing to cooperate in efforts to increase environmental quality of cultivation and processing stages.
ii. Income security. Sometimes the most important variable for the producer is not only the amount of payments, but also how income is spread over the year. This allows farmers to enjoy income security during the entire year.
iii. Distance from farm gate to the collecting point. This variable impacts transportation costs directly. For this reason, mills locate various receiving stations in the area as a strategy to capture supply.

The first two variables are usually resolved in the cooperative system. This type of organization, besides playing a leading role in the dynamics of the coffee industry, exercises influence on the socioeconomic aspects of the entire region. In this sense, agricultural producers tend to identify themselves with a particular cooperative and to operate under principles of confidence and loyalty. In general terms, the cooperative offers support to the grower (low-cost technical assistance, credit and financing) and, as a condition, the grower commits to selling to that mill. Growers often prefer long term relationships in the marketplace, as a hedge against unexpected loss in income caused by instability in international coffee prices[50].

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[49] Nine growers attended the workshop in Dota, six in Tarrazú and seven in León Cortés.

[50] The cooperative system also provides other services, such as loans, machinery and heavy equipment, employment options, training, qualifications and other economic services such as restaurants, supermarkets, gas stations and coffee roasting, among others. This multiplicity of activities increase value

At this point, the following questions arise regarding non-price variables and coffee growers in the areas studied: how important are the non-price variables in farmer decisions? Which is the most important non-price variable? What is the relative importance of non-price variables in relation to final and advance prices? What is the relevance of environmental aspects in farmers' decisions? The answers to these questions are different for the three different sub-regions studied, as will be explained below.

Dota: Area of influence of Coopedota

In this sub-region, as mentioned earlier, around 85% of the coffee produced is processed by Coopedota. This is a clear indicator of the dominant role of this mill in the county; producers in this area have very few options. In this sense, the variables 'trust in the mill' and 'guarantee of income', which are associated with the cooperative system, are the most important. High final grower prices are also very important, but these usually result from the strength of the cooperative and the commercialization strategies developed. These factors motivate grower loyalty to the cooperative. Low advance prices are compensated by additional benefits. As an important note, during the workshops some of the participants mentioned that they considered the presence of other buyers in the area a positive factor, even though they would remain loyal to the cooperative.

In this context, environmental initiatives promoted by the mill are easy to implement: farmers do not have many options for sale of their produce, and they trust the cooperative and support its innovations. Initiatives to increase environmental quality will likely succeed under these conditions, because the willingness exists among agents to cooperate in favour of the environment, as mentioned during the workshop. Generally speaking, environmental consciousness in this area is high. Many of the current environmental regulations were initially promoted by the cooperative (Coopedota) as a programme supported by one of the most important international buyers of green coffee: Starbucks Coffee Company; growers have in general followed these initiatives.

Tarrazú: Area of influence of Coopetarrazu

In the county of Tarrazú, in which Coopetarrazu has its most important influence, the number of competitors exceeds that of Dota, but is not as high as in León Cortés. According to participants in the workshop, final price is a very important variable, but they are conscious that this variable is strongly correlated with the strength of the mill. Therefore, trust in the mill is the most important variable in the medium and long term. In other words, lower final prices in the short term may be accepted by farmers because they are compensated by the additional benefits obtained from being part of the cooperative, but this applies only if the mill is stable and respects its financial commitments. On the contrary, if the mill is not strong enough to be relied upon in the future by the growers, final and advance prices become the most important determinants in farmer decision making regarding sale of their produce. Currently Coopetarrazu is trusted by most growers; however, they have several options, and the cooperative must carefully manage relevant variables to remain reliable and retain its suppliers.

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added and the benefits are transferred to associates (producers). In this sense, the mill is far more than just a raw materials buyer.

Strong environmental regulations have been implemented in this county. As in the case of Dota, the local cooperative (Coopetarrazu) has promoted most of these regulations as a joint programme with Starbucks Coffee Company. According to participants in the workshop, environmental consciousness has become part of their productive culture: a producer uses environmentally friendly technology both to protect resources and to gain access to stable markets. Price premiums are not explicitly considered the engine to move producers from polluting to sustainable technology[51], and farmers trust the cooperative.

In this context, area growers are quite willing to cooperate in favour of the environment, especially those affiliated with Coopetarrazu, which represents a high proportion of growers. However, producers still have the option to not cooperate and to sell their coffee to other buyers who do not impose specific environmental requirements. The cooperative is, however, strong enough to be successful and maintain the loyalty of its suppliers.

León Cortés: Secondary area of influence of Coopetarrazu

According to the participants in the workshop, and considering the competitive conditions explained earlier for this sub-region, the most important variable in farmers' decisions is price, both advance and final. Without the dominating influence of a strong local mill, the presence of other buyers is very important. In this case, price-based competition is more important than in the other counties studied, and the main competitive mechanism is the offer of high advance prices, because long term relationships between farmers and mills are not frequently encountered[52].

We note here that growers sometimes distrust not only the cooperative system but also trans-national firms. This distrust often arises due to negative past experiences. Participants mentioned withholding of information and lack of commitment to growers as the most important sources of this distrust. For this reason, some cultivators are currently trying to develop their own micro-mills in order to control the first processing and exporting stages of the chain.

Under these circumstances, farmers in this area are relatively unwilling to cooperate in favour of the environment, among the three areas studied. In the absence of a clear, mill-sponsored incentive programme to help reduce negative environmental impact, growers will not apply environmental friendly techniques on their own, unless sufficiently motivated by their conscience. As mentioned during the workshop, a grower who does not apply environmentally friendly techniques will still find a buyer.

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[51] We should mention that producers are willing to move to more sustainable technologies, but not necessarily to the extreme end of the spectrum – organic cultivation. This is because the soil characteristics (*altisoles*), topography, and climatic factors are not conducive to organic production, without facing very high costs not compensated by the price premium (Zuñiga, 2008 and Chacón, 2008; personal fieldwork interviews). Most local experiences in organic coffee have not been successful (Calderón, 2007, personal fieldwork interview).

[52] The exception to this is the cooperative Coopellanobonito; however, as explained before, its area of influence is limited.

4.3.3 Concluding remarks on market concentration and environmental cooperation in the coffee berry market in the Los Santos region, Costa Rica.

In the analysis of the market for coffee berry in Los Santos, we have identified three distinct sub-regions: Dota, Tarrazú and León Cortés; each one presents different conditions of market power concentration and competition. In the case of Dota, competition is regulated legally; external buyers cannot locate receiving stations in the county. As a result, the number of options for farmers is very limited. They may take their produce out of the county, but the costs in time and transportation of doing so are prohibitive. The main buyer in this canton is the local cooperative Coopedota, which behaves very much like a monopsonistic organisation. Its price elasticity coefficient is very low, at 0.1. If the Lerner Index of oligopsony power behaves inversely to the supply elasticity coefficient, with the low elasticity coefficient obtained we would expect a high degree of market power for this enterprise.

In Tarrazú, the main buyer is Coopetarrazu, the local cooperative. However, while the majority of local growers are affiliated with the cooperative, other private mills -some of them linked to trans-national companies – also operate in the county. Nevertheless, Coopetarrazu is strong enough to exert a high degree of market power. Non-price variables (trust, for example) play a significant role in the determination of market power. The higher elasticity coefficient obtained in the model for Coopetarrazu (0.2) is consistent with the more competitive conditions in this area.

León Cortés presents the highest level of competition of the three cases studied. No local cooperative exists and the main actors are Coopetarrazu and trans-national enterprises; some small local mills are also present.

We evaluated the influence of non-price variables in farmer decision making through group discussions. In general, farmers are willing to accept lower final prices in the short term if this is compensated with other benefits related to membership in the cooperative. Therefore, trust in the mill becomes a very important variable. In the case of León Cortés, where there is no dominant local mill and long term agreements between farmers and mills are not common, price-based competition is more important than in the other counties studied.

We can also conclude that farmers are more willing to cooperate in favour of the environment when non-price variables, especially trust in the mill, dominate their decision making. In our case studies, we conclude that cooperation in favour of the environment would be easier to achieve in Dota and Tarrazú, where mechanisms of strong vertical coordination between farmers and first processors are well developed and non-price variables are important. On the other hand, cooperation would be more difficult in León Cortés, where price is the most important variable in grower decisions.

In order to move toward more sustainable technology, mills should initiate the switch through the development of vertical coordination and support mechanisms. In this sense, non-price variables must play a significant role.

4.4 Conclusions

Markets for agricultural produce present the typical characteristics of oligopsony structures as described by Roger and Sexton (1994). These characteristics are easily found both in the local market for snow peas in Guatemala and the market for coffee in Costa Rica. This market structure determines the role that price and non-price variables can play in farmer decisions regarding buyers for their product.

Our main conclusion of this chapter is that cooperation in favour of the environment in the two case studies is easier when strong vertical coordination exists between growers and first processors; as the commercialization channel approaches the spot market system and competition increases, cooperation in favour of the environment is more difficult to achieve.

When a farmer decides to whom he will sell his produce, final price plays a very important role but is not the unique determinant. Non-price factors such as trust are also relevant. Among these factors, explicit coordination mechanisms play key roles. These coordination mechanisms usually relate to financing services, technical assistance, complete harvest purchase guarantee, and trust, as well as cultural, social and economic issues. Most of these variables are related to the functionality of the cooperative system. This type of long-term relationship in markets for agricultural products is very important, especially during times of price instability and increasing concerns over sustainability.

5

Upgrading by strategically improving environmental quality in the Guatemalan snow peas chain

5.1 Introduction

The objective in this chapter is to analyse the possibilities for strategic management of environmentally friendly technologies for the upgrading of farmers and first-processors in the Guatemalan snow peas chain. Pesticides are widely used in Guatemala for the cultivation of snow peas, mainly exported to the United States (US) market. An alternative export option is offered by the European Union (EU) market, where higher average prices may be available under certain conditions related to the application of environmentally friendly technology; as established earlier, this application implies higher production expenses and withdrawal costs. Here we determine whether cooperative behaviour in favour of the environment can help farmers move from conventional technology to the alternative, sustainable option.

This chapter is divided into seven sections. After this introduction, section 5.2 summarizes some features of the Guatemalan snow peas chain –already presented in Chapter 4 - which are relevant for the analysis of strategic environmental behaviour of firms. We assess the potential for strategic behaviour in favour of the environment using game theory. We present a farmer-farmer (*horizontal*) strategic interaction game in Section 5.3. In this game, no strict environmental quality controls exist, because transactions generally occur in the spot market. As a result, market setbacks or rejection of the product in the international markets become probable. We address the farmer-processor (*vertical*) relationship with another game in Section 5.4. In this case, farmers and processors must coordinate to meet specific environmental quality standards imposed by the destination market. If such coordination occurs, price mark-ups become possible, and market setbacks are less likely. Section 5.5 develops a simple hypothetical example, and Section 5.6 uses an empirical approximation to estimate the threshold number of firms required for the environmentally sound equilibrium to be sustainable. Section 5.7 points out the main conclusions of the chapter, including some policy recommendations to move from the conventional to a sustainable equilibrium.

5.2 Background: relevant features of the Guatemalan snow peas chain

In Chapter 4 (Section 4.2), through consideration of environmental quality in production and first-processing and requirements of destination markets, we identified two technology options for the Guatemalan snow peas chain: the traditional or unsustainable option, and the alternative or sustainable option. Traditional technology includes intensive use of chemical inputs and is closely related to the production and trade systems of the United States and Canada. Sustainable technology requires reduced use of chemicals through stricter environmental controls, and is more oriented to the European market.

The links between farmers and processor/exporters condition these technology options. With traditional technology, the links among these agents primarily operate through open markets; in the case of sustainable technology, the main link functions through specific coordination mechanisms. These two technologies present different implications for the environment. When processors establish explicit coordination mechanisms with farmers, quality controls are easier to stipulate and enforce. However, when the open market is the primary link, these controls are more difficult to establish, because the supplier of a specific lot of produce cannot be identified.

Therefore, farmers who produce for the open market have no incentives to elect a higher environmental quality technology package, such as one that uses low levels of chemical inputs. On the contrary, they use a great variety and quantity of chemical inputs to achieve desired product appearance and avoid yield loss; of course, this use of chemicals may provoke negative environmental impacts and pesticide residues in the final product that exceed limits set by importing countries. Such consequences have affected the Guatemalan snow peas industry, marked by environmental import standard violations in the US market (Julian, *et al*, 2000: 56-57; Hart and Reisman, 2003: 4-5), the detention of product at US ports of entry, as well as damage to the commercial reputation of Guatemala as a snow peas exporter. Moreover, this has generated economic losses for Guatemalan exporters, in what we have called *market setbacks* (Julian, *et al*, 2000).

The shift to sustainable technology implies withdrawal expenses and higher direct production costs, but, on the other hand, it reduces the risks of market setbacks and may permit access to price premiums for both farmers and processors. The key agent in the technology shift is the first-processor; however, regulations are also important for enforcement of environmental standards and their uniform application to production and post-harvest practices in the industry as a whole.

With this background in mind, we apply the game theory approach in the following sections to assess the potential for shifts by local firms towards environmentally sound technologies. We consider the simple chain structure of the Guatemalan snow peas chain (see Chapter 2) with its two discrete technology options (see Chapter 4).

5.3 Horizontal game among primary producers: the probability of market setbacks

The following assumptions apply for horizontal strategic interactions among farmers:

- n snow peas primary producers or farmers ($i = 1, ..., n$) sell all their product (q) as raw material in the local open market to local brokers (*coyotes*). Farmers are price-takers of P, with P as the farmer price per unit of production.

- Farmers can produce snow peas using polluting technology (t_0) or, alternatively, a higher environmental quality technology (t_1). For an individual farmer, using technology t_1 implies withdrawal expenses and higher direct unit production costs.
- There are no environmental quality controls from local brokers or processing plants over direct producers (farmers). Once the product is sold to local brokers, information on origin of a particular lot of snow peas is lost. Local brokers bring the fresh produce to processing plants for first-processing, packing and export.
- In the destination market, environmental quality control is performed by examining samples of the imported snow peas. If the sample is contaminated, the entire lot is rejected. In this sense, market setback in the import market is possible if the agricultural production process does not fulfil required environmental quality standards. The higher the number of farmers using technology t_1, the lower the risk for market setbacks.

In order to simplify analysis, our model evaluates the additional net benefits obtained by improvement of environmental quality in the production process, both for an individual farmer and for the group as a whole. To do this, we define a point of departure where all farmers use conventional technology. To facilitate the analysis, we assume zero benefits in the point of departure scenario. We will compare benefits reached in this scenario with those obtained in other scenarios where some or all farmers have moved to cleaner technology.

With these considerations in mind, and following the chain organisation structure previously described (see Chapter 4, Section 4.2), the profit function for an individual farmer i will be:

$$\pi_i = P(1-\rho)q_i - c_i t_{ik} q_i;\ i = 1, \ldots, n;\ k = 0, 1. \qquad (1)$$

Where:

- π_i : individual farmer i's profits.
- P: farmer i's price for his produce.
- q_i: quantity of produce by farmer i.
- n: number of farmers.
- $0 \leq \rho \leq 1$: probability (risk) of market setback. A market setback will affect all farmers' expected incomes (whether they use t_0 or t_1) in the form of zero payment for a portion of the harvest, even if the final price remains the same for the volume that is accepted.
- t_{ik}: type of technology used by farmer i. $k = 0$ indicates that farmer i uses conventional technology, while $k = 1$ indicates use of the higher environment quality option. According to our definition of the point of departure, for an individual farmer i, $t_{i0} = 0$ (farmer i's point of departure) and $t_{i1}=1$.
- c_i: farmer i's increased unit production cost and withdrawal costs of switching from technology t_0 to technology t_1 (in our point of departure ($k = 0$), $t_{i0} = 0$, then, $c_i t_{i0} = 0$).

Assuming an *average farm* that produces the same amount of product independently of the technology applied, then[53],

$$(1-\rho) = N/n,$$

with N as the number of farmers that use the higher environmental quality technology (t_1), including representative farmer i. If farmer i does not use the environmentally sound technology, then the number of farmers that do is N-1. As indicated previously, n is the total number of farmers in the industry.

With these considerations, the profit function (1) will be:

$$\pi_i^0 = P\frac{N-1}{n}q_i \qquad \text{if farmer } i \text{ uses technology } t_0 \qquad (2)$$

$$\pi_i^1 = \left(P\frac{N}{n} - c_i\right)q_i \qquad \text{if farmer } i \text{ uses technology } t_1 \qquad (3)$$

Equation (2) represents the benefits for farmer i when other farmers use technology t_1 and farmer i does not. Equation (3) represents a situation when other farmers use technology t_1 and farmer i does the same. The last equation indicates that farmer i will benefit not only from others' actions in favour of the environment, but also from his own; however, in this case, farmer i would face withdrawal expenses and higher direct production costs resulting from the technology shift.

To evaluate whether switching technology from t_0 to t_1 generates additional positive benefits for the individual farmer i, we will analyse for a fixed quantity $q_i = q_i^*$ and subtract (2) from (3).

Decomposing $\frac{N}{n}$ into $\frac{1}{n} + \frac{N-1}{n}$, then

$$\pi_i^1 - \pi_i^0 = \left(\frac{P}{n} - c_i\right)q_i^* > 0 \Leftrightarrow \frac{P}{n} > c_i \qquad (4)$$

This result holds regardless of value of N; it does not depend on the number of other farmers that use the higher environmental quality technology.

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[53] $\rho = \frac{Q_n - Q_N}{Q_n} = 1 - \frac{Q_N}{Q_n}$, where Q_n represents total quantity of snow peas produced, while Q_N represents the quantity of snow peas produced by those farmers who use the higher environmental quality technology. $\rho = 0$ if $Q_n = Q_N$ and $\rho = 1$ if $Q_N = 0$. Assuming an average farm that produces $\overline{q}$ independently of applying t_0 or t_1, meaning that $Q_N = N\overline{q}$ and $Q_n = n\overline{q}$, then, $\rho = 1 - \frac{N\overline{q}}{n\overline{q}} = 1 - \frac{N}{n}$. This implies $(1-\rho) = \frac{N}{n}$. The probability for market setbacks would be even higher if yields for farmers who use technology t_1 are lower, as could be expected.

The second inequality in (4) must be false for farmer populations related to agricultural activities such Guatemalan snow peas cultivation, where numerous small and medium-scale primary producers are the most important suppliers[54].

The economic interpretation is as follows. We can interpret the term $\frac{P}{n}$ in equation (4) as farmer *i*'s contribution to the lower probability for market setbacks. For farmer *i* to obtain positive benefits from the technology change, this term must be higher than the incremental costs of switching technology ($\frac{P}{n} > c_i$). But would this be the case? Would the individual effect of an isolated farmer on the probability for market setbacks be significant enough to compensate for the cost of the technology change? We can reasonably conclude that the answer to this question is no. If a negative country or regional image already exists due to dirty technologies, actions of an *isolated* farmer in favour of the environment likely would not impact significantly this image or influence *industry-wide* final price.

Therefore, if inequality (4) is false, regardless of the technology chosen by other farmers, for individual farmer *i* the *dominant strategy* is "to be locked into the polluting technology". Specifically, if others *do not change to the higher quality technology*, the best strategy for farmer *i* is to stay in the polluting option. If farmer *i* does improve technology, the increase in cost exceeds the increase in benefit.

If others *do switch technology*, the best strategy for farmer *i* is, again, to stay with the polluting technology. This is due to the lack of environmental quality controls, meaning that a specific farmer will benefit from the general situation of lower risks for market setbacks, without facing the cost related to the shift in technology. In other words, incentive exists for *free riding*.

These conditions apply to all farmers; therefore, the *Nash equilibrium* will be "all farmers locked into the traditional technology". The key issue here is the absence of environmental quality controls, while the risks of market setbacks affect all *n* producers, but increasing costs of shifting technology must be faced individually.

Better results may be obtained however for an individual farmer and for the group as a whole if a threshold number (N^*) switch to clean technology t_1. To see this, we compare

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[54] PROOF. From inequality (4) we obtain: $\frac{P - c_i}{c_i} > n - 1$, meaning that for farmer *i* to reach positive benefits from the technology change, the potential mark-up must be higher than *n*-1. That is, if *n*=2, the mark-up must be higher than 100%; if *n*=3, the mark-up must be higher than 200%; if *n*=10, the mark-up must be higher than 900%; if *n*=1000, the mark-up must be higher than 99900%; and so on. These mark-ups are clearly not economically viable. The only case where this inequality may be economically viable is when *n*=1 (monopoly), which is not the case for the Guatemalan snow peas sector. For the snow peas case, as we will see in Section 5.6 of this chapter, *n* was approximately 3330 for Chimaltenango, the Guatemalan department that produced around 70% of the total snow peas of the country in 2002-2003 (Guatemalan Agricultural Census). In this case, the mark-up must be higher than 333000% for inequality (4) to be positive. However, from our field trip results, we found average potential mark-ups of 13.11% and 3.72% for the polluting and the environmentally sound technology, respectively.

the previous Nash equilibrium outcome with the case where *N* of *n* farmers switch technology.

If no farmer switches to the higher quality technology (our point of departure and Nash equilibrium outcome), the average profit function (3) will be[55]:

$$\bar{\pi}^0 = 0 \qquad (2')$$[56]

Now we compare this situation with the benefit obtained by an average farmer when a threshold number (N^*) switch to technology t_1.

$$\bar{\pi}^1 = \left(P\frac{N^*}{n} - \bar{c} \right) \bar{q}^* \qquad (3')$$

Subtracting (2') from (3'),

$$\bar{\pi}^1 - \bar{\pi}^0 = \left(P\frac{N^*}{n} - \bar{c} \right) \bar{q}^* > 0 \Leftrightarrow P\frac{N^*}{n} > \bar{c} \qquad (4')$$

Equation (4') indicates that if N^* farmers use the higher environmental quality technology, then the *aggregate* positive effect on risk elimination for market setbacks might be sufficient to offset the increasing *individual* cost of shifting technology. This will be the case if *N*, as a proportion of *n*, reaches a critical value given by

$$\frac{N^*}{n} > \frac{\bar{c}}{P} \qquad (5)$$

If condition (5) is met, the best result for the whole group of farmers (as well as for any individual farmer) is reached when at least N^* farmers switch to the higher environmental quality technology. Referring to the prisoner's dilemma game, this corresponds to the *cooperation* outcome[57].

The previous results show that interaction among farmers and their decisions to improve environmental quality can be modelled as a prisoner's dilemma game (see Heide and Miner, 1992: 272). First, given the absence of government regulation, we can assume that rational self-interest drives the actions of firms involved in snow peas cultivation. Farmers choose technology depending on the benefits they expect to obtain, and they incorporate these payoffs into the decision structure. Second, interaction among farmers takes place in a context where cooperation and defection possibilities exist for any party. Defection is defined as the continued use of the polluting technology; this is defection

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[55] For the following equations, the line over the symbol indicates average value of the variable.

[56] This is because $\pi_i = P\frac{N}{n}q_i - c_i t_{ik} q_i = 0$ when N=0 and t_{ik}=0 $\forall i = 1,\ldots,n$, which corresponds to our definition of point of departure.

[57] Recall that from equation (4) the strategy "using technology t_1" (*cooperation*) is a strictly dominated strategy for individual farmers, meaning that, even though the cooperation outcome will be a better result for the whole group, it is not a game equilibrium.

because the optimal action for the whole industry is for each farmer to use the higher environmental quality technology. On the contrary, parties may cooperate by shifting to higher quality technology, thereby reducing the probability for market setbacks, which would be the best outcome for the group.

Third, the ordering of the payoffs from cooperation and defection follows the prisoner's dilemma structure. We can expect a farmer's immediate payoff to be:

i) highest if the farmer defects while the others cooperate. If a specific farmer does not cooperate and the others do, that farmer shares in the gains from the reduction of risks that generally accompanies higher environmental quality, but does not face direct costs associated with the shift;

ii) lower than (i), but higher than (iii) when there is joint cooperation. If all farmers cooperate (or at least a critical number N^* do so), the benefits for the whole group will be highest. However, for an individual farmer the benefits of this scenario will be lower than those presented in situation (i), due to costs of the shift;

iii) lower than (ii), but higher than (iv) when there is joint defection. This will be the Nash equilibrium outcome, where no farmer shifts to higher quality technology. There will be no costs associated with a shift, but the risk of market setbacks is highest;

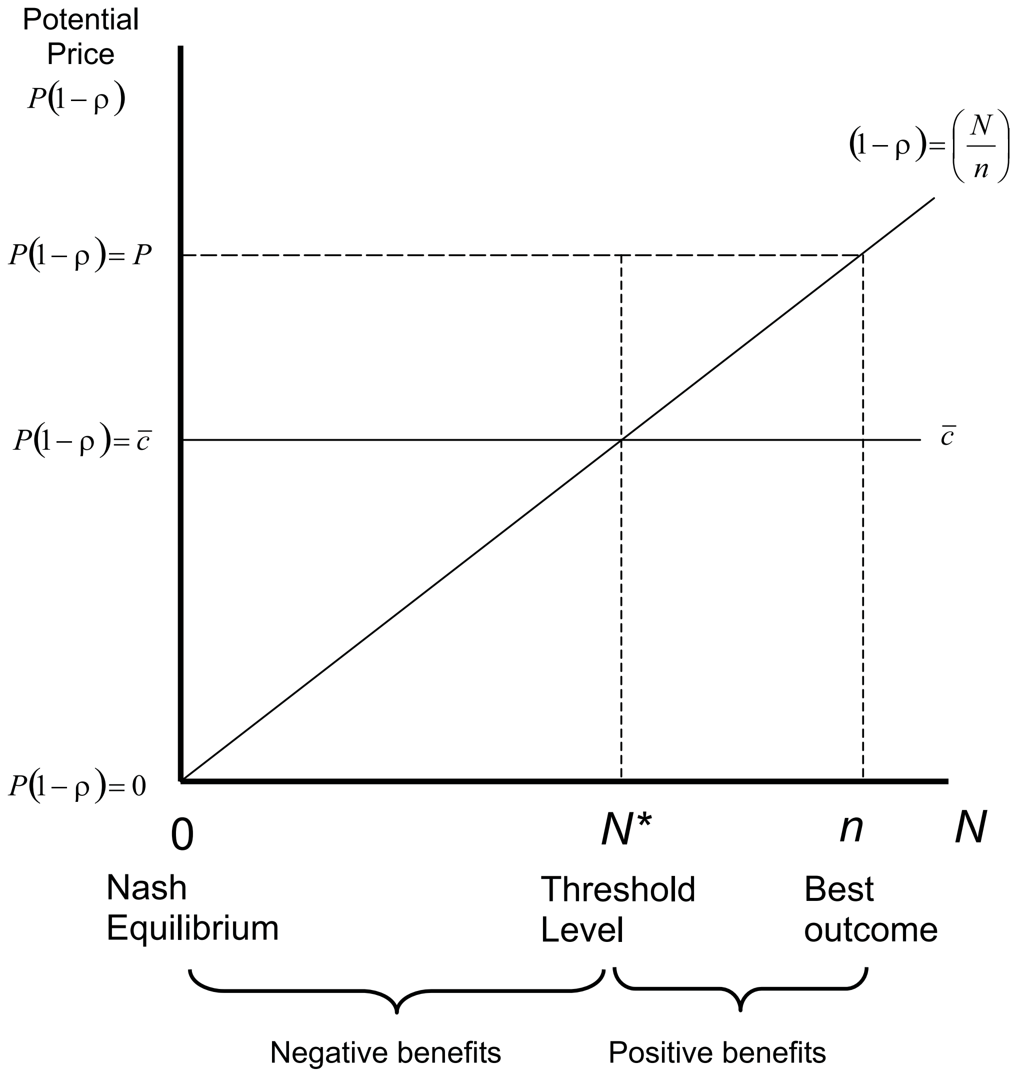
iv) lowest if the specific farmer cooperates while the others defect. If only one farmer changes to t_1, the costs of the shift for the farmer that invests in improving environmental quality will not be offset because the reduction in market setback risk is insignificant.

To summarize, according to the prisoner's dilemma game structure, farmers lock into unsustainable technology, implying that the risk of market setback will be highest $(\rho = 1)$. As a result, the Nash equilibrium of the game is "all farmers playing the strategy 'stay in the traditional technology' (defection)". However, the social optimum would be "all farmers playing the strategy 'use the higher environmental quality technology' (cooperation)", then, $\rho = 0$. The crucial feature is that players gain more from joint cooperation than from joint defection, but they maximise gain if they defect while their colleagues cooperate (Heide and Miner, 1992: 267).

This horizontal game can be summarized in Figure 5.1 (next page), which depicts a relationship between potential price $P(1-\rho)$ and the number of farmers *N* that use the higher quality technology. $P(1-\rho)$ represents the price that farmers would receive after considering the possibilities for market setbacks, which depends on *N* and market price *P*. If $N = n$ $(\rho = 0)$, then $P(1-\rho) = P$. This scenario corresponds with the best outcome: all farmers using environmentally sound technology, with no risk of market setback.

When $N < N^*$, individual benefits are negative for the average farmer since $P(1-\rho) < \bar{c}$; however, benefits will be positive when $N > N^*$. As explained before, the outcome of the game will be the Nash equilibrium where no farmer uses the environmentally sound technology. In this outcome, the possibility for market setbacks is highest.

Figure 5.1:
Horizontal game among snow peas farmers



One-shot Nash equilibrium games may be too limited in scope, so we will end this discussion by referring to the result that could be expected if the game were played repeatedly. In this case, we must refer explicitly to the Folk Theorem, which holds that if players discount the future in a sufficiently small degree, infinitely repeated games allow for cooperative behaviour even when the Nash equilibrium of the one-shot per period game is the non-cooperation outcome (see Gibbons, 1993: Section 2.3.B, among others). However, our fieldwork results show that farmers discount the future at a very high rate, meaning that they prefer to receive cash immediately for their product rather than waiting to receive their payment, even when waiting may produce higher returns. This is one of the reasons why spot market transactions are important in the local market for snow peas in Guatemala (see Chapter 4 of this thesis). This creates obstacles to the cooperative solution in the repeated game with the characteristics of the horizontal game described here.

5.4 A vertical game of primary producers and processors: the existence of price mark-ups

From the previous analysis of a horizontal game among farmers operating in one market, given no quality control on technology, the expected Nash equilibrium is "all producers remain locked into polluting technology", while the socially optimum result would be "all farmers using higher environmental quality technology".

Nevertheless, from a global chain perspective with a sequence of markets, the result may be different. First, we understand explicitly that environmental quality is determined by the actions of two types of agents: farmers and first-processors. This creates options for vertical coordination between these segments. With this coordination in effect, the main drawback of the horizontal game - the lack of environmental quality controls - may be avoided. If environmental controls from processors to farmers exist, these farmers may be willing to use more environmentally friendly technology. This would not only contribute to the reduction of risks for market setbacks, but would also facilitate access to better prices for the environmentally higher quality product.

The following game is based on the real scenario of two export markets for Guatemalan snow peas and their respective chain dynamics, as discussed in Section 5.2. In this game we focus on the strategic behaviour of firms in *farmer-farmer* and *farmer-processor* relationships. The strategic variable is the technology associated with a specific environmental quality level; hence, environmental quality may become a source of product differentiation in the export market. We analyse farmer-processor vertical coordination through specific agreements intended to improve environmental quality and obtain better prices for higher quality product. These agreements include a variety of commitments and imply higher costs from both sides (see Chapter 4 and Section 5.6 of this thesis). For processors, the commitments may include: i) technical advice to farmers in the production process, ii) advances of seed and other inputs, iii) financial support to farmers, iv) fixed prices or guaranteed minimum prices higher on average than local spot price, and v) contract purchases from farmers according to previously established production plans. For farmers, the required commitments could cover: i) complete compliance with technical recommendations in the production process, ii) payback of advances (seeds and other inputs) and loans at end of season, iii) exclusive sale of product to processor and iv) fulfilment of production plans.

With this background in mind, the vertical game operates under the following set of assumptions:

- Participants are '*n*' snow peas farmers and '*m*' processors ($n>m$). Farmers sell their product as raw material either in the local open market to local brokers (*coyotes*) or through agreements with a specific processor. Processors may obtain fresh produce through local brokers or through agreements with a group of farmers.
- Farmers produce snow peas using polluting technology (t_0) or a higher environmental quality option (t_1). For any given farmer, technology t_1 implies higher unit production costs.
- Two export markets are accessible. In market M_0, environmental quality requirements are not strict, but market setbacks are a risk if the product does not fulfil those requirements. In market M_1, environmental quality standards are higher, and this environmental effort is recognised through price premiums.

- Processors can use two types of technologies: i) technology T_0: export to market M_0, and obtain produce through the open market; environmental quality requirements are not strict in this market; ii) technology T_1: export to market M_1, and obtain produce through special agreements with groups of farmers. Minimum scale required to obtain price premium, implying a minimum number of farmers is required to switch technology in order to access this market.
- If processor chooses T_1, this agent must promote agreements with the farmer group in order to increase environmental quality in the final product. The processor also must absorb some withdrawal expenses and higher production costs, resulting from negotiations with farmers.
- Environmental quality controls exist under the agreement system, but not in the open market channel. If the product is obtained through local brokers, information on origin of a particular lot of produce is lost.

The strategic interaction can be modelled as a two-stage game. In the first stage, the processor selects technology (T_0 or T_1), in light of certain expectations regarding farmer reaction to this selection, as we will see later.

In the second stage, once the processor has chosen the technology, farmers make their own technology elections, taking into consideration expected revenues generated by the different environmental quality technologies as well as their associated costs. Farmers will also consider the strategy already chosen by the processor. Specifically, farmer strategies are as follows:

- If processor chooses technology T_0, farmers choose either technology t_0 or technology t_1.
- If processor chooses technology T_1, farmers choose either technology t_0 or technology t_1. Choosing technology t_1 implies an agreement with processor to increase the environmental quality of the produce.

The solution of the game requires a backward induction procedure, where the game is solved from the end to the beginning. At first, the processor must consider how farmers will react to processor decisions regarding technology. Taking into consideration this reaction and the possible result in the last part of the game, the processor decides.

The farmers' sub-games

To begin, we will start with the farmer sub-game, with processor choice of T_0. In this case, any farmer shift to improve environmental quality must be pursued individually. Processors will not support farmers in this switch, because they obtain produce from the open market. This is exactly the horizontal game studied above (Section 5.3). The expected outcome will be the Nash equilibrium, where "all farmers are locked into polluting technology" and the risk for market setbacks is highest.

The second farmer sub-game assumes processor has chosen T_1. Once the processor has chosen T_1, produce can be exported to M_1 if a threshold number of farmers (N^{**}) use technology t_1. If this market is accessed, a price premium will be obtained. If the threshold number is not reached, produce may only be exported to market $M_{0,}$ with the conditions already mentioned.

For a farmer *i* to export to market M_1 and obtain the price premium, this agent must use technology t_1. Additionally, the threshold number of farmers switching technology must be reached.

Farmers choose between technology t_0 and t_1 according to the benefits they expect from their choice. With the previous considerations in mind, and defining $t_{i0} = 0$ and $t_{i1} = 1$, as in the previous game, the profit function will be:

$$\pi_i^0 = P\frac{N-1}{n}q_i \qquad \text{if farmer } i \text{ uses technology } t_0 \qquad (2)$$

$$\pi_i^1 = \left(P\frac{N}{n} - c_i\right)q_i \qquad \text{if farmer } i \text{ uses technology } t_1 \text{ and } N < N^{**} \qquad (3)$$

$$\pi_i^{1**} = [P(1+\delta) - c_i]q_i \qquad \text{if farmer } i \text{ uses technology } t_1 \text{ and } N \geq N^{**} \qquad (6)$$

δ represents the (constant) price premium for export to market M_1, as a percentage of the price *P* paid in market M_0. As in the horizontal game, *N* represents the number of farmers who switch to the higher environmental quality technology.

Equation (2) and (3) reproduce exactly the same situation for farmers as in the horizontal game. In both cases, the reference market is M_0, and technology decisions will depend on conditions in equation (4) from section 5.3. Under these conditions, the best strategy for an individual farmer will be to stay locked into the polluting technology. Therefore, if the threshold number N^{**} is not reached, the best strategy for an individual farmer is to stay locked into the polluting technology. The result for this farmer sub-game will be the Nash equilibrium: "all farmers locked into polluting technology if the threshold level is not reached".

We will now analyse the case where the threshold number N^{**} is reached. In this case, we will compare equations (2) and (6).

$$\pi_i^{1**} - \pi_i^0 = \left(P(1+\delta) - P\frac{N-1}{n} - c_i\right)q_i^* \qquad (7)$$

Then,

$$\pi_i^{1**} - \pi_i^0 > 0 \Leftrightarrow P(1+\delta) - c_i > P\frac{N-1}{n} \qquad (7')$$

Condition (7') shows that the difference between the new price and the additional costs of shifting technology $[P(1+\delta) - c_i]$ must be higher than the price obtained -including market setback risk- if no technology change is made $\left(P\frac{N-1}{n}\right)$. In this case, the incentive for technology change in the vertical coordination game is higher when the risk for market setback in M_0 is higher (the lower the *N*, the higher the risk for market setback), the price premium in market M_1 is higher and the cost of switching technology is lower.

Starting from the Nash equilibrium outcome, where no farmer uses technology t_1 (N=0, then, $\pi_i^0 = 0$), condition (7') becomes:

$$\pi_i^{1**} - \pi_i^0 = \left(P(1+\delta) - c_i\right)q_i^* > 0 \Leftrightarrow P(1+\delta) > c_i . \qquad (7'')$$

That is, once threshold level N^{**} is reached, the incentive for a particular farmer to switch technology depends only on the profitability of market M_1. As long as $P(1+\delta)/c_i > 1$, shifting to the higher environmental quality technology is the best strategy for farmer *i*.

This generates a second Nash equilibrium for the sub-game: "all producers using higher environmental quality technology if the threshold number N^{**} is reached". A particular farmer will not benefit from the shifts of other farmers if the farmer does not move in the same direction. This is because strict environmental quality controls are in place, and free riding is discouraged.

The previous farmer sub-game can be illustrated in Figure 5.2 (next page). When the threshold level N^{**} is reached, benefits of switching technology are positive, with the sustainable Nash Equilibrium as a result. The dotted line indicates the price that a farmer can obtain, and is subject both to the number of farmers that switch technology and the processor's decision regarding technology. $P(1+\delta)$ would be reached if $N \geq N^{**}$ farmers switch technology and the processor also uses the sustainable technology. For prices lower than $P(1+\delta)$ (implying N<N**), the conditions of the horizontal game (Section 5.3) apply.

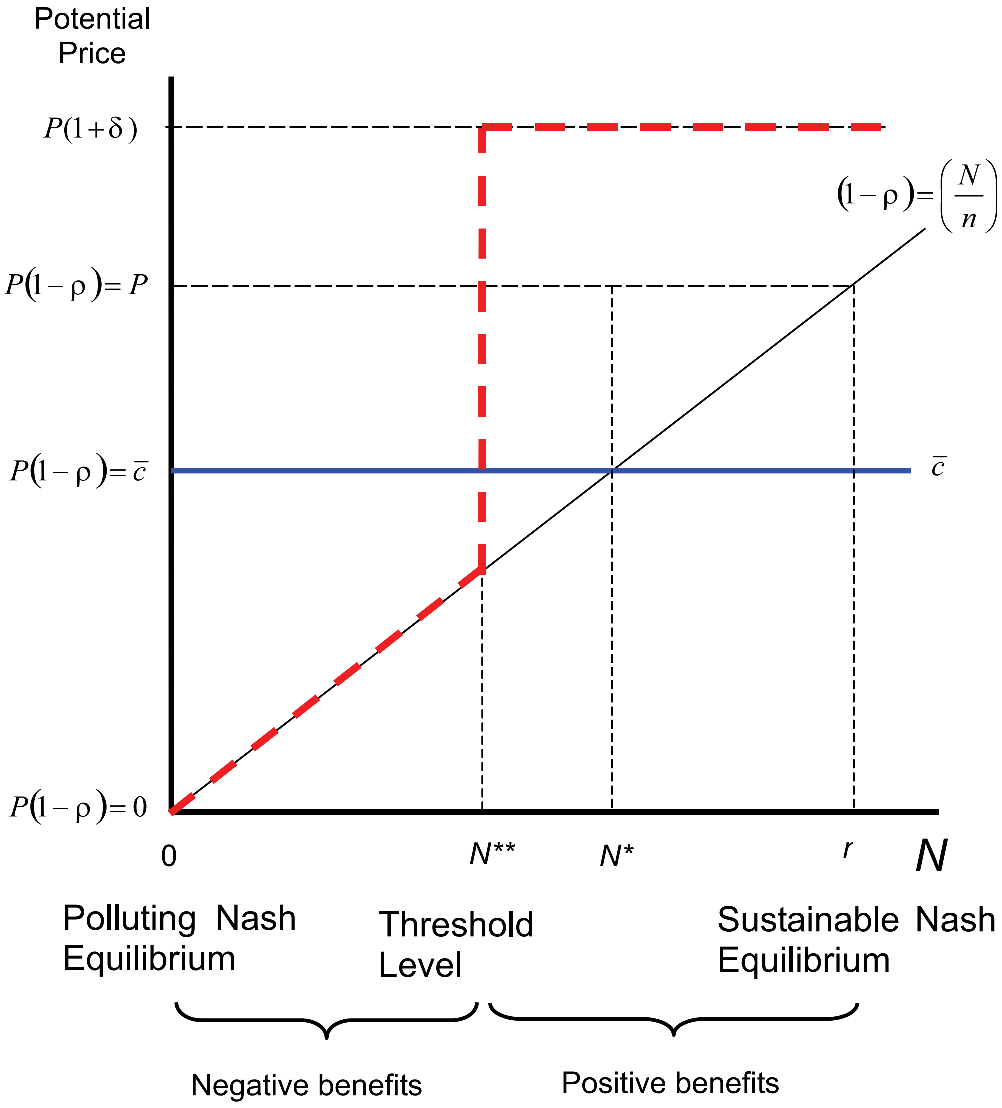
To summarize, when the first-processor chooses technology T_0, the sub-game will generate the Nash equilibrium solution: "all farmers locked into the polluting technology"; however, when the first-processor chooses technology T_1, the sub-game will have two Nash equilibrium solutions: "all farmers locked into the polluting technology if the threshold level N^{**} is not reached" (non-cooperative solution) and "all farmers using the higher quality environmental technology if the threshold level is reached" (cooperative solution).

The first-processor's decision

Now we move to the first stage of the game, which is the processor decision, assuming ex-ante information regarding the number of farmers willing to change technology. As stated before, the processor must choose between technology option T_0 and T_1, but in this case the actor knows beforehand what the final game result will be after making this choice. If the processor chooses technology T_0, the end result will be that all farmers are locked into the polluting technology. This solution will generate a sub-game perfect Nash Equilibrium (SPNE-see Gibbons, 1993: Ch.2, among others): "processor choosing T_0 and all farmers locked into the polluting technology". This is a stable Nash equilibrium for the whole game since no player will shift given the strategies chosen by the other actors. We will call this result $SPNE_0$.

If the processor chooses technology T_1, the game will have one of the following outcomes: “all farmers locked into the polluting technology if the threshold level is not reached” (non-cooperative solution) and “all farmers switching to the higher quality technology if the threshold level is reached” (cooperative solution).

Figure 5.2: Farmer sub-games of the vertical snow peas game. Possibilities to make mark-ups



We will now study whether these situations constitute SPNE solutions, beginning with the non-cooperative solution. This is a non-credible outcome; if the first-processor knows that farmers will not cooperate - meaning that the threshold level will not be reached - then the processor will have incentives to avoid that outcome and the increased costs associated with technology T_1. In this case, the best strategy for this agent is to choose technology T_0, thus moving to SPNE$_0$.

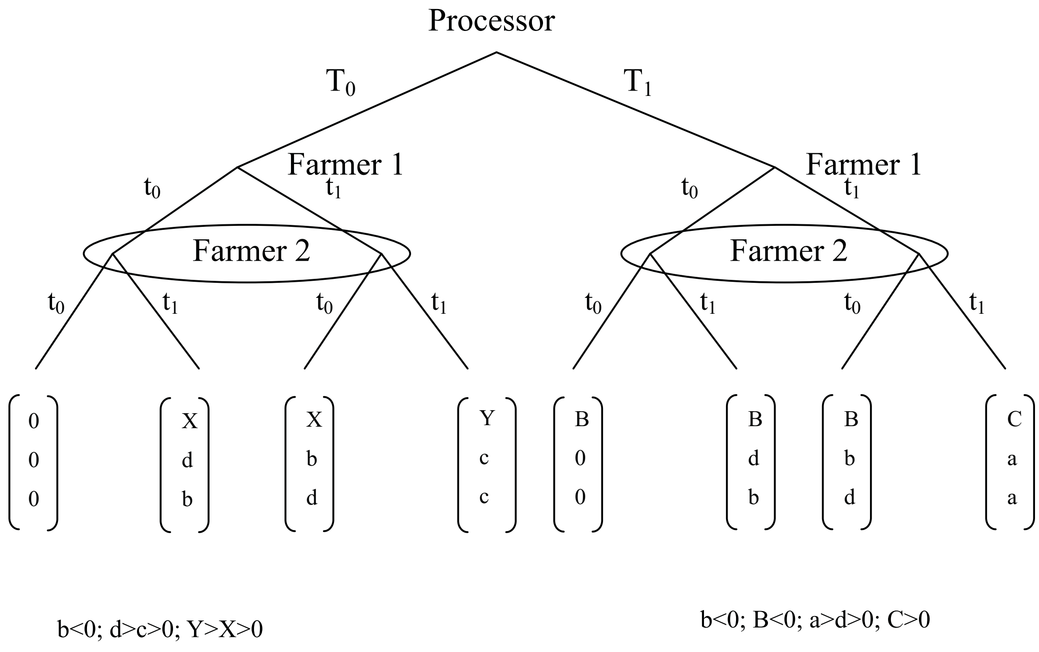
Now we turn to the cooperative solution. This situation occurs if the first-processor chooses T_1 and the threshold level is reached; that is, a minimum number of farmers decide to improve the environmental quality of the production process. This scenario constitutes a SPNE solution for the whole game and is stable because, once again, no player will shift given the strategies chosen by the other players[58]. If the threshold level is reached, the best farmer strategy is to chose a better environmental quality technology, and for the processor to choose technology T_1. We will call this result SPNE_1.

In conclusion, there are two SPNE for the game: what we have called the polluting solution (non-cooperative solution or point of departure) and the *sustainable* solution (cooperative). The key question is how to move from the point of departure (SPNE_0) to the socially and environmentally preferred outcome (SPNE_1). What we must keep in mind is that considering only the farmer segment of the chain (horizontal game), the result will be the non-cooperative solution. However, considering the possibility of vertical coordination between farmers and first-processor, a cooperative solution in favour of the environment may appear. The outcome will not only offer environmental benefits, but may also become a source for upgrading local primary producers and first processors.

5.5 A simple hypothetical example: two farmers and one processor

We will now develop a simple case with two farmers and one processor. Figure 5.3 depicts the extensive form of this simple snow peas game.

Figure 5.3: A simple two-stage game for Guatemalan snow peas



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[58] If the threshold number N^{**} is reached, defection is a strictly dominated strategy. Through defection, players give up the opportunity to become 'a part of the club' and enjoy corresponding benefits.

There are two stages in this game. In the first stage, the processor chooses between T_0 and T_1:

- Technology T_0: export to market M_0 and obtain fresh produce through the open market.
- Technology T_1: export to market M_1 and obtain fresh produce through coordination with a group of farmers.

In stage 2, farmers choose between t_0, the conventional (polluting) technology, and t_1, the alternative (environmentally friendly) technology.

Switching technology from T_0 to T_1 for the processor, and from t_0 to t_1 for farmers implies withdrawal costs. On the demand side, if the product is exported to market M_0 (processor has chosen T_0), no environmental quality controls are in effect. As a result, market setbacks are possible if the product does not meet standards, possibly reflected in non-permitted levels of pesticide residues in the final product. In market M_1, when the first-processor chooses T_1 the final product carries a price premium, but minimum scale and subsequent threshold number of switching firms are required for access to this market. In this simple case, we will assume that the threshold level is reached only if both farmers in the game use technology t_1.

Game payoffs are presented at the bottom of the figure. The first value corresponds to processor profit (π_P), while the second and the third represent profit for farmer 1 (π_{f1}) and farmer 2 (π_{f2}), respectively. For example, in the point of departure outcome, the polluting situation (T_0, t_0, t_0), all players earn zero profit.

Solving the game from end to beginning, we see the solutions for all of the sub-games after the processor decision. We then have two sub-games which are independent, simultaneous horizontal games between farmers. The normal form representation of the first sub-game, after the processor has chosen T_0, is presented in Table 5.1. If both players lock into polluting technology, they will obtain zero benefit. If one farmer switches and the other does not, the one who switches obtains negative profit b; market setback risk is reduced, but not enough to offset the withdrawal cost of the shift. On the other hand, the farmer who does not switch will obtain positive profit d; probability of market setbacks is reduces along with a subsequent increase of expected benefits, but this agent does not face any withdrawal cost from a technology shift.

Table 5.1: Normal form representation of the horizontal snow peas sub-game 1. Processor chooses conventional technology

Farmer 1 \ Farmer 2	t_0	t_1
t_0	(0,0)	(d,b)
t_1	(b,d)	(c,c)

$b<0$; $d>c>0$; $2c>d+b$

If both farmers switch technology, both earn profit c; the risk of market setback is completely reduced, and this compensates withdrawal costs from the technology shift.

However, this is not equilibrium, because if one farmer thinks that the other will choose technology t_1, he will have incentive to choose technology t_0 (defection) and increase his personal benefit ($d>c$). Therefore, the dominant strategy is "playing t_0" and the Nash equilibrium solution of this sub-game will be (t_0, t_0), where payoffs are (0,0).

The second sub-game occurs after the first-processor has chosen T_1, and is presented in Table 5.2. We recall that in this part of the game a higher price for a better environmental quality product will be possible only if a minimum number of farmers (two, in our case) switch. In this case, if both players lock into the polluting technology, they will reach zero benefits as in the first sub-game. If one switches and the other does not, this sub-game reproduces the situation of the first sub-game, because the threshold level is not reached and the produce can only be sold to market M_0. If both switch technology, the critical value is reached and they will receive positive profit a; the new, higher price offsets withdrawal costs from the technology switch, and profits in market M_1 -where farmers use technology t_1- are higher than profits in market M_0, where farmers use technology t_0. In other words, if both farmers switch technology, they have no incentive to move back to the polluting option.

Table 5.2: Normal form representation of the horizontal snow peas sub-game 2. Processor chooses sustainable technology

Farmer 1	Farmer 2: t_0	Farmer 2: t_1
t_0	(0,0)	(d,b)
t_1	(b,d)	(a,a)

$b<0$; $a>d>0$

As a result, we will have two Nash equilibrium solutions of the second sub-game: (t_0, t_0) if the threshold level is not obtained, and (t_1, t_1) if it is.

Now we will move to the initial stage of the game - the processor's decision. This agent already knows that by choosing T_0, the game will end in the farmers' Nash equilibrium (t_0, t_0), and the result for the entire game will then be (T_0, t_0, t_0); this is the point of departure where all players earn zero profit and is also a Nash Equilibrium for the whole game, because no player wants to shift technology, given the strategies played by the others ($SPNE_0$).

If the processor chooses T_1, the game will end in one of the following Nash equilibria for the farmers:

- (t_0, t_0) if the threshold level is not reached; the result for the entire game will be (T_1, t_0, t_0).
- (t_1, t_1) if the threshold level is reached; the result for the game will be (T_1, t_1, t_1), the cooperative solution.

The first case (T_1, t_0, t_0) is not a Nash equilibrium solution. The argument is the same as in the general case; if the processor knows that farmers will not cooperate, he will realise that the threshold level will not be reached and will have incentives to stay with technology T_0. Outcomes will move to the $SPNE_0$.

The second case (T_1, t_1, t_1) does constitute a Nash equilibrium solution for the whole game. Given the strategies of other players, if the threshold level is reached, the best strategy for farmers is to choose the better environmental quality technology (t_1) and for the processor to choose technology T_1; this is the SPNE_1.

As a final result, the game will have two Nash equilibrium solutions: the polluting (SPNE_0) and the sustainable (SPNE_1).

5.6 An empirical approximation to estimate the threshold number N^* and N^{**}

From the horizontal game among farmers, we have the following inequality (see Section 5.3):

$$\frac{N^*}{n} > \frac{\bar{c}}{P} \qquad (5)$$

This ratio represents the minimum proportion of farmers required to switch technology in order to reach the cooperation outcome (social optimum) in the horizontal game, which is a direct function of the average incremental cost of switching technology ($\bar{c}$), and an inverse function of farmer price (P).

From our fieldwork, we estimated average costs and prices for farmers producing for the United States and for the European channels (markets M_0 and M_1 respectively). The data are presented in Table 5.3.

Table 5.3: Guatemala. Costs of production and prices of snow peas farmers

For different technologies. Guatemalan quetzales per kg. 2004/2005

(A)	Technology 1 _*/ (B)	Technology 2 _**/ (C)	Difference (C)-(B) (D)
Average unit cost	3.51	5.38	1.87
Farmers' Price	3.97	5.58	1.61

_*/ Production and export channel to the United States (polluting technology).
_**/ Production and export channel to the European Union (environmentally sound technology).
Source: Author's fieldwork

Based on Table 5.3, we estimate inequality (5) as follows:

$$\frac{N^*}{n} > \frac{\bar{c}}{P} \Rightarrow \frac{N^*}{n} > \frac{1.87}{3.97} = 0.47$$

We see that at least 47% of farmers are required to switch technology in order to reach the cooperation outcome in the horizontal game. To estimate the absolute number N^*, we obtain the average farm size. According to the 2002-2003 Guatemalan Agricultural Census, the total area cultivated with snow peas was 1,365 hectares, and the number of farms was 4497. This gives an average farm size of 0.3 hectares59. Applying the horizontal game for the whole country, at least 2114 farmers of average size (47% of 4497) are required to switch technology in order to reach the social outcome of the game. If we apply the game only for the department of Chimaltenango, which produced 69% of the total snow peas in the country for the period 2002-2003, the threshold number N^* would be of around 1,565 (the number of farms in Chimaltenango is 3,330 and the average area of snow peas cultivation in this particular Department is 0.27 hectares).

For the vertical game, we use an empirical approximation to estimate the threshold number N^{**}, considering the number of farmers needed to supply a processing and exporting plant to reach a minimum exportable quantity of snow peas. In experts' opinion, this number for the department of Huehuetenango is around 700 farmers, for an export volume of at least one 50,000 pound container (22,679.62 kilograms) per week, 22 weeks a year (www.ceibaguate.org/factibilidadarvejachinaregionhuehue.doc). Another study made by the United States Agency for International Development, Guatemala (2003) considers the minimum weekly amount to be 37,500 pounds. If an average farm supplies 3,000 pounds a year, 650 farms of average size are needed to reach the minimum[60]. These figures can be considered the minimum required to access market M_1 and obtain premium prices for the produce. Therefore, this is the threshold number of farmers N^{**} required to reach the sustainable Nash equilibrium in the vertical game: between 650 and 700 farmers, in coordination with the processor.

5.7 Conclusions

We use a global agri-food chain approach in this chapter to assess the potential of strategic behaviour of firms in a *farmer-farmer* and *farmer-processor* relationship. The strategic variable is the technology associated with a specific level of environmental quality and destination markets for the product. We consider that environmental quality is determined by the actions of farmers and processors, and may become a source of product differentiation in the export market. An application is performed for the Guatemalan snow peas chain, which is considered a simple agri-food chain case, keeping in mind the degree of product transformation that takes place in the produce. Also, two discrete technological options are considered, the polluting option and the higher environmental quality technology; these options are related to the destination markets of the produce: the US and the EU, respectively.

From analysis of the horizontal game among farmers without controls over the technology package in use, the expected Nash equilibrium is "all producers locked into the polluting technology", while the socially optimum result would be "all farmers using improved environmental quality technology".

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[59] According to the results obtained in the fieldwork, the average cultivated area of farms producing for the United States production and export channel is 0.25 hectares and for those producing for the European Union is 0.6 hectares.

[60] A minimum weekly amount of 37,500 pounds corresponds to a yearly amount of 1,950,000 pounds. If an average farmer supplies 3,000 pounds a year, 1,950,000/3000=650 farmers of average size are required.

Nevertheless, within a global chain perspective, vertical coordination between cultivators and processors may alter the results of the game. An example of vertical coordination is the introduction of environmental quality controls. If environmental quality control from processor to farmer is in place, and a premium can be paid to farmers for switching technology, then these farmers may be willing to use more environmental friendly technology. However, a threshold number of farms must shift in order for the technology change to be effective. The argument developed in this chapter demonstrates that, given vertical coordination among farmers and processors, two Nash equilibria will result for the entire game: “all firms locked into the polluting technology if the number of firms that switch technology is lower than or equal to threshold number N^{**}” (non-cooperative or *polluting* solution) and “all firms switch to the improved environmental quality technology when the number of firms that switch is higher than the threshold number N^{**}” (cooperative or *sustainable* solution).

For the horizontal game presented here, we estimate the threshold level as a proportion of the total number of farmers (considering an average farm size); the threshold is estimated at 47%. This means that 47% or more of farmers must switch to the higher environmental quality technology for the game to obtain the socially optimum results. An estimation is also made for the absolute threshold number N^{*}. We found that, on a national level, more than 2114 farmers (or average sized farms) of a total of 4497 must switch technology in order to reach the social optimum (cooperation outcome) of the horizontal game; for the department of Chimaltenango, the figure is around 1565 farmers of a total of 3330.

In the vertical game, we consider that the threshold number of farmers required to switch technology in order to reach the *sustainable* Nash equilibrium is the number of farmers needed to supply a processing plant exporting at least one container per week. According to expert opinion, this number is around 650-700 farmers, which is much lower than the threshold level needed in the horizontal game.

A move from the *conventional* (or polluting) to the *sustainable* equilibrium should include consideration of institutional actions such us agricultural extension, market intervention and quality regulations. Regulations also are required in the snow peas industry to enforce general environmental standards in cultivation, post-harvest practices and processing/packing. Agreement systems, including cooperatives, must be strengthened for better control of cultivation practices. Product quality control must be present during cultivation process as well as inside the plant; this will require investment on the part of processors.

Efforts must be made to attain the higher environmental quality equilibrium. This outcome will not only have environmental benefits, but could also become a source of upgrading for local primary producers and first-processors.

6

Environmental quality as a strategic tool in a complex agri-food chain: the Costa Rican coffee case

6.1 Introduction

We have two objectives in this chapter. The first is to evaluate the viability of environmentally sound technologies to increase small producer incomes[61] in long and complex global agri-food chain. We analyse the Costa Rican coffee chain and place special attention on growers and mills. The second objective is to evaluate the role that vertical and horizontal coordination mechanisms between these two chain segments can play in the facilitation of technological change in favour of the environment. The theoretical and methodological framework we use here complements the Global Commodity Chain (GCC) and game theory approaches (see Chapter 3 of this thesis). The first approach permits characterization of the global process of production, transformation and commercialization of a specific product from the agricultural to the consumer stage, as well as the sequence of markets and power dynamics along the whole chain. The game theory approach allows us to formulate behavioural hypotheses for the agents involved and analyse the potential for cooperation toward improvement of environmental quality in the various segments of the chain.

According to the discussion in Chapter 2, the coffee chain is long and complex, considering the distance from cultivators to consumers and the degree of product transformation that occurs[62]. The empirical analysis for this chapter is based on a field study in the West Central Coffee Region (*Región Central Occidental* in the ICAFE zone system) in Costa Rica. This region produces a very good cup-quality product, and, if this quality is well managed, the product may access international specialty markets.

We divide this chapter into 5 sections. After this introduction, Section 6.2 presents an empirical characterization of the main environmental certification programmes and an analysis of the viability of environmentally sound technologies as a tool for product

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[61] We can also view this goal as improvement of positioning (Porter, 1990: 37) of small producers along the chain. When referring to this concept, we refer to promotion of environmentally friendly techniques as a product differentiation strategy, in order to create higher value added.

[62] The short and simple chain is described in Chapter 5, for the Guatemalan snow peas case.

differentiation in international coffee markets; a case study of the West Central Coffee Region of Costa Rica is used to explore the possibility that clean technologies may improve incomes (positioning) of local coffee producers and mills. Section 6.3 starts with a general characterization of technological options in the national segments of the chain, agricultural and milling stages. Based mainly on the results of the case studies, we proceed with a theoretical discussion of the potential costs and benefits of technological change in favour of the environment, for both the cultivation and the milling segments of the chain.

In Section 6.4, we construct a methodological model to identify the advantages of strategic behaviour in favour of the environment, both in the cultivation and first-processing stages. We model a vertical coordination game between cultivators and mills, keeping in mind the restrictions and opportunities of the entire coffee chain. We present conclusions and recommendations for the promotion of technological change in favour of the environment in Section 6.5, considering the advantages of strategic coordination among agents located in different segments of the chain.

6.2 Environmental technology options in the national segments of the Costa Rican coffee chain: an empirical approximation

6.2.1 Environmental quality and coffee certification programmes

Negative environmental impacts from the agricultural and milling stages in the coffee chain have generated external costs for producer countries[63]. This cost has not usually been considered in final markets, although a recent trend toward stricter environmental entrance requirements and the consideration of higher prices may promote such consideration.

These environmental requirements are reflected in international as well as country-specific trade regulations in the main import markets. In markets such as the European Community and the United States, these regulations are essentially becoming entry requirements (Alonso, 2006). In this sense, entrepreneurial strategies that seek to increase environmental quality in coffee cultivation will reduce the risk of exclusion from these markets. On the other hand, the trend toward higher environmental standards is reflected in the higher prices that some consumers are willing to pay for a more environmentally sound coffee (Ponte, 2001). This trend provides producing countries access to higher prices for their product, even if these niches now represent only a small proportion of the total world coffee production. According to Pelupessy (2007), sustainable coffees represented about 1% of global coffee export volume in 2003.

Premium pricing opportunities for high environmental quality coffee can be illustrated concretely through the different certification programmes currently in the market. The main characteristics of the most common certifications available to Costa Rican cultivators and mills are presented in Table 6.1.

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[63] Environmental impacts from the agricultural and milling stages in Costa Rica, as well as actions taken to mitigate this problem, have been widely studied. See for example, among others: Pelupessy, 1993; Hernández, 2002; Boyce, *et al*, 1994; CEPAL, 2001; Pujol, *et al*, 1998; PNUD, 2005; Chacón, 1997 and Chacón, 2005.

Table 6.1: Coffee. Selected environmental certification programmes.

Main characteristics

Certification	**Responsible Organization**	**Objectives**
GLOBAL G.A.P GREEN COFFEE	Euro Retailer Produce Working Group	Increase consumer's confidence in food safety through application of good agricultural practices and product traceability (EUREPGAP, 2004: 3-4; GLOBAL G.A.P., 2007).
Rainforest Alliance	Sustainable Agricultural Network (SAN)	Promote good agricultural practices to preserve natural resources, and improve workers' living conditions and community relations (Andersen, 2003: 10; SAN, 2005; Red de Agricultura Sostenible, 2005).
C.A.F.E. PRACTICES_*/	Starbucks Coffee Company	Guarantee that coffee received by Starbucks is produced and processed in sustainable fashion; as well as promote organizational links with coffee producers that apply sustainable methods of production and processing (Starbucks, 2006: 5).
Organic Coffee	International Federation of Organic Agricultural Movements	Efficiently utilize farm resources, with emphasis on soil fertility and biological activity. Minimize the use of non-renewable resources and protect the environment and human health by avoiding synthetic pesticides (Andersen, 2003: 4).
Bird Friendly	Smithsonian Migratory Birds Center	Guarantee environmental sustainability, with the aim of protecting and/or improving indicators of environmental health. Protect structural as well as species biodiversity to guarantee shelter and food for birds, especially migratory species (SMBC, 2002 and 2007).

_*/ Starbucks C.A.F.E. PRACTICES Coffee Programme, is closer to a verification than a certification programme. However, for our analysis it will be considered the same as the other certification programmes.
Source: EUREPGAP, 2004; GLOBAL G.A.P, 2007; Andersen, 2003; SAN, 2005; Red de Agricultura Sostenible, 2005; Starbucks, 2006 and SMBC, 2002 and 2007.

Tables 6.2 and 6.3 associate these different certification programmes with their respective environmental requirements, both for the agricultural and the milling stages. Environmental standards are checked against a selection of relevant variables. In the agricultural stage (Table 6.2), the relevant variables are agro-chemical use, shade cover and water source protection; for the milling stage (Table 6.3) the relevant variables are water and energy use, and waste management. In the milling segment, conventional technology is included for comparison purposes, reflecting necessary parameters according to national legislation[64]. For a mill, the differences in parameters among the certification programmes are relatively small; in the case of the organic and Bird Friendly certifications, the parameters are the same.

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[64] National legislation focuses on the agricultural stage and does not necessarily establish concrete parameters to be fulfilled for the selected variables.

Table 6.2: Coffee, agricultural production stage. Environmental requirements of different certification programmes.

Certification Programme_*/	Agro-chemical use	Shade cover and natural vegetation	Water sources protection (buffer zones)
Rainforest Alliance (RFA)	An integrated pesticide management programme must be executed. The use of category I and II products in the WHO classification (extreme, high and medium hazard) must be reduced. Over a three year period after certification, the use of category I products must be completely eliminated.	Two strata of shade cover. 70 trees per hectare, 20% native species. At least 40% of total area must be shade cover.	5 metres from each side of water source (10 metres if organic).
C.A.F.E PRACTICES	Category IA and IB chemicals of the WHO classification (extreme and high hazard) cannot be used. Additional points are given if the reduction of agro-chemicals is implemented according to a toxicity weighted index of all agrochemicals currently applied in the farm.	A specific percentage of shade cover is not stipulated; however, equilibrium must exist between product quality and economic and ecological conditions of the region. Additional points if at least 40% of shade cover is maintained along the edge of the productive area; however, this percentage may change if trees compete with coffee plants.	2 metre distance from each side of water source. Additional points for 5 meters.
Organic	The use of agro-chemicals completely forbidden; however, synthetic pest control is allowed, subject to a list of permitted inputs.	Shade cover not required for certification; however, a shade management programme that maintains optimal conditions of local ecology is recommended. Buffer zones (live barriers or trees) must be used to separate organic plantations with non-organic ones (8 metres each side).	No special requirements.
Bird Friendly	Idem.	Tree strata levels of shade cover: 1. Superior or emergent stratum. Approximately 20% of foliage volume. 2. Main stratum or backbone. Approximately 60% of foliage volume. 3. Inferior stratum. Approximately 20% of foliage volume.	5 metres from each side of the water source; 10 meters along the rivers.

_*/ The technological option EUREPGAP GREEN COFFEE (GLOBAL G.A.P.) is excluded because its emphasis is not on environmental aspects.

Source: Starbucks, 2006; OCIA International, 2007; Red de Agricultura Sostenible, 2005; SAN, 2005 and SMBC, 2007.

Table 6.3: Coffee, milling stage.
Environmental requirements of different certification programmes

Technology	**Water use (water volume per)**	**Energy use**	**Waste management (solid and liquid)**
Conventional (national legislation).	1 m^3 per each 46 kg of green coffee processed.	Compliance with specified index in energy use.	Residual water discharge: DQO = 1500mg/l DBO= 1000 mg/l Sediment solids= 1mm/1 Ph: 5-9 Absence of floating matter. Reutilization of solid waste.
C.A.F.E PRACTICES	Compliance with national legislation. Additional points given water efficient methods used in processing.	Sun drying of parchment coffee encouraged. Additional points if energy consumption is reduced progressively and cogeneration of energy from renewable sources is established.	Residual water discharge according to national legislation. Additional points given for residual water treatment plan. Solid wastes stored responsibly.
Rainforest Alliance_*/	Compliance with national legislation.	Compliance with national legislation.	Compliance with national legislation.
Organic_**/	Compliance with national legislation. Minimum water use.	Compliance with national legislation.	Solid waste reutilization and recycling. Transformation to usable inputs (compost, for example)
Bird Friendly_**/	Idem.	Idem.	Idem.

*No special regulations for milling stage. Compliance with national legislation required.
** In cases where the mill processes various types of coffee, equipment must be cleaned before processing organic and Bird Friendly coffee. Also, coffee must be handled separately. This regulation may impact water and energy use.
Source: Starbucks, 2006; OCIA International, 2007; SAN, 2005 y SMBC, 2007.

6.2.2 Costs and prices of change to environmentally sound technology: an empirical discrete technology case study in Costa Rica

In this subsection, we evaluate a specific case study to determine if environmentally sound technologies facilitate product differentiation in the international markets and thereby improve incomes of local coffee producers and mills. The objective is to determine net economic benefits as well as key difficulties (transition costs, cultural change, etc.) related to environmentally sound technology for both agricultural producers and for mills. We take as a case study the West Central Coffee Region of Costa Rica and analyse net benefits of moving along a discrete technology path (see Chapter 3 of this thesis, Section 3.5) offered by each of the different environmental certification programmes. In the case study, we take a representative agricultural producer and a mill for each of the environmental certification programmes mentioned in tables 6.2 and 6.3, as well as for the conventional technology. Although our conclusions may not be generalized for the whole region or country, the cases allow us to generalize some guidelines of cultivator and mill behaviour under different scenarios.

General aspects of the case study

The West Central Coffee Region of Costa Rica is this country's second most important coffee producing area, in terms of production quantity. For the 2005-2006 harvest, 21% of total national production came from this region, second only to the Los Santos region at 27.4% (ICAFE, 2006: 22). During the 2007-2008 harvest, mills in this region paid the second highest average prices to farmers (final price) among all coffee growing regions in the country (see Table 4.4, Chapter 4 of this thesis).

For the study, we applied structured interviews to representative farmers and mills –one for each technology or certification programme- to identify differences for relevant variables such as environmental requirements, yields, costs, prices and profitability. Also, we placed special focus on the strategies used to access specific markets and the role that coordination (vertical and horizontal) plays in these strategies. The interviews took place during November 2006 and January 2007, and the instrument structured to permit comparisons among the different technologies. A general characterization of the representative farmers and millers who participate in the study is made in Annex 6.1.

The case study farms are located at altitudes between 1150 and 1550 meters above sea level. Agro-ecological conditions and altitude allow this coffee to be sold in specialty markets if quality is carefully managed. This scenario allows evaluation of the net benefits of improvements in the environmental conditions of coffee production and milling, given that financial benefits occur when premium pricing is applied.

Even if the objective of considering certification programmes is to classify them according to their environmental impacts, we should make some additional clarifications at this point. First, the certification options chosen are not exclusively dedicated to environmental concerns. These programmes also consider other variables such as social and economic responsibility; all these variables are in fact becoming part of the integral definition of quality. Secondly, we emphasise that our goal is not to propose conversion of all coffee production to organic. In fact, this option may not currently be economically or socially viable. Third, participation in a specific certification programme does not exclude a farmer or mill from obtaining other certifications. On the contrary, having more than one certification is common practice to increase marketing options, reduce commercialization risks, and increase the probability of price premiums.

Moving from conventional technology towards a more environmentally friendly package will undoubtedly bring many environmental benefits. Our case studies show that attention to environmental concerns, supported by good quality management in farming and milling practices, can serve as a tool for quality-based product differenttiation. However, collective coordination strategies must be developed to face transition costs and generate positive externalities that facilitate the process. The advantages of this particular technological change are increased market options, reduction of commercialization risks, and the increased possibilities of premium pricing. However, the most important advantage is a generally increased level of consciousness on the part of cultivators and mill operators of good agricultural practices.

Yields, costs and prices of the technological change

Table 6.4 shows the behaviour of the most relevant variables for each of the case studies. We can see that yields per hectare are highest for the C.A.F.E. PRACTICES case higher even than the conventional production case. This suggests that, after a transition period, yields recover and reach higher levels. On the other hand, yields are low for organic cultivation and even lower for Bird Friendly technologies, suggesting that yields per hectare are reduced at some point as environmental quality continues to increase.

Table 6.4: Costa Rica. West Central Region

Yields, costs and prices of different case studies (2006)

Certification programme	**Yields per hectare *TDH**/ha**	**Unit costs $/*TDH***	**Costs per hectare ($)**	**Farmer price*** ($/TDH)**	**Export price ($/46kg bag)**	**Farmer profita-bility ($/hectare)**
Conventional	25-32**	49	1225-1568	91.84	112	1071-1370.9
RFA	26	51	1326	98.4	120	1232.4
CAFÉ PRACTICES	36	56	2016	131.2	160	2707.2
Organic	17.5	59	1032.5	145.96	178	1521.8
Bird Friendly	13.5	70	945	145.96	178 ****	1025.5

* *TDH*, two double hectolitres, represents the amount of coffee berry required to obtain a 46-kg bag of green coffee. In Costa Rica this measure is also called *fanega*.
** The range represents data from two different cases, as explained in Annex 6.1.
*** Estimated at 82% of the export price as explained in the text.
**** Considered equal to organic price, due to the difficulties in obtaining the exclusive SMBC premium, as explained in the text.
Source: Author's fieldwork

The upper end of the range on yields per hectare in our conventional case (32 *TDH*) is much higher than the national average for the 2005-2006 harvest (24 *TDH*, according to ICAFE, 2006: 22). This suggests that using this case as point of departure may be biased, especially if we consider that the conventional mill in our case study, which has vertically integrated the cultivation and milling stages, has an average yield of 25 *TDH* per hectare, as shown by the lower figure in the range. This figure is more consistent with the national average (24 per hectare). Therefore, considering 25 *TDH* as a point of departure for conventional technology, we conclude that moving towards RFA and C.A.F.E. PRACTICES generates an increase in yields. Additionally, yields are reduced as agents move towards organic and Bird Friendly technologies.

In relation to costs per hectare, we do not find a clear correlation between total costs per hectare and environmental quality, while the unit costs per each *TDH* do show an increasing trend. The increasing unit cost trend is consistent with the expectations when yields are reduced (from C.A.F.E. PRACTICES to Bird Friendly) and the ratio of labour costs to total costs is expected to increase when moving to a more environmentally sound technology.

The data on farmer prices shown in our fieldwork are not consistent with the export prices reported by the mills, so we did not consider these figures in the analysis. Farmers interviewed stated that environmental factors are not the only determinant of their price. The case studies showed that cup quality plays the key role in pricing, and this is in large part influenced by good agricultural and quality management practices by farmers. On the other hand, export prices do tend to increase as agents move from conventional to more environmentally sound technology. If this trend is not reflected in farmer prices, the institutional pricing scheme[65] in Costa Rica may not be working properly. Therefore, to determine profitability, we estimated farmer price from the information given by mills, according to the official methodology defined by the Costa Rican Coffee Institute (ICAFE).

As explained in Chapter 4 of this thesis (Subsection 4.3.1), farmer price is determined by law, taking into account export price, distribution of sales among local and export markets, local price, an efficiency factor assigned to the mill (based on quantity of green coffee obtained from the berry), exchange rate and mill operating costs, among other factors (ICAFE, 2006: 30). For example, for a specific mill during the 2006-2007 harvest, where the proportion of ripe coffee received is 98%, the percent of coffee exported is 80% (20% is allocated for local consumption) and the national price represents 81% of export price (taking into consideration the exchange rate), farmer price is 82% of export price. We use this percentage to analyse profitability.

Another necessary clarification is related to export price in the Bird Friendly case study. The price reported by the Smithsonian Migratory Bird Center is difficult to determine (CIMS, 2004: 23). Given that this coffee must also be organic, in general only the organic premium is recognized (Stendlund, 2007, personal fieldwork interview). According to the interviews, the farmer never knows the final price being offered for this type of coffee, and must accept the price paid. For these reasons, for the determination of export prices we consider the Bird Friendly price as equal to organic.

With these considerations in mind, we analyse profitability for the certification programme cases; results of this analysis are found the last column of Table 6.4. We can conclude that the C.A.F.E. PRACTICES case is the most profitable (per hectare); the factors that contribute to this are the high yields per hectare and the price difference. The second most profitable case is the traditional technology farm, considering the upper yields in the range; in this case profitability comes precisely from the high yield per hectare. However, if the lower yields are considered (25 *TDH* per hectare), the profitability for this case is very similar to that of the Bird Friendly case.

We have not yet considered general quality differentiation criteria, in order to concentrate our analysis on the environmental component. However, the case studies show an association between good agricultural practices and general product quality, including environmental quality. This supports the assertion that environmental quality management is an integral part of good agricultural practices. Farmers should not only try to access price premiums in the short run, but they should also apply good agri-

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[65] The mechanism used to determine farmer liquidation prices establishes a clear relationship between export price and farmer price, as explained in Chapter 4 (see Section 4.3.1). However, sometimes information flow is incomplete (asymmetric information) and the farmer has no choice other than to accept the price given by the mill. This applies especially for our Bird Friendly case study, according to farmers interviewed.

cultural practices in general to save resources and increase grain quality. Price premiums are uncertain and temporary; therefore farmers and mills should work with medium and long term objectives in mind. This practice will help these agents maintain good commercial relationships with strategic buyers, even as price premiums change over time (Barrantes, 2006 and Llobet, 2006; personal fieldwork interviews). Our case studies show that a technology change in favour of the environment can bring net benefits for farmers; however, simply applying good agricultural practices can also increase yields and grain quality. Increasing yields is not only a good strategy to increase incomes, but should be seen as a necessary condition for this outcome. Also, increasing general grain quality is a good way to guarantee stable or increasing prices, regardless of environmental criteria.

In spite of the benefits obtained through technological change, in our case studies we identified elements that do not favour this change. At the outset of a change, some transition costs are unavoidable -these costs are related to investment and training- and price premiums are not automatically obtained to offset these increasing costs. The issue of transition costs was especially important in the conventional and the C.A.F.E. PRACTICES cases. In the first case (conventional), our representative farmer has been trying without success for three consecutive years to join the Starbucks' C.A.F.E. PRACTICES verification programme. This, of course, is a disincentive for the technological innovation because change costs must be covered in advance, before receiving the benefit of the price premium. In the C.A.F.E. PRACTICES case, the farmer we interviewed is considering leaving the programme because he believes the requirements are too rigorous and the conversion timetable too short - this in addition to the costs associated with preferred or strategic provider status. Also, he sees other farmers receiving similar prices without implementing the same changes; his neighbours are successfully differentiating their product through other factors – high altitude, for example. This suggests that environmental price premiums are not sufficient motivators for technological change, when general quality and base price are high.

This last issue brings us to the second most important obstacle to technology change: high base prices do not favour environmental technology change. From our fieldwork we found a group of producers who tried to reduce costs in 2003, when international prices were low, by reducing the use of chemical inputs and adopting a more environmentally friendly technology package. However, when coffee prices started recovering toward the end of 2004 and during 2005, most producers returned to the conventional technology. In the period of our study, four of ten new organic producers were considering leaving the organic certification programme to move to Starbucks' C.A.F.E. PRACTICES, which has lower environmental requirements (Guerrero, 2006; personal fieldwork interview). Additionally, Salazar (2005) described the case of a coffee cooperative in the Los Santos region that has consistently received high prices based mostly on altitude (even higher than premiums offered by Starbucks); this certainly does not support the case for technological change in favour of the environment.

The need for horizontal and vertical coordination

In the efforts to improve sustainability in the cultivation and milling processes, horizontal or vertical coordination among agents along the chain is required. As options for horizontal coordination, we can mention i) farmers acting together to reduce average certification costs, ii) reduction of negative externalities and/or the development of positive ones, and iii) the creation of a regional or national product image. As an example of vertical coordination we can mention quality management initiatives between farmers and mills. We will evaluate each in more detail.

First, we will study how coordination and joint action can help farmers and first-processors reduce certification costs, as an example of vertical and horizontal coordination. According to CIMS (2004: 15), the cost of organic certification varies with the size of the property - if the producer is independent - and the number of associates, if the producer belongs to a producer association. For example, for a producer association with at least 20 farmers, total certification costs are US$1,000 (US$50 each), while if the association has at least 100 members, the total cost is US$2,000 (US$20 each). If the producer is independent and farms less than 50 hectares, his cost is US$500, while if he farms more than 50 hectares, the cost is US$1,200. Therefore, a producer with 5 hectares pays US$500 to certify his farm independently but pays US $50 if he associates first with 20 other producers; this cost is reduced to US$20 if he associates with 100 growers.

According to our study, the Rainforest Alliance certification fee is US$1,500 (evaluation and membership). Calculated for the average 300 hectare farm, the cost is about US $5 per hectare. The producer then must pay an additional US$4 per hectare annual fee. According to the producer interviewed, the total costs of certifying a large farm is almost the same as the cost to certify a small farm; therefore, larger properties pay lower per-hectare costs (Llobet, 2006; personal fieldwork interview).

In the case of Starbucks, our representative farmer paid US$1,000 as a verification fee for a 3 hectare farm – a relatively high fee. In some cases, these verification costs are assumed by the mill, as in the case of a leading cooperative in Los Santos. 100% of this cooperative's growers are included in the Starbucks' C.A.F.E. PRACTICES verification programme; accordingly, the per-hectare verification costs for each farmer is very low (Zúñiga, 2007; personal fieldwork interview).

Another way to reduce the per-hectare certification costs is by participating in more than one certification programme, resulting in shared initial investment and learning costs. This occurs in our Rainforest Alliance case, where the farmer is also certified by C.A.F.E. PRACTICES. The same situation occurs in the case of the Los Santos region cooperative previously mentioned (Zúñiga, 2007; personal fieldwork interview). Producer organizations often hold both organic and Fair Trade certifications; this combination seems to be very successful, especially for small producers facing the transition period to organic (Calo and Wise, 2005).

The Bird Friendly certification is the most difficult to achieve, for several reasons. First, in addition to the already difficult organic certification requirements, the Bird Friendly programme imposes standards related to shade cover and water source protection (see Table 6.2). Second, at the required level of environmental quality, additional shade cover begins to reduce yields. Finally, growers do not usually know in advance what the exclusive price from the Smithsonian Migratory Bird Center is, and in most cases the price premium received is not larger than the organic premium (CIMS, 2004: 23).

This may explain why there is currently just one grower certified with this programme in Costa Rica.

The second way in which horizontal coordination can help is related to the reduction of negative and the increase of positive externalities. First, in the agricultural stage, all certification programmes require, among other things, the establishment of buffer zones to protect the certificated area against conventional technology-using neighbours. The ratio of buffer areas to total area decreases as the certified area increases. Second, positive externalities (related to pest control in the agricultural stage, for example, or water purification in the milling stage) may be more readily perceived if a large number of farmers switch to the environmentally sound technology. These externalities will facilitate the process of joint learning and knowledge transmission. Also, the need for institutional arrangements will be stronger as more agents decide to make the technological change.

The third way in which horizontal coordination can facilitate technological change is through the creation of a national or regional product image, and this must be supported at both the agricultural and the milling stage. However, if the image can be built by others, an individual firm may avoid these costs while taking advantage of the resulting image. From our case study, some agents interviewed believe that this kind of opportunistic behaviour of some agents can make it difficult to generate horizontal image-building efforts at the national or regional level.

In terms of vertical coordination, additional options are very promising. For example, technological change in the cultivation stage is easier to achieve if growers participate in agreements with mills to guarantee product quality and compliance of environmental standards required by certification programmes. Another advantage of vertical coordination at the cultivation and milling stages is the opportunity to reach a threshold volume of produce required to enter alternative commercialization channels[66]. The role of the mill is fundamental, because it can promote the change, advise participating farmers and share transition costs; the mill can also support technology and information transfer.

To summarize this section, these case studies show that environmental quality can be used as a tool to improve incomes of coffee producers and mills; certification programmes are concrete options for access to special (discrete) markets with different environmental requirements. However, environmental quality management must be considered an integral part of a wider strategy based on general quality management, given that cup quality is the main determinant of coffee price. This suggests the importance of good agricultural practices, not only to obtain price premiums in the short term, but also to improve longer-term commercial relations between buyers and growers, guarantee market presence, and protect valuable resources. If farmers and mills can view possible changes from a medium and long term perspective, environmental differentiation can truly become a source of process and product upgrading (see Gibbon, 2001).

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[66] This was mentioned as one of the objectives of our representative organic case, according to the fieldwork.

6.3 Environmental technology as a strategic tool to increase incomes in the cultivation and milling stages

6.3.1 Towards a generalized case of technology continuity

In Chapter 3 of this thesis, we defined technology in terms of: i) environmental quality of the cultivation and first-processing stages and ii) the relevant available markets (see Section 3.5). Environmental quality was considered a result of the intensity of use of variables related to the technology package in question. We may, therefore, establish a technology index that relates environmental quality at the cultivation and first-processing stages with the intensity of use of the relevant variables. For example, at the cultivation stage, environmental quality can be considered an index of the percent of shade cover (x_1) and the intensity of agro-chemical use (x_2); we may also consider a third variable related to the use of alternative or environmentally sound inputs (x_3). At the milling stage, the environmental quality index will be determined by intensity of the use of water (z_1) and energy from non renewable sources (z_2), as well as by the environmental impact generated by waste disposal mechanisms in place (z_3). In both cases (the cultivation and first-processing stages) the technological index changes in a continuous manner in response to changes in the relevant variables. Therefore, considering only environmental quality, technology is continuous.

The second issue in the definition of technology is related to markets. The issue of available markets is relevant to technology when we consider the relationship between environmental quality and the price obtained for the product. In this case, technology can be either continuous or discrete: it will be *continuous* if prices increase in a continuous manner with respect to improvements in the environmental quality and discrete if prices increase in a non-continuous manner. A case in which access to specific markets is based on compliance with minimum environmental requirements would indicate discrete technology; this occurs, for example, with the environmental certification programmes discussed in Section 6.2 of this chapter.

6.3.2 The agricultural stage: yields, costs and prices of technology change

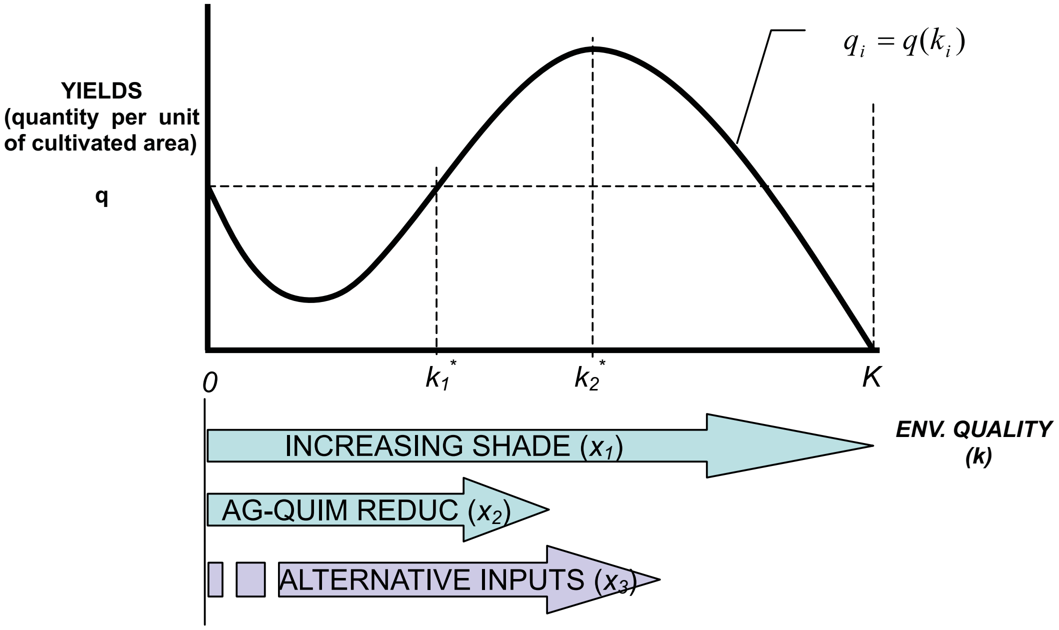
Yields per hectare

Increasing environmental quality in coffee production at the farm level generates direct effects on yield. From the fieldwork presented in Subsection 6.2.2, we found that increases in environmental quality –for instance, a change from conventional to C.A.F.E. PRACTICES technology- may lead to increased yields when good agricultural practices are also in place. However, after a certain point, more demanding environmental requirements (organic and Bird Friendly technologies, for example) may actually imply reduced yields (see Table 6.4 of this chapter). However, the shift from conventional technology to good agricultural practices requires a transition period. During this transition, yields decrease due to the lower levels of chemical inputs, lower intensity in the utilization of productive areas, higher intensity of shade cover, and the creation of buffer zones next to water sources, trails and conventional neighbours (Montero, 2007; Solís, 2007; personal fieldwork interviews).

To obtain a continuous path we can graph the expected relationship between yields and environmental quality; we do this in Figure 6.1 for representative farmer *i*. Yields (q_i) represent production within a specific area, for example, a hectare of land, whereas environmental quality (k) is defined as the environmental impact produced by the intensity of use of the relevant variables described above.

Starting from the lowest environmental quality level (*0*), during the early stages of the change, yields are expected to fall as a result of those factors already mentioned. However, the application of good agricultural practices related to the correct use of alternative inputs will cause yields to recover and, after a transition period (k_1^*), these yields may reach or exceed their original levels (Montero, 2007; Solís, 2007; personal fieldwork interviews. See also Calo and Wise, 2005: 39). However, a third stage is also expected. The limit of the trend of increasing yields occurs when shade cover intensity begins to compete with productivity (Soto-Pinto, *et al*, 2000; Muradian and Pelupessy, 2005: 2035). The extreme situation would be point *K*, where the entire area is shade covered, and no coffee is produced.

**Figure 6.1: Coffee Yields and Technologies.
Agriculture stage**



In this sense, we can identify a mathematical relationship between yields (q_i) and environmental quality of the technology used (k_i):

$$q_i(k_i) = ak_i^3 + bk_i^2 + ck_i + d \text{, where } a<0 \text{ and } d>0 \qquad (1)$$

q_i: quantity of coffee produced per cultivated unit (one hectare) of land, for farmer *i*.
k_i: environmental quality, as defined earlier.

Costs per hectare

Production costs per hectare are expected to increase as environmental quality increases. Although some cost savings will appear as a result of the reduction of chemical inputs, alternative inputs are needed, and these are sometimes more expensive and harder to obtain. Also, higher environmental quality technologies are usually more labour intensive (Lyngbæk, *et al*, 1999; Boyce, *et al*, 1994). Finally, if farmers wish to access certification programmes, they must assume additional and often costly measures to comply with relevant standards and pay certification costs. This implies that moving to a more environmentally sound technology generates additional costs per hectare[67]. However, at some point these costs may trend downward as the reduction in chemical inputs offsets the additional costs of alternative inputs. This trend was confirmed in our fieldwork; costs per hectare increase when moving from conventional to C.A.F.E PRACTICES, but decrease when moving from C.A.F.E. PRACTICES to organic and Bird Friendly (see Table 6.4).

Additional costs per hectare are usually prohibitive for small farmers acting alone (Calo and Wise, 2005: 1; CIMS, 2004: 10; Muradian and Pelupessy, 2005: 2039); however, these costs may decrease as the number of farmers switching technology increases and positive externalities begin to appear. For example, innovation in cleaner technologies requires linkages and cooperation to facilitate economies of scale in pest control and avoid externalities generated by conventional neighbours (Wilson and Tisdell, 2001). Moreover, in some cases the costs per hectare of environmental certifications depends on the number of hectares certified, or on the number of farmers participating in the process (CIMS, 2004: 15-16); hence, a larger certified area (or number of participating producers), implies a smaller per hectare costs for certification (see also section 6.2.2).

Considering the expected cost path resulting from changes in environmental quality and the number of farmers who switch technology, the per hectare cost function may assume the following general form:

$$C_i = C(k_i, N_k) + FC_i \qquad (2)$$

With $$\frac{\partial C(k_i, N_k)}{\partial k_i} > 0, \ \frac{\partial C(k_i, N_k)}{\partial N_k} < 0; \qquad \frac{\partial C^2(k_i, N_k)}{\partial k_i^2} < 0, \ \frac{\partial^2 C(k_i, N_k)}{\partial N_k^2} < 0 \qquad (3)$$

C_i: total production costs per hectare
k_i: environmental quality
N_k: Number of farmers who choose a specific environmental quality k (assuming an average producer).
FC_i: Fixed costs of farmer *i*. These can be related to certification costs and/or the construction and maintenance of required infrastructure to comply with environmental standards. Following Wilson and Tisdell, 2001, we will call these *withdrawal costs*.

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[67] Wilson and Tisdell establish as 'withdrawal costs' the initial costs related to the shift from polluting technology to the more sustainable options, and these are specifically related to the difficulty of eliminating pesticides (Wilson and Tisdell, 2001: 458). "This is because, despite the economic, social and ecological gains that could be derived from biological controls, once adopted as the dominant pest control strategy, pesticides will continue to be used in larger quantities despite the very serious negative effects that have arisen" (Wilson and Tisdell, 2001: 459).

Coffee prices and environmental quality

In relation to coffee prices, we propose three reasons to assume that prices maintain a positive relationship (or at least non-negative) with environmental quality: i) the existence of a direct relationship between environmental quality and the intrinsic quality properties of the product (Alonso, 2006; Muradian and Pelupessy, 2005: 2035) that are determiners of final price (CIMS, 2004; Muradian and Pelupessy, 2005: 2035); ii) the reduction of the risk of exclusion from traditional markets; iii) higher possibilities for access to special markets that pay price premiums for certified higher environmental quality products. In our fieldwork we identify a positive price trend toward higher environmental quality technologies, from conventional to organic (see Table 6.4). However, as we have noted, that study represents the case of discrete technologies. For the same reasons mentioned before, we may expect a more general case where prices increase in a continuous manner as the environmental quality of production processes increases; this is the assumption of continuous technology.

We also identify a second variable expected to affect price. Special markets will only be accessed if a threshold number of farmers – we will call this N_k^*- decides to adopt environmental quality *k*. This number of farmers is needed for the processor to reach the threshold scale of production for those markets.

To summarize, prices should be considered a *direct* function of environmental quality technology (k_i) and the number of producers who adopt that technology (N_k).

$$P_i = P(k_i, N_k) \qquad (4)$$

Where: $\frac{\partial P_i}{\partial k_i} > 0$ and $\frac{\partial P_i}{\partial N_k} > 0$; $\frac{\partial^2 P_i}{\partial k_i^2} < 0$ and $\frac{\partial^2 P_i}{\partial N_k^2} < 0$ (5)

Condition (5) reflects the assumption of technological continuity with respect to both environmental quality (k) and the number of farmers who switch technology (N_k). Also, the trend is positive but shows decreasing returns with respect to both variables, suggesting risk of market saturation.

To separate the effects of individual variables on price, we can assume a specific price function:

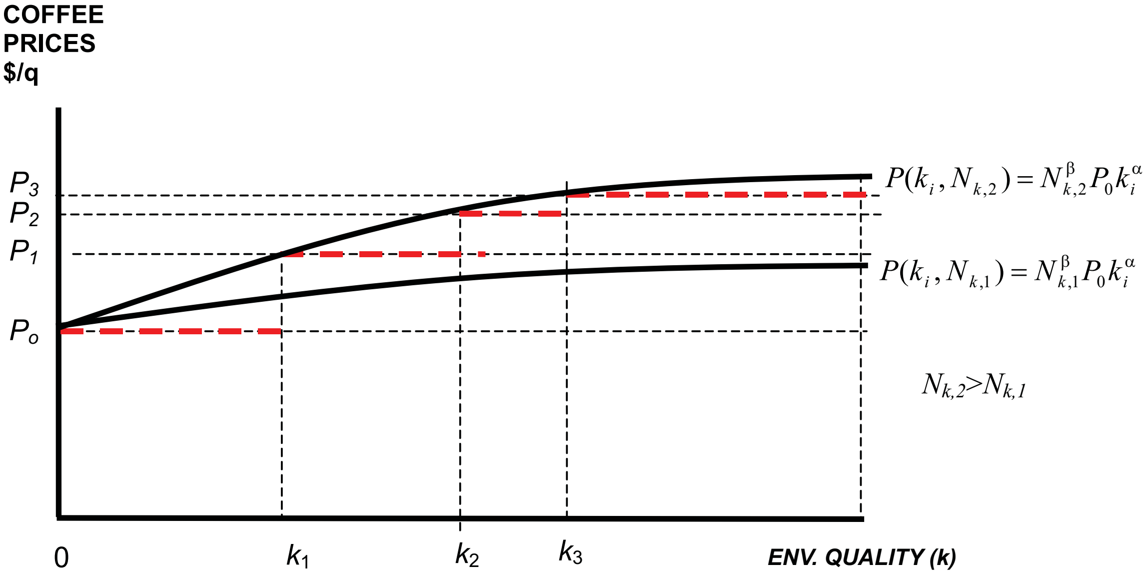
$$P(k_i, N_k) = P_0 k_i^{\alpha} N_k^{\beta} \qquad (6)$$

shown graphically in Figure 6.2 (next page). This figure depicts the relationship between price and environmental quality for specific levels of N_k.

The positive price trend is represented with the continuous lines $P(k_i, N_{k,1})$ and $P(k_i, N_{k,2})$. Prices are expected to increase as environmental quality increases; however, diminishing returns are expected at some point as price premiums begin to decrease in proportion to further increases in environmental quality (CIMS, 2004: 53). Different levels of N_k will move the price trend in the same direction.

The particular, discrete certification cases can be located in this figure. Hence, the price increase curve should be interpreted as the 'envelope' of a price series that increases in non-continuous terms as higher environmental quality permits access to markets with increasing standards. To access those specific markets, a threshold number of farmers who use the required technology is needed to fulfil minimum production scale required in these markets. In this case, for example, the price trend $P(k_i, N_{k,1})$ does not reach the price assigned to any of the certification programmes presented. This is because $N_{k,1}$ is not high enough to reach minimum scale for access to any of those markets; therefore, in those cases the price obtained is P_0.

Figure 6.2: Coffee prices and environmental quality.



We should mention that the environmental quality of green coffee (output of the milling stage) cannot be isolated from environmental quality at the cultivation stage. We stated in Chapter 3 (Section 3.2) that final product quality in agri-food chains is a complex result of actions taken by all agents involved in the different stages of the global chain. That is, a specific environmental quality level at the milling stage assumes a specific environmental quality at the cultivation stage; there is a direct correspondence between the environmental qualities at the two stages. This relationship has implications for prices received at both the cultivation and the milling stages; this concept will be used extensively for the rest of this chapter.

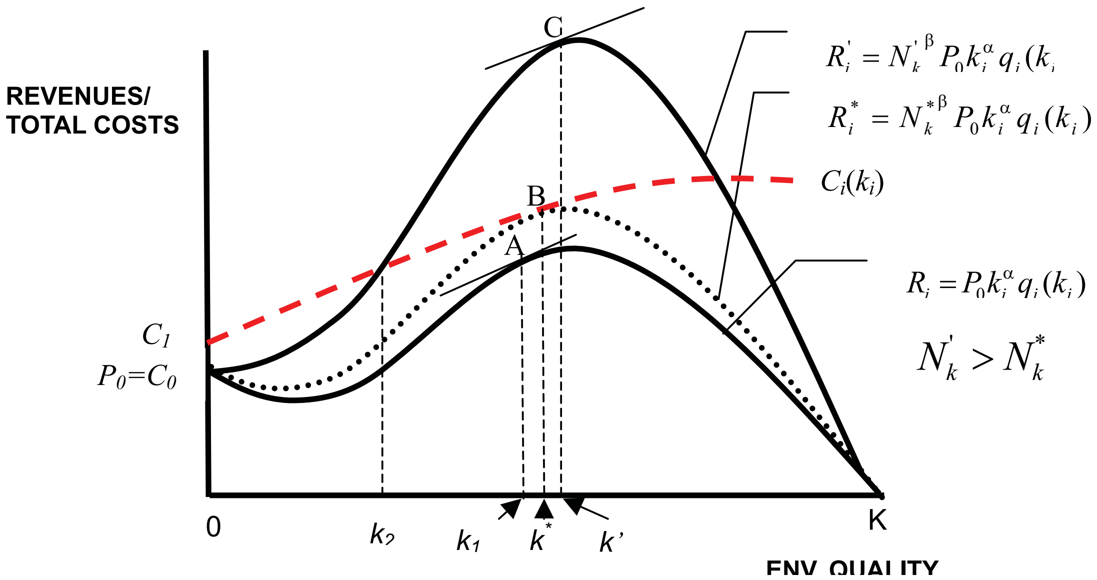
The farmer's maximisation conditions in the case of continuous technology

Considering equations (1), (2) and (6) and restrictions (3) and (5), the maximisation problem for an individual farmer i with respect to k_i can be shown in Figure 6.3. To simplify the analysis, we avoid the effect on cost reductions provoked by increasing numbers of farmers (N_k) presented in equation (2). The profit maximisation problem can be stated as:

$$\pi_i = N_k^{\beta} P_0 k_i^{\alpha} q_i(k_i) - C_i(k_i) - FC_i \qquad (7)$$

The figure represents total cost $C_i(k_i)$ and total revenue (R_i) functions. We assume a point of departure ($P_0 = C_0$), meaning that at the lowest level of environmental quality (0), profits are zero. The shape of the cost function reflects the assumptions explained for equation (2) and restriction (3), avoiding the effect on cost reductions provoked by the increasing number of farmers N_k.

Figure 6.3: Profit maximisation for a representative coffee farmer



The level of the revenue function depends on the level of N_k, which is the number of farmers that use a specific technology k. The lowest revenue function depicted in the figure, $R_i = P_0 k_i^{\alpha} q_i(k_i)$, represents the case of a farmer in isolation - $N_k=1$. In this case, the level of revenues is not sufficient to cover the costs of moving to a higher environmental quality technology, even when this farmer is optimizing (minimizing losses) at point A[68].

The intermediate revenue function depicted, $R_i^{*} = N_k^{*\beta} P_0 k_i^{\alpha} q_i(k_i)$, represents the case where $N_k = N_k^{*}$. This is the threshold number of firms required for benefits to be non-negative[69], as can be seen in profit maximisation point B, where net benefits are zero. Higher levels of N_k will allow farmers to accrue positive net benefits, as shown in point

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[68] At point A, where environmental quality is k_1, the slope of the revenue function should equal the slope of the cost function. To simplify the figure, we have not drawn the slope of the cost function.

[69] Recall from our previous definition, N_k^{*} is the minimum number of farmers who choose the specific environmental quality k, required to access the prices paid in the higher environmental quality markets.

C, where $N_k^{'} > N_k^{*}$. Therefore, it can be seen from our analysis that the sign of the value of net benefits of the technology change will depend upon whether the threshold number of farmers N_k^{*} is reached.

We can estimate the threshold level N_k^{*} from equation (7) as follows:

$$\pi_i > 0$$

$$\text{if } N_k^{*} \geq \left(\frac{C_i(k_i) + FC_i}{P_0 k_i^{\alpha} q_i(k_i)} \right)^{\frac{1}{\beta}}$$

N_k^{*} is a direct function of individual costs and an inverse function of revenues. Therefore, the number of farmers required to shift technology for net benefits to be non-negative will be greater as individual costs of the technology shift increase and the impact an individual farmer's decision may have on price decreases. The threshold level of famers will also be affected by the effect on prices caused by N_k, which is reflected in the exponent β. As the value of β increases, the value of N_k^{*} will decrease.

Figure 6.3 also shows that as N_k increases, the lowest environmental quality required for an individual farmer to start obtaining positive benefits decreases. When $N_k = N_k^{*}$, the environmental quality required for the benefits to be non-negative is k^{*}; however, when $N_k = N_k^{'} > N_k^{*}$, the environmental quality required for the benefits to be non-negative is $k_2 < k^{*}$. However, the environmental quality that maximises profits increases as N_k increases. This means that as the value of N_k increases, we will observe a higher level of environmental quality that maximises profits as well.

The algebraic maximisation conditions for specific functional forms

To obtain the algebraic equilibrium conditions for farmer decisions, we simplify the analysis to avoid the effects on yields from increasing environmental quality (equation (1)). Then, we assume an average farm that produces a fixed quantity $\bar{q}$ regardless of environmental quality. We can also consider a specific functional form for the cost function and avoid the effects on cost reductions provoked by the increasing number of farmers (N_k) presented in equation (2). Therefore, equation (2) can be transformed into (2'):

$$C_i = C_0 k_i^{\varphi} + FC_i \qquad (2')$$

with $0 < \varphi < 1$.

Then, considering equations (2') and (6) and restrictions (3) and (5), the maximisation problem for an individual farmer *i* corresponds to maximising equation (7') with respect to k_i to determine the optimal level of environmental quality that maximises profits.

$$\text{Max } \pi_i = P_0 k_i^{\alpha} N_k^{\beta} \bar{q} - C_0 k_i^{\varphi} - FC_i \qquad (7')$$

The traditional first order maximisation condition implies that:

$$k_i^* = \sqrt[\varphi-\alpha]{N_k^{\beta}\left(\frac{P_0}{C_0}\bar{q}\right)\frac{\alpha}{\varphi}} \qquad (8)$$

Equation (8) will have a solution only if $\varphi > \alpha$. This implies that cost elasticity (φ) should exceed price elasticity (α), with respect to environmental quality. The environmental quality that maximises profits will increase as the rate of change of prices (α) increases and the rate of change of costs (φ) decreases, due to changes in environmental quality.

The other result obtained from equation (8) is the existence of a different solution for any level of N_k. This implies that as N_k increases, the profit-maximising environmental quality also increases.

We can rearrange equation (8), to obtain the ordered pairs (k, N_k) that maximise profits:

$$N_k = k_i^{\frac{\varphi-\alpha}{\beta}} \sqrt[\beta]{\frac{\varphi}{\alpha}\frac{C_0}{P_0\bar{q}}} \qquad (9)$$

For a specific level of k_i, N_k increases as β and α decrease and φ increases. It will also increase as the ratio of initial costs over initial income increases.

We could have estimated the optimal levels of N_k and k; which are the optimal number of farmers that use a specific sustainable technology and the optimal level of environmental quality that is the best solution for the group. However, because of the shape assumed for the functions, the curve has no critical point, meaning that if the number of farmers that uses a specific environmental quality technology changes, the technology that maximises profits will also change[70].

6.3.3 The first-processing stage: the profit maximisation issues

Yields at the milling stage

Output at the milling stage is directly related to total quantity produced at the cultivation stage. Given the specificity of inputs, we must assume a direct correspondence between the quantity of coffee berry received by the mills and green coffee produced[71].
Then, assuming a one-to-one correspondence, we have:

$$Q = \sum_{i=1}^{n} q_i(k_i) \qquad (10)$$

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[70] The situation would be different if we consider the effects of changes of environmental quality on yields per hectare, as described in equation (1) of this chapter.

[71] As mentioned before, under normal efficiency conditions in Costa Rica, a mill can produce one 46 kg bag of green coffee from one *fanega* (two double hectolitres) of berry coffee.

with:

Q: quantity of green coffee produced (processed) by mill,
q_i: quantity of coffee produced per cultivated area (one hectare) of land, for farmer i.
k_i: environmental quality at the cultivation stage.
n: number of farmers

Equation (10) can be rewritten as:

$$Q = n\overline{q}(k) \qquad (11)$$

where $\overline{q}(k)$ is the per hectare average production corresponding to environmental quality k.

For a given number of farmers using a particular environmental quality technology (N_k), equation (11) can be transformed into

$$Q_k = N_k\overline{q}(k) \qquad (12)$$

Also, as explained earlier (Subsection 6.3.2 of this chapter), a direct correspondence between environmental quality at the cultivation and the milling stages must exist, meaning that a specific environmental quality must be obtained at both the cultivation and milling stages to reach the sustainable markets. In this case,

$$Q_k = Q(l, N_k) \qquad (10)$$

with l as environmental quality at the milling stage. Every level of l is associated with a corresponding level of k.

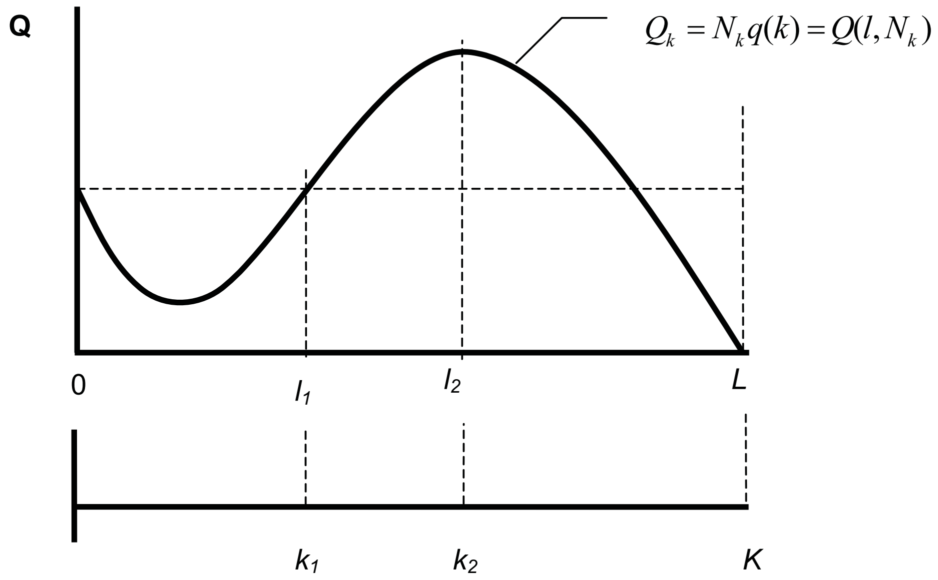
Given these assumptions -and considering the behaviour of yields (q_i) and environmental quality at the cultivation stage presented in equation (1)- the relationship between environmental quality at the milling stage (l) and the coffee processed (output at the milling stage) will have the curve depicted in Figure 6.4; this curve has the same shape as the curve in Figure 6.1 for the cultivation stage. One of these functions will exist for each level of N_k.

Costs

Experience in Costa Rican has shown that it is possible to use higher environmental quality technologies in the milling stage without causing negative impact on production costs and yields; moreover, some indicators have even improved (CEPAL, 2001: 49). However, the change to technologies of higher environmental quality implies withdrawal costs at the milling stage. These costs are associated mainly with new plant investment as well as the establishment of controls over growers and, in most cases, technical support, with the objective of guaranteeing the quality of the berry coffee. Additionally, if the mill also processes different types of coffee not subject to the same environmental criteria, the plant must follow strict management practises, such as cleaning the equipment and separating lots, especially for organic and Bird Friendly product (OCIA International, 2007, Section 4.9.5; SMBC, 2007: 6-7).

In the medium term, these costs may be compensated by the reduced use of resources such as water and energy. Therefore, total costs at the milling stage are expected to behave as we have shown for the agricultural stage: as environmental quality improves, costs increase initially, but this increase is mitigated later by savings in the use of strategic resources. This behavioural relationship is presented in equation (13) with conditions (14).

**Figure 6.4:Coffee. Production and technologies.
Milling stage**



$$C_m = C_m(l) + FC_m \quad (13)$$

$$\text{With } \frac{dC_m(l)}{dl} > 0\,; \qquad \frac{\partial C_m^2(l)}{\partial l^2} < 0 \quad (14)$$

C_m: total processing costs
l: environmental quality at milling stage
FC_m: Fixed costs for mill

Prices, revenues and profit maximisation problem

The direct correspondence between environmental quality at the cultivation and milling stages must be reflected in the final price obtained. For example, we can assume that a one-to-one correspondence holds between environmental quality at the farmer level (k) and at the milling stage (l). In this case, the ordered pairs are matched as follows: $\{(k_1, l_1); (k_2, l_2); \ldots; (K, L)\}$. The relationship between price and environmental quality at the cultivation stage will also show this correspondence. If this is not the case, for example (k_2, l_1), prices will correspond with the lower bound value of the ordered pair, reflecting the minimum environmental quality. In this case, the lower value is l_1, which corresponds with the ordered pair (k_1, l_1), with $k_1<k_2$.

Additionally, prices at the cultivation stage relate directly to the price at the milling segment. This is especially the case in Costa Rica, where farmer price is regulated and essentially indexed to mill prices.

The relationship between price and environmental quality at the milling stage will show the same curve presented in Figure 6.2 for the agricultural stage.

$$P_m = P_m(l, N_k) \qquad (15)$$

Where: $\frac{\partial P_m}{\partial l} > 0$ and $\frac{\partial P_m}{\partial N_k} > 0$; $\frac{\partial^2 P_m}{\partial l^2} < 0$ and $\frac{\partial^2 P_m}{\partial N_k^2} < 0$ (16)

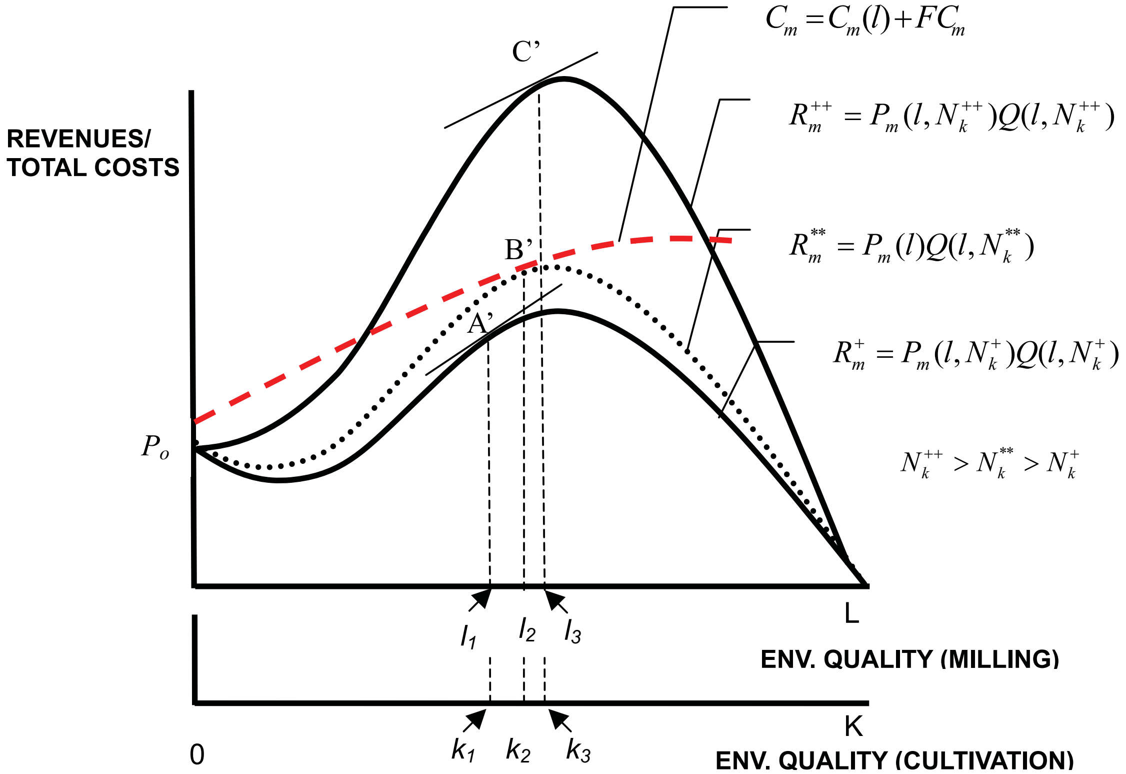
If this is the case, revenues will follow the same curve we have presented for the cultivation stage, shown in Figure 6.5. Let us recall that a specific environmental quality level at the milling stage (l) assumes a specific environmental quality at the cultivation stage (k), given the one-to-one correspondence between environmental quality at these stages.

We may have different revenue functions, where its final level depends on N_k; then, a threshold level of farmers are required to use technology k for the net benefits to be non-negative. In our figure, this level is N_k^{**}.

We should note that the threshold level for the mill (N^{**}) will not necessarily match the threshold level at the agricultural stage (N^{*}); also, the environmental quality that maximises profits at the mill (l_1^*) may not match the quality which maximises profits at the agricultural stage (k_1^*). We will return to these issues in the next section.

In the next section, we use the game theory framework to analyse potential benefits of vertical strategic coordination in the first stages of the Costa Rican coffee chain (cultivation and milling) to increase environmental quality and the incomes of cultivators and mills.

Figure 6.5: Profit maximisation at the milling stage



6.4 Improving incomes of coffee growers and mills by strategically managing environmental quality at coffee production and processing stages

The majority of a developing country's coffee exports are in the form of green coffee (ICAFE, 2006: 11), the result of the milling stage. However, the final quality of the grain is the result of joint actions taken by both cultivators and mills. This implies the need for strategic coordination between these two stages in the chain. We can find opportunities for horizontal strategic coordination both in the growing and in the milling stage. Also, vertical strategic coordination can occur in the relationship between cultivators and mills, or further down the chain, among mills and exporters and/or importers[72]. Horizontal strategic coordination is relevant at both the cultivation and milling stages, as we have shown before in our case study. Horizontal coordination is important to build (or maintain) a regional or country image based on higher environmental quality, requiring the coordination of actions at the cultivation and milling stages. However, although we can find country or regional images in the international coffee markets (for example, Colombia or Kenya, at the country level or

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[72] In line with Poulton et al (2004: 521), horizontal coordination is that which takes place among agents at the same stage of a market system; while vertical coordination occurs among different stages of the market system. See Chapter 3 of this thesis for further discussion of this concept.

Tarrazú -Costa Rica- and *Antigua* –Guatemala- for the regional image case), Costa Rican coffee is commercialized mainly through product differentiation strategies based on branding at the mill or exporter level. In this differentiation process, as stated before, quality management practices play the most important role, and among these practices is management of environmental quality as an integral part of general quality. Mills look for a specific quality level in order to differentiate their product in the international markets and obtain favourable prices. In this sense, a vertical coordination game among cultivators and mills will reflect the productive and commercial reality of the coffee activity in the first stages of the Costa Rican coffee chain. We will concentrate our efforts for the rest of this chapter on this vertical game among farmers and mill.

In this strategic relationship between the cultivator and the mill, the latter is considered the key national agent. This is because the mill plays a strategic role both upstream and downstream in the chain. Moving forwards, this agent processes the berry and commercialises it in the form of green coffee. Looking backwards, the mill defines quality requirements for the produce it receives. Additionally, according to Costa Rican coffee legislation, as we have noted before, the final farmer price is directly related to the green coffee export price (Asamblea Legislativa de Costa Rica, 1961).

In this game, the objective is to improve environmental quality of green coffee, which is the result of technological choices of both cultivators and mills. To determine if technological change in favour of the environment is favourable for farmers and mills, the model will evaluate additional economic benefits (the difference between revenues and costs) obtained after the environmental quality decision is made.

The vertical coordination game among farmers and mills is based on the following assumptions:

1. One mill[73] and *n* cultivators.
2. Final quality of green coffee is determined by environmental quality in both the cultivation and milling stages[74]. We assume a one-to-one correspondence between environmental qualities at the cultivation and milling segments. If that correspondence is not obtained, the price is determined by the lower bound value of the ordered pair, related to the lower environmental quality level, as explained in Subsection 6.3.3 of this chapter.
3. Technology is continuous at the farmer and mill stage as explained in Subsection 6.3.1 of this chapter. We take current technologies of minimum environmental quality as the point of departure, and move toward technologies of higher environmental quality, which imply higher initial production costs for cultivators and mills, as shown in subsections 6.3.2. and 6.3.3. of this chapter.

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[73] To simplify the analysis, the game is structured for *n* farmers and just one mill. A specific quantity of green coffee is produced through this coordination relationship. However, the coordination game attempts to simulate the competitive and cooperative relationships among cultivators and mills, so that their individual decisions are influenced by the actions of other agents, whether they are located in the same or different segments of the chain.

[74] To reduce the analysis to only the consideration of environmental quality, we assume other quality determinants are constant, such as the intrinsic characteristics of the product. Where intrinsic properties of quality do change, this change is assumed to be caused by the change in environmental quality.

The strategic interactions between cultivators and the mill can be modelled as a two-stage game. In the first stage, the mill chooses its level of environmental quality ($l = [0, L]$), where L is the highest environmental quality option and 0 the point of departure, or lowest (conventional) environmental quality level. In the second stage, cultivators are aware of the mill's decision and elect their own environmental quality $k_i = [0,K]$ where $i = 1, \ldots, n$ is a representative cultivator, K is the highest environmental quality in the cultivation stage and 0 the conventional (lowest) environmental quality, or point of departure. Environmental quality becomes the strategic variable and $k_i = [0,K]$ and $l = [0, L]$ are the set of strategies for farmers and for the mill, respectively.

Individual agents make their technology selection according to their self interest; however, the final result of the game will depend on the decisions of all players, which in this case include the group of farmers and the mill. The solution to this type of game requires application of the backward induction procedure (see Gibbons, 1993: Chapter 2, among others). At first, we identify possible farmer strategies related to environmental quality for any of the mill's possible decisions; then the mill, taking into account possible farmer reactions, chooses its level of environmental quality. We will start by studying farmer reactions for each of the mill's possible decisions.

The farmers' decision

Given continuous technology in the milling stage, we must evaluate farmer decisions for each of all possible mill strategies. We can take a given level of environmental quality chosen by the mill - l^{λ} for example. We conclude from Figure 6.3 that farmers will choose the corresponding environmental quality level at the cultivation stage, let us say, k_i^{λ} if: i) the number of farmers choosing that level is high enough (threshold) for profits to be non-negative and, ii) environmental quality is lower than or equal to the level that maximises profits for the farmer. In Figure 6.3, this corresponding environmental quality k_i^{λ} will lie between k_2 and k'; and $N_k = N_k^{'} > N_k^{*}$. Farmers will not choose a lower environmental quality level $k_i < k_i^{\lambda}$ if the threshold number is reached because, in this scenario where profits are non-negative, benefits will increase as environmental quality increases, as long as the farmer profit maximisation point has not been reached, as will be explained later. Farmers will not choose a higher environmental quality level $k_i > k_i^{\lambda}$ because, from point k_i^{λ} forward, additional revenues are lower than additional costs. The one-to-one correspondence between environmental quality at the cultivation and milling stages does not permit prices to increase if the mill stays locked into a specific environmental quality level[75].

What will occur if the corresponding environmental quality for farmers is higher than the one that maximises their profits? In this case, farmers will not choose this corresponding level of quality. They will select the environment quality level that maximises profits; they do not need to move forward if they have reached the profit maximisation point. Additionally, what will occur if the threshold level is not reached? In this case, for any specific environmental quality chosen by the mill, farmers will

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[75] Recall our assumption that prices will be determined by the lower value of the correspondent environmental quality level.

move to the point of departure, the lowest environmental quality *0*; there is no incentive to improve environmental quality.

To summarize, according to the previous analysis, for any of the mill decisions related to environmental quality at the milling stage, farmers will chose the corresponding environmental quality at the cultivation stage only if the threshold level of farmers is high enough for farmer profits to be non-negative, and corresponding environmental quality is lower than or equal to the one that maximises profits.

The mill's decision

We will now analyse the mill's decision, once the operator knows the possible results in the agricultural stage as a reaction to the mill's election of environmental quality technology. The mill operator knows that if the threshold number of farmers needed for their profits to be non-negative is not reached, they will not choose the corresponding environmental quality level; in this case, the best strategy for the mill is to stay locked into the point of departure (environmental quality *0*). This is explained by the one-to-one correspondence between environmental quality at the cultivation and milling stages; prices will not go up if both types of agents do not increase their environmental quality, and additional costs related to improving quality will not be compensated. The former outcome is considered to be a stable equilibrium, because, once farmers and processor are at the lowest environmental quality level, none will act to change strategy. We can call this outcome the conventional Nash equilibrium.

We will now analyse the case where the threshold number of farmers is reached. The mill operator knows that if this occurs farmers will choose the corresponding environmental quality level at the cultivation stage if that level is lower than or equal to the level that maximises their profits. In this case, for any given number of farmers we have multiple Nash equilibria: {(the mill chooses a specific environmental quality, l^{λ}); (farmers choose the corresponding environmental quality level, k_i^{λ})}. However, from those possible equilibrium points, only one is stable. If neither farmers nor the mill have reached the environmental quality that maximises profits, both will be willing to move to a higher quality until one of them reaches the level of profit maximisation.

On the other hand, the mill operator also knows that if the corresponding environmental quality at the cultivation stage is higher than the one that maximises profits for farmers, farmers will choose the level that maximises profits. Therefore, given the one-to-one correspondence between environmental quality at the cultivation and milling segments, and considering that the profit-maximizing quality level at the milling stage does not necessarily correspond to the level that maximises profits at the cultivation stage, the equilibrium will be comprised of one of the following options; (we will let λ identify the correspondence between environmental quality in the cultivation and processing stages, and * to identify the environmental quality that maximises profits:

- {(mill elects the environmental quality that maximises mill profits, $l^{\lambda *}$); (farmers choose corresponding quality, $k_i^{\lambda} \leq k_i^{*}$)}

or,

- {(mill chooses the corresponding environmental quality that maximises farmer profits, $l^{\lambda} \leq l^{*}$); (farmers choose the environmental quality that maximises their profits, $k_i^{\lambda *}$)}.

We can call this outcome the sustainable Nash equilibrium and we will have one of these equilibrium points for any number of farmers, once the threshold level is reached. Therefore, when the threshold number of farmers is reached, we will have multiple Nash equilibria: one per each number of farmers N_k that use a specific environmental quality k.

Both sets of strategies that we have called conventional and sustainable outcomes constitute Nash equilibria[76] for the whole game. This occurs because when players are located at one of these points no one will change strategy; a change by one player in this situation, while the others remain unchanged, does not add any additional benefits for the player who moves. The principal aspect that determines if the final outcome is conventional or sustainable is the real expectation about the number of farmers that decide to choose a specific technology level.

In conclusion, the consideration of vertical coordination options related to improving environmental quality in the cultivation and milling stages in the Costa Rican coffee chain permits identification of multiple equilibrium solutions. The first equilibrium is the case where all agents (farmers and the mill) stay locked at the minimum environmental quality technology. This is the point of departure; and environmental quality does not allow access to premium prices. We have called this result the conventional equilibrium. However, we may find multiple sustainable equilibrium points, and these are the cases where quality standards and the number of producers willing to make the technological change are high enough for the market to reward these efforts through higher prices. We call these results sustainable equilibria. How clean would these equilibria be? This will depend on the level and rhythm of changes in yields, costs and prices as a result of movements toward higher environmental quality in the cultivation and the milling stages, as well as the number of farmers that move to a specific sustainable technology.

The use of game theory to analyse the vertical coordination relationships between agents located in different segments of an agri-food chain allows us to see cooperative solutions in favour of a sustainable equilibrium. In the path from conventional to sustainable equilibrium, processor support is fundamental; the mill must be committed to the technological change, implying strict environmental regulations at the agricultural stage. If the mill operator, who is in charge of commercialization of green coffee, does not commit to the change, its product will be sold as conventional even if cultivators switch technology. On the other hand, cultivators cannot free ride; they will not access price premiums if they have not also made the technological change. Also, the existence of a minimum number of farmers who are willing to shift is determinant.

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[76] In a Nash equilibrium, each player's strategy choice is the best response to rival player strategies (Mas-Colell et al, 1995: 246).

6.5 A numerical example

In this section we develop a hypothetical numerical example in order to clarify the arguments of the chapter. Let us assume the following behavioural functional forms for the mill:

$$P_m = 112{,}5 l^{0{,}25} N_k^{0{,}05} \tag{17}$$

$$\frac{Cm}{Q} = 10 l^{0{,}5} \tag{18}$$

Where:

P_m: Export price obtained by the mill
C_m: total processing costs
l: environmental quality at the milling stage
Q: quantity of green coffee produced (processed) by the mill
N_k: Number of farmers who choose a specific environmental quality k at the cultivation stage, assuming an average farm.

We can also make the following assumptions for the cultivation stage:

$$P_f = 0{,}8 P_m = 90 l^{0{,}25} N_k^{0{,}05} \tag{19}$$

$$C_i = 900 k_i^{0{,}5} \tag{20}$$

$$q_i = 25 \tag{21}$$

Where:

P_f: Farmer price (as a proportion of the export price, as explained in the text)
C_i: Total costs per hectare for a representative farmer
q_i: Yields per hectare for a representative farmer (q_i=25 indicates fixed production per hectare for all farmers regardless of environmental quality).
k_i: Environmental quality at the cultivation stage for farmer i.

Assuming a one-to-one correspondence between k and l, as explained in the text, we can transform the farmer price function as follows:

$$P_f = 90 k^{0{,}25} N_k^{0{,}05} \tag{19'}$$

Table 6.5 presents the profit maximising results for all variables at different levels of N_k. The results assume the one-to-one correspondence between environmental qualities at the milling and cultivation stages.

Table 6.5: Hypothetical example. Profit maximising results for relevant variables

	N_K=1	N_K=100	N_K=200	N_K=300
k^*	2.40	6.10	7.00	7.60
P_f	112.02	178.06	190.80	198.75
π_i	1,406.22	2,228.75	2,388.72	2,487.56
l^*	1.60	4.00	4.60	5.00
P_m	126.53	200.29	214.73	223.74
Π_m	316.41	50,146.90	107,492.32	167,910.66

Where:

k^*	Grower environmental quality that maximises profits for farmers
P_f	Farmer price
π_i	Farmer *i*' profits
l^*	Mill environmental quality that maximises profits for the mill
P_m	Mill price
Π_m	Mill profits
N_K	Number of farmers who use a specific environmental quality *k*.

We can see from this example that, at the cultivation stage, the levels of *k* that maximise profits are higher as N_k increases; prices and revenues also increase as N_k increases. At the milling stage, the situation is the same: as N_k increases, the level of environmental quality that maximises profits also increases, with a different profit maximisation point at each level of N_k.

Focusing on the cultivation stage, we can consider the relationships among farmers as a simultaneous horizontal game. In this case, we have a Nash equilibrium for each level of N_k that corresponds with the following set of strategies: "all farmers use environmental quality level that maximises profits". As mentioned before, it is assumed that improvements in environmental quality at the cultivation stage will be met with similar actions at the milling segment, and these efforts will be rewarded in the form of increased prices.

The farmers' decision in a vertical game

We can analyse the strategic interactions between cultivators and mill as a two-stage vertical game. The solution to this type of game (backwards induction) first requires the identification of the best strategy for farmers (environmental quality *k* at the cultivation stage) for all possible strategies chosen by the mill (environmental quality *l* at the milling stage).

We will analyse the case where N_k=100. The mill chooses environmental quality level $l^*_{100} = 4.0$ (the symbol * represents the profit maximising result). On the farmer side, when N_k=100, farmers would choose level $k^*_{100} = 6.10$, which is the environmental quality level that maximises their profits. However, for farmers to obtain the expected profits, the mill must have chosen the corresponding environmental quality

$l_{100} = 6.10 > l^*_{100} = 4.0$. As that is not the case, farmers must adapt their expectations to the environmental quality level chosen by the mill, which is $l^*_{100} = 4.0$.

But what is the best strategy for farmers when the mill chooses $l^*_{100} = 4.0$? From our simulation, starting from the lowest environmental quality level, farmers will increase environmental quality at least until reaching the level that corresponds to mill level, or $k_{100} = 4.0$. This would be the case where corresponding environmental quality is lower than the environmental quality that maximises profits, as shown by our example. Once farmers are at environmental quality $k_{100} = 4{,}0$, the results also show that farmers will obtain lower benefits if they continue to increase the environmental quality at the cultivation stage while the mill remains locked at quality level $l^*_{100} = 4.0$. In our simulation example, when $l^*_{100} = 4.0$ and $k_{100} = 4.0$, farmer *i*'s benefits are $\pi_i = 2205$; however, when $l^*_{100} = 4.0$ and $k_{100} = 4.1 (> k_{100} = 4.0)$ for example, benefits are reduced to $\pi_i = 2183$. This reduction is explained by the assumption of the one-to-one correspondence between environmental qualities in both segments of the chain: prices will not increase if environmental quality increases in only one of the two segments. Therefore, when the mill chooses environmental quality $l^*_{100} = 4.0$, farmers will chose the corresponding environmental quality at the cultivation stage: $k_{100} = 4.0$.

The same analysis can be performed for any level of N_k. As a result, we can assume that, for any environmental quality level chosen at the milling stage (l^λ), farmers will choose the corresponding environmental quality at the cultivation stage (k^λ), when the corresponding environmental quality is lower than or equal to the level that maximises profits for farmers.

The mill's decision and the existence of sub-game perfect Nash equilibria

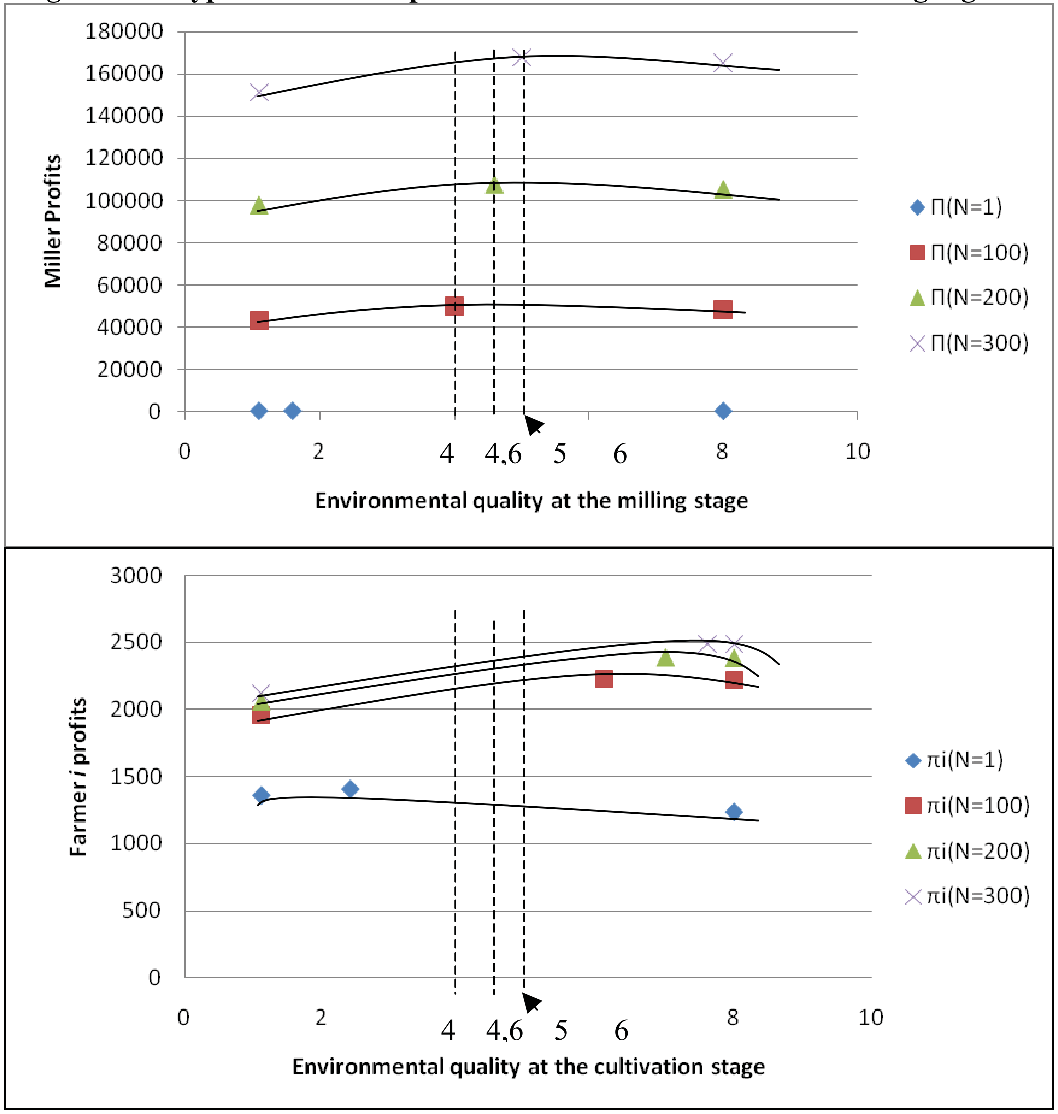
Moving backwards, the mill operator knows that farmers will choose the corresponding environmental quality at the cultivation stage (k^λ) for all strategies chosen at the milling segment, when this quality level is lower than the environmental quality that maximises farmer profit. In this case, the operator will choose the environmental quality that maximises the mill's profits ($l^{\lambda *}$) and this level will depend on the number of farmers that choose a specific environmental technology. Then, in our example, when $N_k = 100$, $l^*_{100} = 4.0$; when $N_k = 200$, $l^*_{200} = 4.6$; when $N_k = 300$, $l^*_{300} = 5.0$. Combining these results with the strategies chosen by the farmers, we obtain the following (sustainable) sub-game perfect Nash equilibria for the whole game:

- ($l^*_{100} = 4.0$; all farmers choosing $k_{100} = 4.0$) when $N_k = 100$.
- ($l^*_{200} = 4.6$; all farmers choosing $k_{200} = 4.6$) when $N_k = 200$.
- ($l^*_{300} = 5.0$; all farmers choosing $k_{300} = 5.0$) when $N_k = 300$.

Here we have a Nash equilibrium solution for each number of farmers that uses a specific environmental quality technology. Also, as N_k increases, the environmental quality equilibrium level increases both at the cultivation and milling segments.

These results are shown in Figure 6.6. The upper half of the figure shows the profit functions and the profit maximising points for the mill at different number of farmers that choose a specific environmental quality technology. The lower half does the same for a representative farmer. The dotted vertical lines in the upper half of the figure show the environmental quality levels that maximise profits for the mill at different numbers of farmers. At the cultivation stage (lower half of the figure), these lines show the corresponding environmental quality levels. It can be easily seen that the corresponding environmental quality levels at the cultivation stage are lower than the ones that maximise profits at that stage. The sets of corresponding quality levels at the milling and cultivation stages, where the mill maximises profits, represent the sub-game perfect Nash equilibria solutions of the whole game, one per each number of farmers N_k.

Figure 6.6: Hypothetical example. Profits at the cultivation and milling segments



To close this analysis, two additional aspects must be addressed. First, our example shows that increasing environmental quality at the cultivation stage (assuming that the mill chooses the corresponding environmental quality) will yield positive benefits even for the minimum number of farmers N_k=1. This may not be always the case, as explained in the text. In many cases, moving to a higher environmental quality technology requires a threshold number of farmers to reach positive benefits. When the threshold number of farmers is not reached, the equilibrium point will be the point of departure, or conventional technology. This is not shown in our current example. Second, if the corresponding farmer environmental quality level is higher than the environmental quality that maximises their profits, farmers will not choose the corresponding environmental quality level; they will choose the profit maximising quality level. This is also not reflected in our example.

6.6 Conclusions

The Global Commodity Chain approach (GCC) and the game theory framework are used in this chapter to evaluate the potential benefits of strategic behaviour in favour of the environment on the part of producer and first-processor, operating in a relationship of vertical coordination. The strategic variable is environmental quality, which can be used to differentiate products in the international export markets. We apply these constructs to the Costa Rican Coffee chain, which is considered to be complex, taking into consideration the degree of product transformation, the distance between the agricultural producer and consumer, technological options and markets involved. In the case of the Costa Rican coffee chain, we conclude that, by improving environmental quality in productive process at both cultivation and milling stages, the relevant agents may improve their incomes. However, this improvement will not be viable if individual firms act alone. Strategic coordination (cooperation) is needed to facilitate improvement of environmental quality, through which economies of scale and positive externalities will arise.

In general terms, keeping in mind the vertical relationships between farmers and mills, the exercise and analysis in this chapter permit us to envision a scenario where farmers and mills cooperate in favour of the environment. Unlike the snow peas case (simple chain) presented in Chapter 5 of this thesis, in the Costa Rican coffee chain we obtain multiple Nash equilibrium solutions. For the sustainable solutions to be possible the mill must support farmers and be willing to adopt technological change. Additionally, a minimum number of farmers must be willing to make the shift, and this reinforces the importance of horizontal coordination at the cultivation stage.

The empirical case study performed in the West Central Coffee Region in Costa Rica showed that the Starbucks C.A.F.E. PRACTICES technology was the most profitable option, and the main reason for the success of this program is the related requirement of good agricultural practices in cultivation. However, a difficult transition period of lower yields and possible losses does accompany entry into this programme. Support from the mill as well as the participation of a threshold number of farmers in this challenge have been key elements in success of this programme.

Now, we must answer a crucial question: how can we move from the conventional to the sustainable equilibrium? The path implies the promotion of diverse types of agreements among different agents along the agri-food chain; agreements that seek, among other objectives, compliance with environmental quality standards in the cultivation, post-harvest and milling stages. These efforts must be complemented with institutional intervention such as agricultural extension and quality regulations, both for process and final product.

7

Discussion, conclusions and recommendations

7.1 Recalling the research problem and the need for an innovative methodology

> "*Agriculture is one of the main contributors to the deterioration of the world's environment: it contributes to climate change, soil deterioration, water depletion and the loss of biodiversity, and may in fact endanger future food production in developing countries. It is a major challenge to make agricultural production sustainable, given the growth in food demand in developing countries. Changes in agricultural management and the pricing of externalities may contribute significantly to the sustainability challenge. In this context, food supply chains face the challenge of reducing costs and prices while meeting consumer demand for variety, quality and convenience. [...] The reorganization of the supply chain will be made possible by improvements in information technology and supply chain coordination*" (Bunte, *et al,* 2007: 2)[77].

The importance of sustainable agricultural production is hardly a questionable matter. However, trying to achieve it through pricing of externalities as suggested in the statement above may be ineffective. In traditional environmental economics theory, externalities pricing implies the consideration of higher production costs, resulting in higher prices for consumers (Perman, *et al*, 2003, among others). However, in a global chain perspective the efficient transmission of price from consumers to cultivators is not guaranteed, even when final consumers may be willing to pay price premiums for a sustainable product. This is because cultivators are located far from consumers and lead firms closer to consumers frequently exert market power. Therefore, sustainable agricultural production cannot be achieved without explicitly considering the existence of global chain governance forces.

On the other hand, moving to more sustainable technologies generates increasing costs that small producers in isolation may not be able to afford (Wilson and Tisdell, 2001; for the coffee case, see Calo and Wise, 2005: 1; CIMS, 2004: 10; Muradian and Pelupessy, 2005: 2039). These increased costs are especially relevant in the first stages of technological change and may be reduced only after producers complete the initial

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[77] Second Conference on *The Food Economy: Global Issues and Challenges* held in The Netherlands on 18-19 October 2007. Conference organized by Netherlands Ministry of Agriculture, Nature Management and Food Quality in collaboration with the Agricultural Economics Research Institute (LEI), Wageningen University, and the OECD. The aim of the conference was to identify the challenges that the changing global food economy presents for industry, society and governments. The conference was structured so as to identify major changes that are underway in the food economy and to explore the emerging issues and paradoxes that are often linked to changing lifestyles and societal expectations (http://www.foodeconomy2007.org/NR/rdonlyres/6C1DDC4F-0FCF-4CCE-BD36-C5176CF6263A/53015/Conferencesummary.pdf). See Bunte, *et al* (2007).

learning process. This increase in costs arises mainly from higher prices for sustainable inputs as well as productivity reductions sometimes associated with sustainable technologies. In this context, *the challenge of reducing costs and prices while meeting consumer demand for variety, quality and convenience*, as suggested in the Conference, is almost impossible to achieve in the short term for conventional markets.

The Conference also considers the reorganization of the supply chain as an important factor in the conversion to sustainable agricultural production. However, explicit consideration must be made of the existence of chains of different complexities, when accounting for the distinct degrees of product transformation (Chapter 2). Additionally, chain complexity is closely related to technology options. In this thesis, we define *technology* as the relationship between markets and environmental quality in production and transformation processes (Chapter 3). According to this definition, technology is a mechanism related to market access that influences the relationships among market actors. As the complexity of the chain increases, so does the number of transformation processes and market options involved.

The presence of a governance force also has implications for the existence of imperfect markets along the global chain. Leading firms are located closer to consumers, where markets are more profitable and the chain control is exerted through the creation of entry barriers based on access to capital, technology and information. Downstream toward consumers, the leading firm or firms posses information and other conditions required to supply consumers with a customized product. Upstream in the chain, to assure a specific product quality for consumers, including environmental quality, the leading firm must guarantee adequate raw material supply channels, and it must decide which coordination channel is more effective. When deciding the coordination mechanisms, the leading firm has options ranging from open spot-market transactions to full vertical integration, with strategic alliances and contracts lying between these two extremes (Hobbs, 1996: 19-20; Hobbs and Young, 2000; Van der Meer, 2006: 11). Therefore, the development of adequate coordination mechanisms by the leading firm or firms will lead to the creation of market imperfections, meaning that the analysis of market dynamics must consider other forms of market organization, rather than relying on assumptions of perfect competition (FAO, 2007: 5).

Improving supply chain coordination is also one of the recommendations from the Conference cited earlier, to encourage sustainable agricultural production. Chain coordination should focus on achieving required quality at the consumer stage and permitting grower access to the higher prices of more environmentally sound products; thus, coordination should be aligned with the objective of improving environmental quality. This issue is especially relevant when small-scale cultivators participate in the first stages of the chain and have very limited options for movement into the more sophisticated segments of the chain (Díaz, 2003).

In summary, we must explicitly consider the role of global chain governance and its implications regarding the existence of market imperfections. Both considerations suggest that coordination mechanisms go beyond the parameters of perfect competition models. Efforts to make agriculture sustainable should also take into account the existence of chains of different complexities and their relationships to available technologies.

Additionally, one must also consider that in a market system all agents at every stage of the chain make their own decisions driven by self-interest. Agents in the chain will choose options that generate the highest revenues for themselves; this decision making process includes decisions regarding switching technology. Moreover, in an imperfect market scenario, where agents possess different market power, the final payoff for an individual agent will depend not only on that agent's decisions but on the decisions of others as well; this is especially the case with decisions related to environmental quality. So we have a scenario of mutual payoff dependence where individuals make decisions strategically with no guarantee that an individual producer in isolation moving to a higher environmental quality technology will obtain higher incomes. Therefore, chain coordination must be in line with cooperation for improvement of environmental quality, and switching technology becomes a strategic decision.

In this context, the research problem of this thesis is 'how can local producers cooperate in the application of environmentally friendly technologies to improve their competitive position in global agri-food chains?' The focus is on the benefits of cooperation to implement environmentally friendly techniques and, as a result, improve small producer income in global agri-food chains, considering market imperfections and chains of different complexities.

To study strategic decisions in a world of market imperfections and mutual payoff dependence, we complement Global Commodity Chains (GCC) with theories of industrial organization and strategic behaviour. We use non-cooperative game theory to capture interactions among firms' decisions and the need for alignment and coordination of actions. As mentioned in Chapter 3 of this thesis, the literature offers some examples of cooperative and non-cooperative game theory applied to supply chain management (Nagarajan and Sosic (2006), Meca and Timmer (2008), Purwaningrum, *et al* (2010), Radhakrishnan and Srinidhi (2005) and Faße, *et al*, (2009), for example). However, none of those studies apply non-cooperative game theory to behaviour in global agri-food chains, considering environmental quality as the strategic variable. Our emphasis falls on the relationship among farmers and between farmers and first-processors.

Additionally, a characterization of chain complexity applied to agri-food chains and their relationships and implications for technology options is required. This concept of chain complexity is different from the use given to the term when applied to manufacturing chains, as in the case of Bleker, *et al* (2005) or Sairamesh (2004) who relate complexity to the diversity of products or players associated with the value chain.

In the next section, we present a general discussion of the main findings of the thesis for each of the following lines of reasoning:

- A typology of agri-food chains of different complexities.
- The conceptualization of technology based on the relationship between environmental quality and markets.
- The study of unequal power structures in a sequence of imperfect markets along the chain.
- The implications of chain complexity for product differentiation.
- The need for the development of vertical and horizontal coordination mechanisms among agents in the chain to improve environmental quality in production processes.

7.2 Main findings

Agri-food chains of different complexities; developing a typology

In Chapter 2 we addressed the complexity of agri-food chains, defined according to the degree of product transformation. This conceptualization differs from the use given to the term when applied to manufacturing chains. For example, Bleker, *et al*, (2005: 48) state "complexity can be interpreted as the variety in objects, structures and processes. [. ..] Such as a manufacturer, producing a huge number of diverse product variants can be characterized more complex than one producing a uniform product in a lower quantity". Sairamesh, (2004) considers complexity in association with production processes, in the case of what he calls large and segmented value chains, such as Automotive, Electronics, Petroleum, Aerospace and Heavy Equipment Engineering, where "specialized" vendors evolve for services, parts, repair and maintenance. Our conceptualization of this term is different. By defining complexity according to the degree of transformation of the product in agri-food chains, we associate the term with the qualitative distance between cultivator and final consumer. The definition is more appropriate for agri-food products because it permits study of the links between farmer and consumer, and it identifies the constraints and opportunities that the global chain offers to small scale producers located at the beginning of the chain.

Two chains of different complexities form the empirical foundation of this thesis: the Guatemalan snow peas and the Costa Rican coffee chains. At one extreme, the Guatemalan snow peas chain is a very good example of a relatively simple and short chain. The final characteristics of the snow peas, ready for consumption, are very close to raw material form. This means that very little productive transformation of the product occurs along the chain; "processing" includes mainly selection, packing and conservation activities. The coffee chain, on the other hand, is a good example of a long and complex chain. From coffee berries at the farm to the brew in the cup, the chain includes several segments of far- reaching changes and implies significant transformation of the product. The distance between farmer and final consumer is large and includes a sequence of markets. Intermediate examples can be seen in the cashew nut and sesame seed chains, as presented in Chapter 2.

The complexity of the chain is closely related to the technology chosen. The more transformed the product is, the longer the chain becomes and the more possibilities exist for complex transformation processes and numerous participating agents. For this reason, complex chains more readily allow for the application of environmental technology innovations. In the case of short and simple chains, the only way to shift technology in favour of the environment is through radical moves; however, in long and complex chains with continuous technologies, incremental or marginal moves should be the norm. If we assess the possibilities for small-scale producers to introduce environmentally friendly technologies in global agri-food chains, we see that this is more likely to occur in complex chains with continuous technologies, where technology shifts can occur along an incremental –not radical- path.

Chains of different complexities also involve diverse processes of value creation and distribution and offer possibilities for product differentiation and development coordination mechanisms. We will address these issues in the following pages.

The conceptualization of technology: environmental quality and markets

Making agriculture sustainable does not only concern the supply side; it should also consider market requirements (demand) in relation to environmental quality. Environmental quality is determined by the *technology package*, which is defined as the quality and quantity of material inputs required to obtain a specific product. In this thesis, we have defined *technology* as relationship between environmental quality and available markets. As previously stated, it represents the relationship between market access and production processes, where coordination mechanisms must be developed in order to obtain the environmental quality at the production stage required to gain access to specific markets (demand). Therefore, *technology package* is only one component of the definition of *technology*.

We assume a positive relationship between price and environmental quality and demonstrate this relationship in the case studies. Lead firms influence the technology pack that farmers and first processors will choose by defining minimum quality standards necessary to guarantee market access. When producers choose a technology, they are choosing a particular environmental quality and, at the same time, a specific market in which to sell their product. In this way, the demand side influences environmental quality in production and transformation processes along the chain by influencing the choice of technology. Nevertheless, we must consider technology an endogenous variable for cultivators and first processors. This is because these agents make their final technology decision based on the potential income that this represents. Technology change decisions should be coordinated with lead firms, even when benefits of the innovation may not be equally distributed. Large companies and small and medium enterprises should be considered partners in this process, and not competitors.

In the case studies, the move to a more environmental higher quality technology appears to be easier in the complex chain (coffee), where technology shifts can be marginal and continuous (see Chapter 6 of this thesis). In the simple (snow peas) case, access to the higher environmental quality market –the move from the United States to the European Union market- can be assured only after a radical environmental quality jump (see Chapter 4 of this thesis). Additionally, in the complex case, options for innovations coming from the producer side are more frequent than in the simple case; this may offset the chain control force on the demand side.

Unequal chain power structure, imperfect markets and cooperation for the environment

As mentioned before, market power concentration is explained by the existence of a governance power exerted by lead firms located closer to consumers (downstream), where activities tend to be more profitable. In the coffee chain, the lead firms are located at the roasting/retailing stages, while in the snow peas chain they are located at the broker or retail stages. When considering the market knowledge and capital-intensity required at later stages, we can conclude that actors involved at the initial stages of the chains have no access to these more sophisticated segments.

The consideration of imperfect and non-competitive markets offers several implications for the study of chain dynamics. In our case, the implications relate to the ease or difficulty with which cooperation mechanisms arise in favour of environmental quality.

From Chapter 4, we know that market structure affects the level of willingness to cooperate in favour of the environment. However, we found no differences between complex and simple chains, apart from the number of markets available. In the cases studied, willingness to cooperate in favour of the environment is lower when coordination mechanisms approach a spot market structure. Where non-price variables such as trust, quality commitments, technical support and historical relationships are important, cooperation in favour of the environment will more likely take place. Market mechanisms alone do not support technological change in favour of the environment. This implies that leaving the role of pricing externalities and solving environmental problems to spot markets has not been efficient.

The result obtained coincides with arguments in favour of the development of non-price coordination mechanisms, as presented by Ayala (2003), Gereffi, *et al* (2005), Gibbon (2001), Muradian and Pelupessy (2005), Pelupessy (2003 and 2007), Poulton, *et al* (2004), among others. The conclusion is also in line with most of the case studies presented in FAO (2007), which emphasises cases of farmers producing under contract systems –and not under perfect competition- making explicit the need to change the theoretical approach to study coordination relationships in agricultural markets.

Chain complexity and the potential for product differentiation

To appreciate the implications of chain complexity for the possibilities of product differentiation, we must explicitly consider both intrinsic and extrinsic product characteristics (Jongen, 2000). Long and complex chains may present several complex transformation processes, as illustrated in the coffee case; this allows for control of the intrinsic characteristics of the final product (flavour, odour, and texture, for example) through mixing of products of different origins or by managing the transformation processes. If this is the case, raw materials with special intrinsic characteristics can be differentiated from generic products and may obtain better prices. In later stages of the chain, agents may differentiate the product, based on its particular qualities.

The differentiation process described above cannot be accomplished in short and simple chains, where transformation of the product is negligible; in most cases even the packing process ends at the place of origin. In these cases, quality improvement or product transformation will not likely occur at later stages of the chain, so the entire supply will be considered *generic* product. The challenge in these cases is to preserve original quality. We illustrate this with the Guatemalan snow peas chain studied in detail in this research. Snow peas suppliers around the world offer little difference in product quality, so availability becomes one of the most important variables in the purchasing decision[78] (Benjert, 2008; personal fieldwork interview).

When considering extrinsic characteristics of the final product, we should note that improving environmental quality in any stage of the chain will contribute to the general quality of the product and thereby facilitate product differentiation. In this regard, complex chains with more transformation possibilities will present a greater number of options for quality differentiation. On the other hand, in the case of simple chains with

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[78] Other important variables are trust in the provider and transportation costs, when the general level of supply is adequate (Benjert, 2008; personal fieldwork interview).

limited options, as in the Guatemalan snow peas case, once the product appears in a market, agents have no options for product differentiation within the same market.

This conclusion is slightly different than the findings of the Food Economy Congress on the same issue. The Congress distinguished between customers and consumers and emphasized the level in the supply chain under analysis: "*Food components will be produced on a mass scale. Moreover, retail demand for private brands will remain important in the decades to come. This implies a demand for scale, low costs and uniformity*" (Bunte, *et al*, 2007: 4). Firstly, this position seems to consider only demand based on intrinsic characteristics of the product; secondly, the demand for scale, low cost and uniformity in products dominates only in simple and short chains. In chains of higher complexity, the demand for more differentiated products appears to prevail.

The need for vertical and horizontal coordination

In the same way that possibilities for product differentiation are not the same for the different chain categories in our typology, potential for coordination also differs with chain complexity. Generally speaking, in simple and short chains, where transformation of the product is negligible, we observe a reduced number of stages, including those where transformation processes take place. As a result, agents have fewer opportunities for coordination. In these chains, horizontal coordination is more important; it can, for example, guarantee a specific quality at the beginning of the chain that may then continue into later stages. To access desired markets, vertical coordination may be needed to guarantee the commercialization channel of a specific technology and its corresponding environmental quality further along the chain. Between farmer and first-processor, vertical coordination has great potential to develop quality control mechanisms at the cultivation stage that will guarantee access to more environmentally demanding markets. We also found in this thesis that market mechanisms on their own do not guarantee the type of horizontal coordination needed to facilitate the minimum environmental quality requirements of the more demanding markets. However, vertical coordination in the global chain might guarantee the jump from conventional to sustainable outcomes.

For long and complex chains with more technology options, vertical coordination plays an important role, not only for commercialization purposes but also to guarantee the environmental quality needed to access a higher number of markets. Farmers and processors at different stages of the chain will have more options to develop coordination mechanisms and generate vertically differentiated products. In a longer chain, there are more transformation processes and more market options.

In this thesis we study vertical and horizontal coordination mechanisms in chains of varying complexities with different technology options (Chapter 5 and 6). The study has shown that possibilities for small-scale producers to improve their incomes by shifting to environmentally friendly technologies are largely subject to the development of horizontal and vertical coordination mechanisms to support the shift.

Acting together in pursuit of a shared level of quality through horizontal coordination gives the actors enough credibility to proceed, in expectation of cooperation from others. This thesis demonstrates that access to markets for sustainable produce requires a threshold number of producers willing to switch technology, to obtain a minimum scale of production. Horizontal coordination facilitates this minimum scale and at the same time strengthens the positive image of the group. Complementary, vertical coordination may guarantee the quality required to satisfy the buyers' needs and enable the development of price differentiation mechanisms needed to access special markets.

For the development of vertical coordination in the local stages of the chain, first-processors in the developing country must play the leading role, in coordination with the lead downstream firm in the developed country. In the coffee chain, farmers rely on support from the international buyer and the mill to face the initial transition costs of moving from conventional to a more sustainable technology. The development of vertical coordination relationships among international buyers, the mill and the farmers, as well as the participation of a threshold number of farmers in the technology shift, are the main reasons for success in this case. After applying good agricultural practices for some time, farmers recognize the importance of the conservation of their natural resources.

In the snow peas case, the processing firm also promotes and supports the development of vertical coordination at the local stages of the chain as it supplies the sustainable market. In this commercialization channel, as explained in Chapter 2, buyers located forward in the chain also promote coordination with agents located backward in the chain. Their business is based on trust, long term relationships and mutual commitments, sometimes without the necessity of formal agreements (Benjert, 2008; personal fieldwork interview).

From the Costa Rican coffee and the Guatemalan snow peas cases, we see that coordination in a global commodity chain is related to its governance, although it also affects distribution of profits among segments of the chain (Díaz, 2003: 54). Leading firms promote coordination oriented toward vertical differentiation because this will assure the volume and quality of product needed to supply restricted markets or access higher prices[79]. However, as we show in this thesis, market imperfections often prevent appropriate price transmission from consumers to growers. According to the examples presented in Chapter 2 for the Guatemalan snow peas case for the year 2005 and the Costa Rican coffee case for the year 2004, farmers receive higher mark up in the more sustainable channel, with mark up defined as a proportion of the price difference in each stage of the chain as a percentage of the consumer price. These are nevertheless very specific cases from which we may not derive general conclusions.

In spite of the potential benefits of technology change, we should mention the possible implications for small producers and the sustainability of this change if the environmental innovation is generalized. First, in the long term markets niches will likely disappear, as will price premiums for environmentally sound products. If that is the case, environmentally friendly products will eventually be sold at conventional prices. This situation is a minor problem if it is a consequence of the generalization of environmental innovation from the producer side, meaning that small producers will have enough time to adjust to the new technologies. However, if market niches

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[79] The case of Starbucks Coffee Company is especially illustrative. This company may promote sustainable production in essence to avoid risk to its source of raw material in developing countries. This is because current trends in coffee production are not environmentally sustainable. Regardless of motives, the support from this company in the promotion of sustainable technologies at cultivation and first processing stages has been of great importance.

disappear as a consequence of strict regulation from the demand side, small producers may suffer the consequences of not having enough time to adjust, and some may disappear. In these cases, small producers may assume the leading role in adjusting to market trends and initiate technology change in coordination with leading firms located downstream in the chain.

Switching technology in coordination with the leading firms in the chain has another consequence for local, developing country firms; they must accept their current position in the chain as raw materials providers. Trying to move forward in the chain may lead to unsuccessful attempts to compete with leading firms for the same markets. These local agents should maintain chain position and try to obtain the best possible prices for their product.

Another consequence of the generalization of technology change in the medium or long term is the possibility that benefits of environmental innovation will be unevenly distributed in favour of leading firms. The innovations that will likely succeed are those that have the support of the leading firms, in an example of enlightened self-interest; benefits for firms located upstream in the chain are not in equal proportions. Horizontal coordination at the primary producer end may provide a good opportunity to increase market power, but it is difficult to achieve; we have modelled horizontal games at the farmer stage of the chain as a prisoner's dilemma game where the result is a Nash equilibrium where all producers stay locked into the conventional technology.

Summarizing the main findings: returning to the objectives of the research

In this subsection, we summarize the main findings of the thesis by referring to the specific objectives of the research.

> *First objective: to study the opportunities and restrictions for environmentally friendly technologies as a source of competitiveness for small holders in global agri-food chains.*

Environmentally friendly technologies are economically feasible for smallholders in agri-food chains under certain conditions. Markets for environmentally sound products exist, but innovation must be directed toward the move from traditional to sustainable technologies. Technology innovation must include the development of mechanisms to access new markets where price premiums are available for environmentally sound products. The complexity of the chain is important. Depending on the complexity of the chain and the technology options available -continuous or discrete- innovation may be radical or marginal. We can expect that shifts are more feasible in those cases where technology is continuous and available options numerous; in this case, shifts can be achieved step by step and not radically. However, in all cases coordination mechanisms must be developed, especially those oriented toward vertical differentiation[80]. The chain leader and any agent who controls the dynamics of a particular segment must take on special roles. At the horizontal level, a minimum number of producers must adopt innovation in favour of sustainable technologies in order for these agents to absorb transition costs in the short and medium term.

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[80] In this thesis we focus on the relationship between farmers and first-processors.

> *Second objective: to explain why the degree of market concentration fosters cooperation for improved environmental quality in production processes.*

The degree of market concentration facilitates agent cooperation for higher environmental quality in production processes, but the distribution of the benefits of environmental innovation must be discussed. Market concentration results from the operation of a chain governance force in the more profitable segments of the chain, located close to consumers. Leading firms along the chain promote environmental innovations and these innovations respond to their interests; they create coordination mechanisms in all stages of the chain that are in line with their interests, leading to the generation of market concentration. This explains why cooperation in favour of the environment is reduced in those cases where existing coordination mechanisms are closer in form to sport market transactions. Therefore, market concentration does affect the adoption of sustainable technologies; however, adequate mechanisms of distribution of benefits are not guaranteed.

> *Third objective: to analyze why differentiation of environmental quality may help to increase revenues for local producers in global agri-food chains.*

With a global chain perspective, environmental quality can form the basis for product differentiation through positive influence on the extrinsic characteristics of the product. However, vertical mechanisms for quality differentiation must exist to guarantee access to sustainable markets. In this manner, environmental quality becomes a strategic tool, when we take into account that individual benefits result not only from individual decisions, but also group actions. In this case, the whole group -all agents involved in the application of a technology option– or a threshold number of its members must understand the need to act strategically toward a common purpose; that common purpose is to attain a specific environmental quality standard. Vertical coordination mechanisms in global chains may stimulate the improvement in environmental quality standards required to access markets for sustainable produce, and horizontal mechanisms can guarantee the minimum scale of sustainable production and reduce negative while creating positive externalities. Small scale producers may participate when they fully integrate into a sustainable technology option; however, chain leaders must accompany and motivate these producers. Again, the complexity of the chain is relevant to the availability of technology options.

7.3 Policy recommendations

In order to accomplish the fourth objective of the thesis, in this section we will formulate policy recommendations in support of environmentally friendly technologies as a tool for increasing incomes of developing country small producers in global agri-food chains. We present recommendations at the institutional, sectoral and individual firm levels.

At the institutional and public policies level

Institutions shape the behaviour of firms and other organisations (Edquist and Johnson, 1997)[81]. In general, changes in the institutional framework are considered innovations when they are focused on explicit objectives (Orozco, 2010). In our case, we recommend institutional changes to promote innovation at the industry level. Actions in favour of improved access to information, market research, technical support for farmers, and technology development are especially relevant. Innovation programmes should involve collaboration between research institutes, business and governments, as illustrated in the Australian case presented in the Food Economy Congress (Bunte, *et al*, 2007: 6).

General environmental quality regulations could be strengthened and monitoring strictly enforced. This will help improve environmental quality in production and transformation processes and at the same time facilitate access to niche markets of more environmentally friendly products. Institutional innovation generates positive externalities that support small producers as they face the transition from conventional to higher environmental quality technologies.

Public policy should explicitly consider the possibilities of effective market intervention to guarantee technology shift and control the distribution of value-added in the innovation process. It has been shown in this research that agents are less willing to cooperate in favour of the environment as market organization approaches an open spot market structure. Therefore, liberalization does not seem to be the engine for environmental innovation. In this case, vertical coordination mechanisms should be strongly promoted, and attention given to non-price variables in cooperation, such as mutual trust, technical support, quality commitments and supervision[82].

The role of national and international non-state organisations[83], especially NGO's, is also essential. At the local level, internal conditions should stimulate the establishment of organisations in favour of eco-labelling and social and environmental responsibility. These organisations indirectly influence the direction of the technology change by determining conditions for local agent participation in the chain. Most of these

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[81] Institutions are the sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions among individuals and groups. Organizations are formal structures consciously created with explicit purposes (Edquist and Johnson, 1997; Orozco, 2010).

[82] As an illustration, the Canadian Government introduced a new Agricultural Policy Framework in 2002, as presented in the Food Economy Congress. The framework rests on five pillars: food safety and quality, the environment, small farm assistance, science and innovation, and business risk management. The policies pursued with respect to these five issues involve technical farm assistance, the development of voluntary and mandatory standards, research, education, network formation, income stabilization and insurance programmes (Bunte, *et al*, 2007: 7).

[83] "The term non-state actors (NSA) is used to describe a range of organisations that bring together the principal, existing or emerging, structures of the society outside the government and public administration. NSAs are created voluntarily by citizens, their aim being to promote an issue or an interest, either general or specific. They are independent of the state and can be profit or non-profit-making organisations. The following are examples of NSAs: Non-Governmental Organisations/Community Based Organisations (NGO/CBO) and their representative platforms in different sectors, social partners (trade unions, employers associations), private sector associations and business organisations, associations of churches and confessional movements, universities, cultural associations, media" (Commission of the European Communities, 2002: 5).

organisations are branches of international entities[84]. Additionally, the participation of NGO's directly in the chains by improving environmental quality management practices will create consciousness in local producers regarding good agricultural practices[85]. As a result, access to market niches will be facilitated by the creation of new commercial channels. These private initiatives should be encouraged by governments.

At the sectoral level

Innovations are generated in interactive processes of learning. Normally, individuals cannot innovate in isolation, without interaction with other agents or without reference to existing knowledge (Edquist and Johnson, 1997). In our context, innovation should be developed within a global chain perspective, where horizontal and vertical coordination are especially relevant.

The most important recommendation of this thesis is the promotion of vertical coordination mechanisms between firms to meet the minimum environmental quality standards for access to niche markets, price premiums or increased market opportunities. This coordination process should be promoted with lead agents located close to consumers. Agents should act to create more value-added in the same position of the chain and not necessarily attempt to move forward in the chain. This is because, closer to final consumers, entry barriers are high and attempts to move into those stages may fail. Therefore, cooperatives and producers associations should be promoted to develop mechanisms of vertical and horizontal integration. These organisations also play leading roles at the local stages of the chains while influencing economic policies.

Market research and other technological innovation processes must be implemented to identify and classify consumers according to environmental quality preferences. Also, innovation should promote increased chain complexity through the development of more complex transformation processes. This will allow producers along the chain to participate in incremental innovations and will facilitate technology shift.

At the individual firm level

Our third recommendation is at the firm level; farmers should apply sustainable technologies not only to increase incomes but also to preserve their own natural resources. Producers should not necessarily aim for the organic scenario; consumer preferences may not guarantee sufficient benefits to justify the high costs associated with this option. A higher number of alternative technologies will be available as the complexity of the chains increases.

7.4 Indications for future research

We have left a number of issues unresolved, and these issues may provide insights for further research:

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[84] Examples of these organisations are GlobalGAP and OXFAM.

[85] Examples of these groups are Fairtrade Labelling Organisation International and Max-Havelar.

- The empirical base of this research is limited. Further research may use the typology developed in this thesis to analyse dynamics and strategic behaviour in other chains.
- Researchers should study vertical coordination mechanisms in stages closer to final consumers, as well as governance forces in global chains. The importance of big retailers, supermarket chains and transnational food industries is well known. The possibility of strategic alliances of developing country small producers with these agents may require research on international vertical coordination at all stages of the chain.
- Our research has focused on strategic behaviour of private firms. Complementary studies on institutional framework will help the design of public policy recommendations.
- Innovation studies should be developed to promote the chain complexity and development of more technology options.
- This thesis has explored studies on income distribution. Further research will help clarify the distribution of added value along different stages of the chain.

As a final comment, we hope this research will in some way help make sustainable technology options a reality for our representative snow peas farmer from Patsún, Guatemala. In this way, he could be integrated into a global chain under conditions that give higher incomes to him and environmentally friendlier produce to consumers.

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Annexes

ANNEX 4.1: The influence of price on farmer decisions in the market for coffee berry: an econometric model.

Regression output.

```
Dependent Variable: LOG(Quantity)
Sample: 1991 2003
Included observations: 13
Total panel (balanced) observations: 78
One-step weighting matrix
White Heteroskedasticity-Consistent Standard Errors & Covariance
==========================================================================
     Variable (P: price)      Coefficient  Std. Error  t-Statistic   Prob.
==========================================================================
            C                  9.681648    0.354001    27.34918    0.0000
     FJ--LOG(PFJ(-1))          0.090438    0.037944    2.383487    0.0198
     SD--LOG(PSD(-1))          0.144846    0.037540    3.858494    0.0002
     CU--LOG(PCU(-1))          0.060840    0.035924    1.693579    0.0947
     DO--LOG(PDO(-1))          0.103068    0.037205    2.770254    0.0071
      TA--LOG(PTA(-1))         0.202682    0.036690    5.524103    0.0000
     MS--LOG(PMS(-1))          0.155461    0.054081    2.874586    0.0053
==========================================================================
     Weighted Statistics
==========================================================================
R-squared                      0.994107  Mean dependent var      13.43573
Adjusted R-squared             0.993610  S.D. dependent var      4.335112
S.E. of regression             0.346551  Sum squared resid       8.526940
Log likelihood                -12.40743  F-statistic             1996.359
Durbin-Watson stat             1.811521  Prob(F-statistic)       0.000000
==========================================================================
    Unweighted Statistics
==========================================================================
R-squared                      0.662518  Mean dependent var      10.89184
Adjusted R-squared             0.633998  S.D. dependent var      0.575114
S.E. of regression             0.347933  Sum squared resid       8.595059
Durbin-Watson stat             1.597817
==========================================================================
```

Identification	**Mill name**
FJ	F.J. Orlich
SD	Volcafe San Diego
CU	Coopeunion
DO	Coopedota
TA	Coopetarrazu
MS	La Meseta Los Santos

ANNEX 4.2: The influence of price on farmer decisions in the market for coffee berry: an econometric model.

Explanatory variables correlation matrix

	PFJ	PSD	PCU	PDO	PTA	PMS
PFJ	1,00	-0,25	-0,50	-0,30	-0,85	-0,58
PSD	-0,25	1,00	-0,01	0,44	0,25	0,69
PCU	-0,50	-0,01	1,00	0,55	0,53	-0,10
PDO	-0,30	0,44	0,55	1,00	0,40	-0,03
PTA	-0,85	0,25	0,53	0,40	1,00	0,40
PMS	-0,58	0,69	-0,10	-0,03	0,40	1,00

P: stands for price

Identification	***Mill name***
FJ	F.J. Orlich
SD	Volcafe San Diego
CU	Coopeunion
DO	Coopedota
TA	Coopetarrazu
MS	La Meseta Los Santos

ANNEX 6.1: West Central coffee region in Costa Rica. Socio-productive profile of case studies

In this annex, we characterise the representative agricultural producers and mills for each of the environmental certification programmes considered in the case studies.

A. Conventional Case

The case study for conventional technology is represented by a medium-scale producer (26 hectares) who sells to a private mill and to a cooperative. The private mill has vertically integrated the agricultural and milling stages, but its production volume is not large enough to meet the demand for its gourmet coffee; therefore it has assembled a small group of strategic providers, and our representative farmer is part of this group. As a strategic provider for this mill, this farmer has the opportunity to obtain higher prices for his produce.

Our representative farmer has been growing coffee for more than 40 years. His plantation is high-altitude, situated between 1150 and 1200 meters above sea level. The soil is volcanic and rich in nutrients. Total cultivated area on the property measures 26 hectares, and average productivity in the last two harvests has reached between 30 and 32 *TDH* per hectare. According to the interview, the ecological conditions of the farm allow for production of high-altitude grade coffee (approximately 70% of this farm's production receives this classification) and this differentiation allows the producer to obtain higher prices.

The berry collected by this farmer is sold at two different mills: a very well recognized local cooperative and a private mill; different reasons motivate this representative farmer to choose these mills. For his choice of the cooperative, the main reason is tradition and loyalty, while in the case of the private mill the motivation is economic (higher advance and final prices). The relationship of our farmer with the private mill is favourable considering his status as a strategic provider.

Given these characteristics, the following aspects were considered in the selection of this farmer as representative of the conventional technology case. First, he is a very experienced producer and one of the founders of the cooperative of the region. Second, this grower constantly looks for ways to innovate and increase competitiveness along the chain. Third, and perhaps most importantly, he represents the current reality of many coffee producers who are making efforts to adapt to new mill requirements – including those related to environmental issues - which are generally imposed by external buyers located closer to final consumers. This reality adds some uncertainty to the already uncertain panorama of coffee growing.

At the mill stage, the plant chosen has vertically integrated cultivation and milling activities. In the cultivation stage, the plant has 130 hectares in cultivation, at an altitude of 1200-1500 meters. The average yield is around 25 *TDH* per hectare, important figure considered as a reference in our case study. However, the plant still requires produce from strategic providers to fill its quota for high quality coffee; this is where our representative provider plays his role.

The selection of this mill to represent conventional technology is supported by the following. First, it is one of the few mills that does not yet have any of the various certifications available; however, at the time of the interview, the operators were making efforts to certify the plant according to the ISO 9001 and ISO 14001 guidelines. Second, the plant is very well recognized for the cup-quality of its product. Third, the plant is very modern and represents the situation of the new group of firms that are adjusting and accepting change.

B. Rainforest Alliance case

The Rainforest Alliance (RFA) case study is an example of vertical integration. In the West Central Region, only two mills are RFA certified, and the mill in our study has been certified for the longest, since 1999.

In the agricultural stage, the cultivated area totals approximately 552 hectares, where coffee (at approximately 414 hectares) is combined with sugar cane (approximately 138 hectares, or 25% of cultivated area). The coffee grows at an altitude of approximately 1250 meters, and the soil is rich in nutrients and generally flat, so erosion is not an issue.

According to the principles of the RFA certification, rural development initiatives are of great importance in our case study, and community initiatives are part of the normal activities of the firm.

Our RFA case study agent is also certified with the Starbucks' C.A.F.E PRACTICES programme. According to the interview, the initiatives undertaken to obtain the RFA certification served as the basis of the C.A.F.E PRACTICES certification; these two certifications complement each other, and have helped the firm increase revenues.

The cup quality of the coffee produced at this plant has been internationally recognized. At the end of the 2005, a group of international experts (traders and roasters) from Germany, Russia, Denmark and Japan visited Costa Rica to evaluate various different coffees. In the West Central Region, the coffee provided by our representative mill was considered among the best, due to cup quality (balance and acidity).

C. Starbucks' C.A.F.E PRACTICES case

The C.A.F.E PRACTICES case concerns a small, independent grower and a vertically integrated farmer-mill. The small farmer (2.6 hectares) has been growing coffee for more than 30 years, and the altitude of his farm ranges from 1200 to 1250 meters. Average yield is around 25-27 *TDH* per hectare. The producer has been using environmentally sound practices for more than three decades; for this reason, he has protected the fertility of the soil, and is able to produce high quality coffee.

This specific producer has been considered a success story in the C.A.F.E PRACTICES programme. He has served as an example for other producers in the programme to follow. This producer considers that the programme requirements are very strict and costly and are not necessarily offset by the additional revenues generated by participation.

The mill provides a good example of vertical integration. Both the farm and the mill are located where ecological conditions and the altitude (above 1200 meters) permit the production of a high quality product, as has been internationally recognized the past two consecutive years. This recognition has allowed the plant to be considered by Starbucks as a preferential provider, and was one reason why we chose the mill as a Starbucks case study.

The benefits of participation in the C.A.F.E PRACTICES programme are viewed differently by our representative farmer and mill. While the producer has doubts about the net benefits, the mill owners consider the experience as very positive, not only because they have access to price premiums, but also because they have brought production and milling processes in line with international standards and requirements.

D. Organic case

The organic technology case study is represented both in the agricultural and the milling stage by an organic coffee producers' association with 13 members, certified for the past five years by the **Organic Crop Improvement Association (OCIA)**. Apart from coffee, their main product, they also produce cherry tomatoes and other organic vegetables, using what they call a "productive unit" system.

In the agricultural stage, the farm has a cultivated area of approximately 14.6 hectares, located at an altitude of around 1550 meters, where coffee is combined with vegetables. The average yield comes to around 15 to 20 *TDH* per hectare. In the milling stage, our representative is the second most important organic mill in the region. In the commercialisation stage, they are developing their own channels to avoid traditional options, such as Starbucks Coffee Company.

E. Bird Friendly case

For the Bird Friendly case study, we only analysed the cultivation stage. Our case study concerns the only farmer in the country certified by the Smithsonian Migratory Bird Center (SMBC). This small operation covers about one hectare at around 1150 meters above sea level. The farm received its organic certification (Eco-logica) in 2001, and the Bird Friendly certification one year later.

At the milling stage, all requirements applied to the organic case also apply for the Bird Friendly technology.

Summary

Analysis of globalisation has been recently approached in the literature on the study of international trade and production networks. The intention has been to understand how people, places and processes are linked to each other in the global economy. In this context, the concept of Global Commodity Chains (GCC) has been used to study the whole range of activities involved in the design, production and marketing of a product. A global agri-food chain (GAFC) is a particular type of global commodity chain; it refers to the production, transformation and commercialization of agri-food products. In the dynamics of the international trade of tropical agri-food products, commodities usually go from developing countries to developed ones, following a traditional North – South trade pattern, where firms in developing countries function as raw material suppliers.

Products at different stages of transformation are traded through specific markets along the whole chain. Usually these markets are imperfect and lead firms are frequently located in developed countries, close to consumers, where markets are more profitable and entrance barriers are higher because of specific knowledge or investment requirements. Direct primary producers have little influence on prices and revenue distribution along the chain.

The governance force of the chain also influences the technology used by local producers in developing countries, because it determines the quality requirements of raw materials from upstream segments of the chain. These technologies have caused significant negative environmental impacts all along the chains, and these impacts are unequally distributed as well. Impacts from cultivation and the earliest agro-processing stages are among the most evident in this sense, and these stages are frequently located in developing countries.

In this context, the purpose of this research has been to study the benefits of cooperation in the use of environmentally friendly techniques to improve small producer income along global agri-food chains. Environmental cooperation is expected to contribute not only to the solution of local environmental problems associated with production processes but may also lead to increased market power through the vertical differentiation that can be achieved by producing and selling a better quality product.

Strategic application of environmentally friendly technologies to improve the competitiveness of local producers must consider the complexity of the chains, its relationship with the technology used and its implications for product differentiation and the potential for coordination. It should also consider the degree of market concentration.

Agri-food chains of different complexities; developing a typology

Complexity of agri-food chains is defined according to the degree of product transformation. The definition permits study of the links between farmer and consumer, and it identifies the constraints and opportunities that the global chain offers to small scale producers located at the beginning of the chain.

Two chains of different complexities form the empirical foundation of this thesis: the Guatemalan snow peas and the Costa Rican coffee chains. At one extreme, the Guatemalan snow peas chain is a very good example of a relatively simple and short chain. The final characteristics of the snow peas, ready for consumption, are very close to raw material form. This means that very little productive transformation of the product occurs along the chain; "processing" includes mainly selection, packing and conservation activities. The coffee chain, on the other hand, is a good example of a long and complex chain. From coffee berries at the farm to the brew in the cup, the chain includes several segments of far- reaching changes and implies significant transformation of the product. The distance between farmer and final consumer is large and includes a sequence of markets. Intermediate examples can be seen in the cashew nut and sesame seed chains.

The conceptualization of technology: environmental quality and markets

The complexity of the chain is closely related to the technology chosen. The more transformed the product is, the longer the chain becomes and the more possibilities exist for complex transformation processes and vertically differentiated products. For this reason, complex chains more readily allow for the application of environmental technology innovations. In the case of short and simple chains, the only way to shift technology in favour of the environment is through radical moves; however, in long and complex chains with continuous technologies, incremental or marginal moves should be the norm. This path has been found in the case studies of this thesis.

Making global agri-food chains sustainable does not only concern the supply side; it should also consider market requirements (demand) in relation to environmental quality. Environmental quality is determined by the *technology package*, which is defined as the quality and quantity of material inputs required to obtain a specific product. In this thesis, we have defined *technology* as relationship between environmental quality and available markets. It represents the relationship between market access and production processes, where coordination mechanisms must be developed in order to obtain the environmental quality at the production stage required to gain access to specific markets (demand). Therefore, *technology package* is only one component of the definition of *technology*.

Lead firms influence the technology package that farmers and first processors will choose by defining minimum quality standards necessary to guarantee market access. When producers choose a technology, they are choosing a particular environmental quality and, at the same time, a specific market in which to sell their product. In this way, the demand side influences environmental quality in production and transformation processes along the chain by influencing the choice of technology. Nevertheless, we must consider technology an endogenous variable for cultivators and first processors. This is because these agents make their final technology decision based on the potential income that this represents; however, technology change decisions must be coordinated with lead firms, even when benefits of the innovation may not be equally distributed.

Unequal chain power structure, imperfect markets and cooperation for the environment

The consideration of imperfect and non-competitive markets offers several implications for the study of chain dynamics. In our case, the implications relate to the ease or difficulty with which cooperation mechanisms arise in favour of environmental quality. The research showed that market structure affects the level of willingness to cooperate in favour of the environment. However, we found no differences between complex and simple chains, apart from the number of markets available. In the cases studied, willingness to cooperate in favour of the environment is lower when coordination mechanisms approach a spot market structure. Where non-price variables such as trust, quality commitments, technical support and historical relationships are important, cooperation in favour of the environment will more likely take place. Market mechanisms alone do not support technological change in favour of the environment. This implies that leaving the role of pricing externalities and solving environmental problems to spot markets has not been efficient.

Chain complexity and the potential for product differentiation

To appreciate the implications of chain complexity for the possibilities of product differentiation, we must explicitly consider both intrinsic and extrinsic product characteristics. Long and complex chains may present several complex transformation processes, as illustrated in the coffee case; this allows for control of the intrinsic characteristics of the final product (flavour, odour, and texture, for example) through mixing of products of different origins or by managing the transformation processes. If this is the case, raw materials with special intrinsic characteristics can be differentiated from generic products and may obtain better prices. In later stages of the chain, agents may differentiate the product, based on its particular qualities.

The differentiation process described above cannot be accomplished in short and simple chains, where transformation of the product is negligible; in most cases even the packing process ends at the place of origin. In these cases, quality improvement or product transformation will not likely occur at later stages of the chain, so the entire supply will be considered *generic* product. The challenge in these cases is to preserve original quality. We illustrate this with the Guatemalan snow peas chain studied in detail in this research. Snow peas suppliers around the world offer little difference in product quality, so availability becomes one of the most important variables in the purchasing decision.

When considering extrinsic characteristics of the final product, we should note that improving environmental quality in any stage of the chain will contribute to the general quality of the product and thereby facilitate product differentiation. In this regard, complex chains with more transformation possibilities present a greater number of options for quality differentiation. On the other hand, in the case of simple chains with limited options, as in the Guatemalan snow peas case, once the product appears in a market, agents have no options for product differentiation within the same market.

The need for vertical and horizontal coordination

In the same way that possibilities for product differentiation are not the same for the different chain categories in our typology, potential for coordination also differs with chain complexity. Generally speaking, in simple and short chains, where transformation of the product is negligible, we observe a reduced number of stages, including those where transformation processes take place. As a result, agents have fewer opportunities for coordination. In these chains, horizontal coordination is more important; it can, for example, guarantee a specific quality at the beginning of the chain that may then continue into later stages. To access desired markets, vertical coordination may be needed to guarantee the commercialization channel of a specific technology and its corresponding environmental quality further along the chain. Between farmer and first-processor, vertical coordination has great potential to develop quality control mechanisms at the cultivation stage that will guarantee access to more environmentally demanding markets. We also found in this thesis that market mechanisms on their own do not guarantee the type of horizontal coordination needed to facilitate the minimum environmental quality requirements of the more demanding markets. However, vertical coordination in the global chain might guarantee the jump from conventional to sustainable outcomes.

For long and complex chains with more technology options, vertical coordination plays an important role, not only for commercialization purposes but also to guarantee the environmental quality needed to access a higher number of markets. Farmers and processors at different stages of the chain will have more options to develop coordination mechanisms and generate vertically differentiated products. In a longer chain, there are more transformation processes and more market options.

This thesis demonstrates that access to markets for sustainable produce requires a threshold number of producers willing to switch technology, to obtain a minimum scale of production. Horizontal coordination facilitates this minimum scale and at the same time strengthens the positive image of the group. Complementary, vertical coordination may guarantee the quality required to satisfy the buyers' needs and enable the development of price differentiation mechanisms needed to access special markets. For the development of vertical coordination in the local stages of the chain, first-processors in the developing country must play the leading role, in coordination with the lead downstream firm in the developed country.

From the Costa Rican coffee and the Guatemalan snow peas cases, we see that coordination in a global commodity chain is related to its governance, although it also affects distribution of profits among segments of the chain. Leading firms promote coordination oriented toward vertical differentiation because this will assure the volume and quality of product needed to supply restricted markets or access higher prices. However, as we show in this thesis, market imperfections often prevent appropriate price transmission from consumers to growers. The study cases showed that farmers receive higher mark up in the more sustainable channel, with mark up defined as a proportion of the price difference in each stage of the chain as a percentage of the consumer price. These are nevertheless very specific cases from which we may not derive general conclusions.

In spite of the potential benefits of technology change, we should mention the possible implications for small producers and the sustainability of this change if the environmental innovation is generalized. First, in the long term markets niches will likely disappear, as will price premiums for environmentally sound products. If that is the case, environmentally friendly products will eventually be sold at conventional prices.

Switching technology in coordination with the leading firms in the chain has another consequence for local, developing country firms; they must accept their current position in the chain as raw materials providers. Trying to move forward in the chain may lead to unsuccessful attempts to compete with leading firms for the same markets. These local agents should maintain chain position and try to obtain the best possible prices for their product.

Another consequence of the generalization of technology change in the medium or long term is the possibility that benefits of environmental innovation will be unevenly distributed in favour of leading firms. The innovations that will likely succeed are those that have the support of the leading firms, in an example of enlightened self-interest; benefits for firms located upstream in the chain are not in equal proportions. Horizontal coordination at the primary producer end may provide a good opportunity to increase market power by local firms, but it is difficult to achieve. We have modelled horizontal games at the farmer stage of the chain as a prisoner's dilemma game where the result is a Nash equilibrium where all producers stay locked into the conventional technology.

Policy recommendations

Public policy should explicitly consider the possibilities of effective market intervention to guarantee technology shift and control the distribution of value-added in the innovation process. General environmental quality regulations could be strengthened and monitoring strictly enforced. Vertical coordination mechanisms should be strongly promoted and attention given to non-price variables in cooperation, such as mutual trust, technical support, quality commitments and supervision.

Coordination process should be promoted with lead agents located close to consumers. Agents should act to create more value-added in the same position of the chain and not necessarily attempt to move forward in the chain. Cooperatives and producers associations should be promoted to develop mechanisms of vertical and horizontal integration. These organisations also play leading roles at the local stages of the chains while influencing economic policies.

Market research and other technological innovation processes must be implemented to identify and classify consumers according to environmental quality preferences. Also, innovation should promote increased chain complexity through the development of more complex transformation processes. This will allow producers along the chain to participate in incremental innovations and will facilitate technology shift.