



THESIS

**AN ANALYSIS OF THE SUPPLY RESPONSE
OF ROBUSTA COFFEE IN VIETNAM**

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**GRADUATE SCHOOL, KASETSART UNIVERSITY
2006**



THESIS APPROVAL
GRADUATE SCHOOL, KASETSART UNIVERSITY

Master of Science (Agricultural Economics)

DEGREE

Agricultural Economics

FIELD

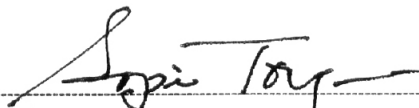
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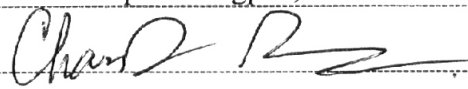
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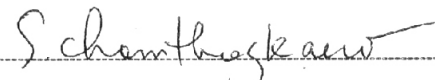
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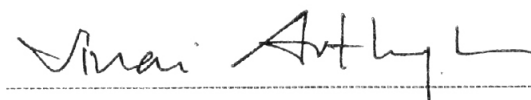
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THESIS

AN ANALYSIS OF THE SUPPLY RESPONSE OF ROBUSTA COFFEE IN VIETNAM

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**A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Master of Science (Agricultural Economics)
Graduate School, Kasetsart University
2006**

ISBN 974-16-1399-7

Trinh Van Tien 2006: An Analysis of the Supply Response of Robusta Coffee in Vietnam. Master of Science (Agricultural Economics), Major Field: Agricultural Economics, Department of Agricultural and Resource Economics. Thesis Advisor: Professor Sopin Tongpan, Ph.D. 71 pages. ISBN 974-16-1399-7

This study attempts to provide a deeper insight on the supply response of robusta coffee in Vietnam. Its framework was designed primarily to estimate the robusta coffee supply response and analyze factors affecting robusta coffee production. The Bateman model was used to develop a modification model of which without using the sub-model stock adjustment, and the Ordinary Least Squares (OLS) method of estimation was used to derive the parameter coefficients. The objective was met by fitting the dynamic supply response to time series data covering the period 1990-2004.

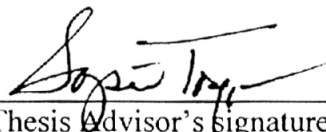
The empirical findings showed that robusta coffee supply is price inelastic and that coffee growers are less responsive to price in planning their production. The estimated elasticities of acreage and yield were inelastic, both in the short-run and the long run. Other economic and non-economic factors are somewhat influential in determining the supply of the crop.

Though the previous studies have no investigation on supply elasticity of robusta coffee in Vietnam, the crop supply elasticity with respect to its price is relatively corresponding to the industry situation. The supply elasticity is 0.44 that demonstrate the character and problematic industry, which rapidly expanded in acreage and yield improvement through the intensive cultivation.

Since the unplanned supply and world coffee crisis in the past, the Vietnam coffee industry has leant that it needs to be improved in the planning acreage and marketing system. Therefore, coffee acreage is stable in the near future, so policy makers should be concentrated on how to improve yield and quality of coffee bean in the supply aspect.



Student's signature



Thesis Advisor's signature

Mar 21 06

ACKNOWLEDGEMENTS

I would like to express my thanks to the Ford Foundation and the Ministry of Agriculture and Rural Development (MARD) who provide the scholarship for my studying in Kasetsart University - Thailand.

I would like to express my deep appreciation to Professor Dr. Sopin Tongpan, the chairman of my thesis committee and advisor, for his guidance and valuable advice during the preparation of this thesis. I also wish to express my appreciation to Dr. Charuck Singhapreecha, and Assistant Professor Dr. Sungvien Chanthongkaen, for their valuable comments and suggestions as a committee member. My grateful thanks are extended to Associate Professor Dr. Ruangrai Tokrisna, Assistant Professor Dr. Penporn Janekarnkij, and Associate Professor Somporn Isvilanonda, for their kindness and suggestions, all my professors and other officers in the department of Agricultural and Resource Economics for their kindness and helps.

I also would like to give many thanks to Dr. Dang Kim Son (MARD) for his comments, which are very constructive, critical and valuable to the revision of my thesis. I am also grateful to MA. Phan Sy Hieu, MA. Pham Quang Dieu, and others in Institute of Policy and Strategy for Agriculture and Rural Development who have been always willing to give me help, provide me material and valuable suggestions.

I am heavily indebted to my parents for their support, understanding and untiring efforts to help me build my career. My special thanks go to my beloved wife for her constant communication and as my research assistant in Vietnam, and to my daughter for her prayers.

Finally, I would like to thank to all my friends for timely assistance and encouragement.

The shortcoming of this thesis is of my own responsibility.

Trinh Van Tien

March, 2006

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ABBREVIATIONS

AFTA	=	ASEAN Free Trade Area
ASEAN	=	Association of Southeast Asian Nations
DARDD	=	Department of Agriculture and Rural Development of Daklak
FAO	=	Food and Agriculture Organization
FOB	=	Free on Board
FSIU	=	Food Security Information Units
GSO	=	General Statistical Office
Ha	=	Hectare
ICA	=	International Coffee Agreement
ICARD	=	Information Center of Agricultural and Rural Development
ICO	=	International Coffee Organization
IFPRI	=	International Food Policy Research Institute
MARD	=	Ministry of Agricultural and Rural Development
MISPA	=	Mobilisation d'Information Pour Sever les Politiques Agricoles
NPC	=	Nominal Protection Coefficient
OLS	=	Ordinary Least Square
RCA	=	Revealed Comparative Advantage
SDC	=	Sustainable Development Consultant Company
SOEs	=	State Owned Enterprises
TCVN	=	Vietnamese Quality Standard
USDA	=	United States Department of Agriculture
USD	=	United States Dollar
VBARD	=	Vietnamese Bank of Agriculture and Rural Development
VICOFA	=	Vietnam Coffee and Cacao Association
VND	=	Vietnamese Dong
WB	=	World Bank

CHAPTER I

INTRODUCTION

Problem Statement

Coffee is not originally native in Vietnam. It was introduced into Vietnam by French at the middle of the 19th century. At the beginning, coffee has been planted in some small plantation under supervised by French colonies. Up to the decade's 1980s, coffee was still distributed for the domestic consumption with a bit production. By 1990, Vietnam opened economy, and it was an opportunity for developing Vietnam coffee industry.

During the time from 1994 to 1999 when the world coffee price has undergone dramatically increased, mainly affected by frosts in Brazil, the Vietnam coffee industry has made great achievements. Vietnam gradually conversed from a low output along with export revenue base since early of 1990s to the second largest coffee producer in the world. Vietnam's position was ranked only after Brazil. Vietnam has also become the world's largest exporter of robusta, providing 42 percent of the world supply in 2001. Coffee bean has classified as the second important export among agricultural products, behind rice - the traditional food of Vietnam. According to the statistic, coffee export revenue fluctuates from 400 millions to 600 millions of USD/year. Coffee industry has created 600 thousand of permanent jobs and around 1 million part-time jobs as well as substantially contributed into the process of economic growth, changing economic structure and alleviating poverty in Vietnam (DARDD, 2002).

Nearly all coffee production in Vietnam is of robusta variety. Only 4 percent of coffee production is domestically consumed, with the rest exported. Between 85-90 percent of planted area is cultivated by small farmers, each holding from 1 to 2 ha. The four provinces of Kon Tum, Dak Lak, Gia Lai, and Lam Dong in the Central Highlands account for over 80 percent of coffee production. Arabica is produced

mainly at a subsistence level in mountainous regions in the North. (Dung and Tauer, 2004).

Technically, robusta coffee production in Vietnam was rapidly expanded in the short period (1990-2000). This expansion is achieved by three main reasons: firstly it is intensive cultivation on small farms of 1 to 2 hectares with high level of fertilizer application and irrigation on high yielding robusta varieties; secondly robusta coffee in Vietnam is spaced at 2.5x3.0 m or 3.0x3.0 m for a density of either 1300 bushes or 1100 bushes per hectare (Kotecha, 2003); thirdly it is rapid expansion area (see table 1). The expansion of robusta areas, which reached 20.7 percent per year in period 1990-2000, occurred without government control. The consequence of the unplanned and unmanaged expansion is that the historical data on planted estimates have to be treated as indicative at best, many previous research have shown the result as description on what happening in the coffee areas.

Coffee price is volatile and fluctuate by the time. Meanwhile, Vietnam coffee industry tightly depends on the world coffee price due to 96 percent of production for export. The history data provided completely one cycle of coffee price fluctuation in period 1991-2001 (table 2). The first half fluctuation cycle with the highest price in 1995 had boosted the industry on expanding area and improving production, the second half fluctuation cycle with the lowest price in 2001 dropped to its record level over 40 years. Accordingly, benefits of coffee sector in general and participants who involved in coffee supply chain in particular have been affected dramatically. Evidently, Vietnam coffee industry is clearly influenced by the world coffee price, but the degree of the supply response to the price is still not clear at all. None of the previous studies have investigated the Vietnamese coffee supply response yet.

The decline of coffee contribution to Vietnam economy in the recent years makes it absolutely necessary to have a complete knowledge of all facets of the industry. In particular, the supply response of coffee to both economic and non-economic factors needs to be thoroughly examined and analyzed. This information is vital in the formulation of appropriate policies geared toward.

Objectives of the Study

The frame work of this study is designed to provide a comprehensive assessment of the Vietnam robusta industry with emphasis on its supply aspect. Two objectives have indicated as follows:

1. Estimate the robusta coffee supply response function.
2. Analyze factors affecting robusta coffee production.

Expected Benefit

Specification of robusta supply response model will benefit the public sector in planning not only on coffee industry, but also on other crop industries.

Scope of the Study

A study of supply response for robusta coffee is designed for a specific region that is the Central Highlands - a biggest area of robusta coffee in Vietnam. The commodity in question is robusta green bean. Time series data used in the econometric model is in a period of 1990 - 2004.

Source of the Data and Limitation

Only 15 years (1990-2004) of data are available to analyze Vietnam robusta coffee supply. Before 1990, the world coffee market was tightly regulated through quotas by the International Coffee Agreement (ICA) to which Vietnam was not a member. It was only after the collapse of the ICA (1989) that the global coffee market becomes fully competitive and open to Vietnamese coffee grower. As such, price before 1990 might not be appropriate for modeling robusta coffee supply in Vietnam, which occurred under recent competitive market condition.

For examining different specific objectives of the study, the secondary data has been collected from various sources such as the General Statistical Office (GSO), Ministry of Agriculture and Rural Development (MARD), the Vietnam Coffee and Cocoa Association (VICOFA), and other government agencies.

Primary data was employed from a survey on “impact of the global coffee trade on Daklak province, Vietnam”, conducted by ICARD of MARD in the early 2001. This survey contained the specific data on the farm gate price of robusta bean, alternative crop such as pepper, and other factors such as fertilizer price, irrigation fee, and labor wage rate in the 1990-2000 periods.

The lack of time series data (2001-2004) is fulfilled by author through the coffee survey, which performed by the Institute of Policy and Strategy for Agriculture and Rural Development in November 2005.

Data limitation is that the time series data to be used in this study would cover the period from 1990 - 2004. Technically, majority statistical models to be used in the study belong to the autoregressive model and they need more observations to remedy problem of the serial correlation. Actually, our data have only fifteen years; therefore, though we can detect the serial correlation in an equation, it is not easy to fix this problem.

Another limitation is that there has no official statistics on coffee production cost; therefore, data used in the study were not purely secondary. For the data that is not available, the study used primary data that employed from the previous survey and collected by author, therefore they may not accurate or statistically significant in analysis robusta coffee supply.

Literature Review

Lewin *et al.* (2004) considered the global coffee market in their research “The Coffee Market - New Paradigms in Global Supply and Demand”. The analysis has concentrated on two groups’ country that represents the world supply and demand side. It shows that a significant structural change in the coffee market means that new and emerging paradigms is likely to dictate coffee’s future, which will have permanent effects on the livelihoods of the millions who depend on it. Meanwhile, one area of structural change is in the nature of supply, particularly increases in both the quantity and quality of Brazilian and Vietnamese coffee. For the case of Vietnam,

a primary robusta coffee producer, the authors have indicated that the planted area in the past was expanded without planning and managing by government. Vietnamese coffee growers are attracted by the signal price in the mid-decade 1990s and area-expanding by themselves under the neglected government. However, other factors affecting supply are not concerned in this report; therefore, the whole picture of Vietnamese coffee supply is still not highlighted.

Information Center for Agriculture and Rural Development (ICARD) and Oxfam Hong Kong (2002) conducted the research "Impact of the Global Coffee Trade on Dak Lak Province, Vietnam". The research has emphasized the role of coffee not only a key export of the Vietnam economy, but also an important crop for local people in the Central Highlands of Vietnam. The research has also indicated the rapid increase in coffee cultivation (on average 20.7 percent per year in the period 1990-2000), low domestic consumption and therefore tightly dependent on global economy, difficult market structure, institution, and policy that was caused the poor coffee growers under the impact of fluctuation of world coffee price. One important recommendation, which withdrew from the analysis and involved directly to the supply side, is reducing coffee planted area. However, this recommendation is derived from the context of world coffee's price downturn, 2001, so that it is less persuaded.

Kotecha (2003) carried out an analysis of Vietnam competitiveness in the global scenario. The study gave an international overview of the current global of the coffee commodity chain through production, world prices, consumption, and the comparative advantage of the Vietnamese coffee. The study has indicated that (i) the coffee growth in Vietnam is achieved by intensive cultivation on small farm of 1 to 2 hectares with high level of inputs use, high yielding, and the increased total planted area; (ii) the cost per tone is considerably lower than other countries; therefore (iii) Vietnam's farmers received the highest percentage of the export price compared with farmers in other robusta producing countries; (iv) with improvement in the cup quality for robusta coffee, the availability in volume is a comparative advantage that can be explored with the controlled supply and appropriate marketing strategies. The author also gave suggestion on how to reinforce these comparative advantage with a

budgeted farm level production, value addition processing, appropriate quality standard, price risk management through the supply chain, minimum guaranteed prices to the farmers, and above all incorporating all these techniques in a coordinated marketing strategy that integrates all such factors with world market requirements for better prices and revenue. Finally, five main policy recommendations were suggested: (i) liberal foreign exchange regulation for price protection; (ii) develop a betterment global marketing strategy for coffee products as well as green beans; (iii) reinforce the extension system; (iv) optimize marketing strategy with improved coffee export quality on robusta and arabica especially by implementing the Vietnam quality standards (TCVN) resolution to the extent possible according to market requirements and (v) put over all emphasis in a betterment global rural development strategy (including infrastructures, diversification, regional costs of production studies to identify efficiencies), optimizing soil pH acidity levels for better productivity.

Focusing entirely on the coffee industry, Chi (2003) also used the econometric model to identify the role of Vietnamese coffee in the world market. The author has carried out the causality test for the world coffee prices and quantity of Vietnamese coffee export. The result has shown that after 6 months and onward Vietnam exports have somewhat influence on the fluctuation in the world prices, and this influence is increasingly bigger since early 1999. However, because of the limited time and data, the author did not indicate how strongly Vietnam coffee exports can influence the world prices.

Duyen (2003) examined whether the volatility in the world market has been passed through coffee producer price in Vietnam by her research “Impact of Price Fluctuations on Coffee Producers: A Case Study of Dak Lak Province”. The author used the econometric model to determine coffee output, including capital (land, investment cost), labor and quality of these factors, and considered simultaneously group household classified by revenue. Base on these people groups which ranked by revenues, the author searched the impact of the coffee price fluctuation on the farmers who depend on the coffee distribution to their income. Consideration of some indices such as changing in earning, indebtedness, changing investment behavior, and

diversification of agricultural product of coffee farmers, the author has indicated that coffee price fluctuations in the recent years has significantly affected the farmers' life, but effect of the coffee prices on the farmers has varied among household groups and regions. So far looking the context of world coffee price and Vietnam coffee industry in recent years, the author draw conclusively that (i) a disturbing characteristic of the world coffee market is the prevalence of a high degree of price instability, which is primarily explained by shocks from supply side; (ii) the impact of international price volatility to domestic producers' price is not completely followed by market mechanism and it somewhat affected by organisation of the industry; and (iii) the study has expected to find a similarity from the reform of Vietnam's coffee industry towards liberalization in sector of coffee exports since 1999, however, it is not so. Shares of farm-gate prices in export prices even declined in the period of 1999-2001. This is probably explained by the risk of downward trend of export prices since 1999, which farmers bear most, distorted impacts of the reform on coffee farmers.

Nash *et al.* (2002) has mentioned the ability to provide the risk management tools for the agricultural producer based on the survey and research of authors in 2002 under the report "Vietnam: Agricultural Price Risk Management in Three Selected Commodities: Coffee, Rubber, Pepper". The report has outlined the measurement of dependence of Vietnam economy on the agricultural sector. Specifically, a case of coffee, report has concluded that the country is vulnerable to the consequences of unexpected price moves. Vietnam has, therefore, not been exempt from the problems of global coffee sector, and falling prices have hit export revenue hard, despite of the rising volume.

CHAPTER II

VIETNAM COFFEE INDUSTRY AND EVOLUTION OF ROBUSTA COFFEE SUPPLY

This chapter firstly reviews the historic perspective of Vietnam coffee industry, and then highlights the evolution of coffee supply through the description of key factors that affect to the industry such as the planted area, production and technology, farm size, yield, production cost, and the structure of the coffee industry.

The Booming of the Vietnam Coffee Industry

A rapid development of the Vietnam coffee industry during the past decade has surprised the world coffee sector. From a country that has a small coffee production and that was not popular to the world consumer, Vietnam spent only 10 years for coffee development, and it gained the great achievement in which the country became the second largest coffee exporter in 2001.

By 1980, the country has 20 thousand hectare of coffees with about 10 thousand hectares harvested, and its production was very modest about four to five thousand tons of green bean. After 20 years developed, the Vietnam coffee industry has a haft million hectare of coffees of which 90 percent of coffee bearing tree, and it provides on average approximately 800 thousand tons of coffee green bean. Coffee export revenue fluctuated from 400 millions to 600 millions of Dollar per year.

Coffee is one of the industries that attracted more jobs in rural and mountainous areas in Vietnam. For the coffee acreage of 500 thousands hectares, the industry directly used 600 thousand of permanent jobs and around 1 million part-time jobs as well as contributed substantially into process of economic growth, and changing economic structure and poverty in the rural areas of Vietnam.

The great achievement of the industry is characterized by some key issues. First, Vietnam has a strategy for developing coffee in the Central Highlands at the early 1980s. Accordingly, the government encouraged internal migration of ethnic

Vietnamese into the so-called New Economic Zones of the western parts of the Central Highlands. Along with this process, Vietnam has also implemented the cooperative program to produce coffee with the former Soviet Bloc and Eastern Bloc countries. Second, a 1986 policy reform process that allowed the establishment of the private sector in agriculture, and allocated cooperative land to individual farm households; this was an incentive for farmers to switch cash crops to perennial and export crops in particular by maintaining some controls on basic foodstuff prices. The process of reform was continued up to the 1990s in which the great achievement was gained further improvement of liberalization. Consequence of the process was also created the suitable environment for an explosion of coffee industry. Third, evolution of world coffee price was a strong power to the industry. Because 96 percents of coffee production is exported, Vietnamese coffee price is strongly affected by the world coffee price, and thereafter, affected the evolution of coffee supply of industry.

Historic Perspective of Vietnam Coffee Industry

Coffee was firstly planted in Vietnam in 1857. The land area for coffee was remained at minimum of few thousand hectares until the 1970s. The development of Vietnam coffee industry has been started since 1980 - a milestone - that was highlighted by the 5 year program for coffee development (1980-1985) and it simultaneously carried out with the project on developing coffee region in the 1980-2000 periods, which conducted by government. Accordingly, the plan for developing the coffee industry up to year 2000 was reached the aims in which the total area planted was 180 thousand hectares and total production was 180 thousand tons, respectively. The cultivated area of coffee was initially defined in the Central Highlands where have basalt soils, then it expanded to some provinces of the South East, and the North Central Coast region. Since then the coffee acreage is gradual expansion and go far further the target of 180 thousand hectares of the plan by the great figure of haft million hectares in the 21st century.

Increasing the planted area took place as a result of some key triggers (i) the government's project on developing coffee region in period 1980-2000, (ii) a 1986 policy reform process, and (iii) the two frosts and drought in Brazil which led to a

price hike, picking up again after the subsequent price rise in 1997 and the changes of processing technology of international roaster.

The first milestone was started in the year 1980, the industry was characterized by the opening up of the main coffee regions in and around Dak Lak province began with a process of the government encouraging internal migration of ethnic Vietnamese (Kinh) into the new economic zones. It was then also picked up by some ethnic minorities, some of whom appear to have been looking for more stable living arrangements. This planned migration continued beyond the period of *Doi Moi* reform, but by this time, spontaneous migration into the region by ethnic Vietnamese started to exceed planned migration. Although it is clear that not all this was to grow coffee, there is a close relationship between total migration and the expansion of the coffee areas (Tan, 2000). Along with this process, Vietnam has also implemented the cooperative program to produce coffee with the Former Soviet Bloc and Eastern Bloc countries. The result of the program is about 40 thousand hectares of coffee planted, infrastructure constructed, and the most important is that the industry has a favourable opportunity to expand the coffee acreage in the Central Highlands.

The next stage - a 1986 policy reform process - that allowed the establishment of the private sector in agriculture, allocated cooperative land to individual farm households, legalized the private ownership of productive assets, and further liberalization throughout the 1990s. This process had also provided an appropriate environment for an explosion of coffee production.

Along with this process, growth of the industry was simultaneously fueled by two external factors. Weather problems in Brazil led to substantial global price hikes in 1994 and again in 1997. This coincided with the increased willingness of roasters to utilize more robusta coffees in their blends due to technological processing improvements, which softened the harsher flavor characteristics of this coffee variety. This considerably increased the demand of Vietnamese coffee, and created a unique market opportunity for Vietnamese robusta coffee to capture a considerably larger share of the world market.

Table 1 The Evolution of Price and Acreage of Vietnam Coffee Industry

Year	Total area (ha)	Yearly new planting (ha)	Index price (USD/Ton)	Evolutions
1981	19,100	-	2,262.1	
1982	19,200	700	2,423.7	
1983	26,500	6,700	2,731.5	The cooperative programs were started, Vietnam coffee industry had received the investment and developed production
1984	29,500	7,000	3,036.8	
1985	44,600	15,100	2,648.6	
1986	65,600	21,000	3,244.3	
1987	92,300	26,700	2,248.5	
1988	119,900	27,600	2,079.1	
1989	123,100	3,200	1,655.4	
1990	135,500	12,400	1,181.6	The investment from cooperative programs were invalidated
1991	135,000	0,00	1,071.9	
1992	135,000	0,00	940.5	
1993	140,000	5,000	1,157.4	
1994	155,500	15,500	2,620.6	The evolution of coffee industry followed the market mechanism.
1995	205,000	49,500	2,770.7	
1996	285,500	80,500	1,806.0	
1997	385,000	99,500	1,736.1	
1998	485,000	100,000	1,822.5	
1999	529,000	44,000	1,488.8	
2000	533,000	4,000	912.9	
2001	535,000	2,000	607.1	The year started world coffee crisis

Source: Area provided by the VICOFA and the price followed by the ICO

With three key triggers affecting the industry, the coffee planted area has been increased rapidly; in the period of 1985-1990, coffee acreage increased from 44.6 thousand hectares up to 135.5 thousand hectares, the increase reached on average 18 thousand hectares each year; the coffee price was very low in 1992, then coffee acreage expansion was temporarily stopped on two years latter; the next period 1995-1999, the acreage increased from 205 thousand hectares to 529 thousand hectares, the increase reached on average 80 thousand hectares each year; this leads the growing rate on average 23.9 percent per year during the 1990s. Between 1980 and 2000, the Vietnamese coffee production area increased 23 times while output increased more than 83 times. It caused the total coffee area in the year 2000 has reached 533 thousand hectares and the production has about 800.000 tons (ICARD - Oxfam Hong Kong, 2002). As a result, the production growth of Vietnam coffee industry in history

up to 2000 has taken Vietnam to the position of the second largest producer, and the largest exporter of the robusta variety.

The massive increase in Vietnam's coffee supply is widely believed to be a factor leading to the price crisis of 2001. This price collapse substantially devastated the livelihoods of Vietnamese coffee growers and also whole stakeholders in the industry. To remedy the oversupply, the government has implemented a strategy to cut down 100 thousand hectares of coffee acreage. Therefore, the planted coffee area has been decreasing in recent years.

Table 2 Coffee Area, Production, and Export of Vietnam Coffee Industry

Year	Total Area (ha)	Trading area (ha)	Average yield/ ha (tons)	Total production (tons)	Export volume (tons)	Total value (Thousand USD)	Unit price (USD/ton)
1980	22,500	10,800	0.78	8,400	-		
1981	19,100	9,500	0.49	4,630	4,600		
1982	19,200	9,100	0.51	4,600	4,600		
1983	26,500	9,100	0.44	4,000	3,400		
1984	29,500	19,100	0.65	12,340	9,400		
1985	44,600	19,800	1.03	20,400	23,500		
1986	65,600	26,500	0.84	22,140	26,000		
1987	92,300	29,400	1.15	33,820	30,000		
1988	119,900	44,700	1.07	48,000	45,000		
1989	123,100	65,600	0.95	62,100	56,900		
1990	135,500	92,300	1.00	92,000	68,700	59,160	861.14
1991	135,000	111,900	1.06	119,000	76,800	65,437	852.04
1992	135,000	123,000	1.11	136,000	87,500	63,862	727.79
1993	140,000	135,500	1.04	140,500	124,300	113,000	909.09
1994	155,500	135,000	1.34	181,200	163,200	320,000	1,960.78
1995	205,000	135,000	1.81	245,000	222,900	533,524	2,393.56
1996	285,500	140,000	2.00	280,000	248,500	366,200	1,473.64
1997	385,000	155,500	2.57	400,000	375,600	479,116	1,275.6
1998	485,000	205,000	2.00	410,000	387,200	600,700	1,551.39
1999	529,000	285,000	1.75	500,000	646,400	563,400	871.6
2000	533,000	385,000	1.87	720,000	705,300	464,342	658.36
2001	535,000	485,000	1.86	900,000	844,452	338,094	400.37
2002	500,000	450,000	2.00	750,000	702,017	300,331	427.81
2003	450,000	420,000	1.71	720,000	693,863	446,547	643.57
2004	-	-	-	900,000	889,705	576,087	647.5

Source: VICOFA (2005)

Briefly, Vietnam's dramatic coffee expansion since 1990 has been occurred as a result of three series of events: (i) an overwhelming, and at least partly unexpected,

response to the government's initial direct stimuli, which was combined with (ii) agricultural liberalization and spurred by (iii) a uniquely favourable set of developments in the world market for coffee. Its closest volume competitor, Columbia, took nearly 75 years of growth to achieve the volumes reached by Vietnam in about a decade (WB, 2004).

Historic Perspective of Robusta Coffee Industry

Coffee is planted in Vietnam with two kinds of coffee, robusta is distributed in the Central Highlands and the Southeast region due to it is grown at lower altitude (below 1200 meters) and suitable with basalt soils, arabica is preferred the fertile soils condition and distributed in the North where has higher altitudes from 1200 to 2000 meters.

Especially, robusta coffees have been thrived in many of the upland areas and were quickly recognized as lucrative crops. The initial expansions of the coffee growing areas occurred in and around Dak Lak province with government encouragement of the internal migration of ethnic Vietnamese (Kinh) in to the western parts of the Central Highlands, the so-called New Economic Zones of these provinces. A long with this process, some other ethnic minorities also settled agricultural areas in response to government urging.

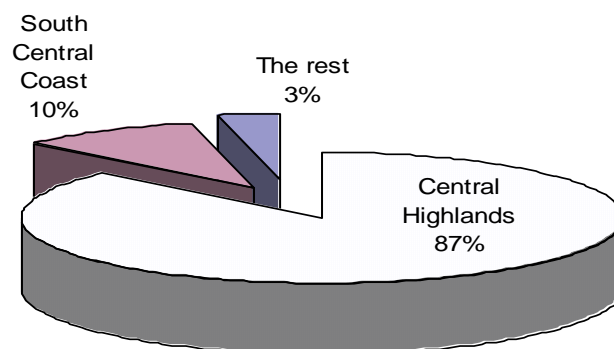


Figure 1 Distribution of Coffee Area Planted by Main Regions of Vietnam in 2004

Source: Data provided by FSIU (2005)

In the 1990s, coffee production was concentrated on the Central Highlands and the Southeast region. Over 90 percents of the coffee produced in Vietnam is robusta of which the Central Highlands contribute 80 percent and Southeast 16 percent of the total production (Minot, 1998). As for arabica varieties, it was until the last 1990s that the government has been promoting the expansion of arabica areas, particularly in the Northern region. Therefore, almost arabica area is belonging to young coffee tree, and the contribution of arabica to the production is very little.

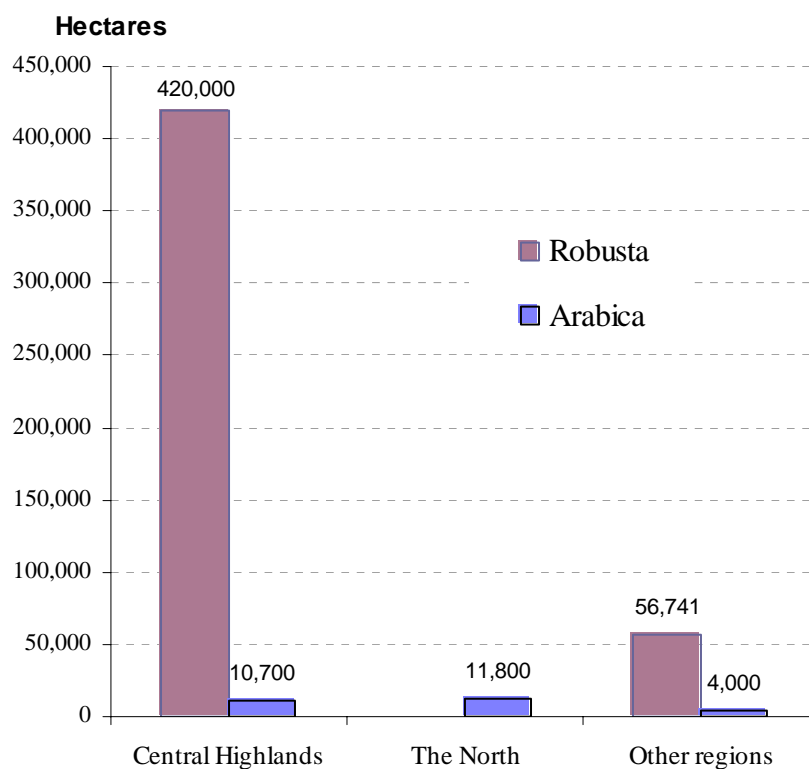


Figure 2 Distribution of Robusta and Arabica of Main Regions of Vietnam in 2004

Source: Data provided by FSIU (2005)

The Evolution of Coffee Supply

Planted Area

The highest figure is that 535 thousand hectares were planted to coffee in 2001; nearly all coffee area is of robusta variety with the exception of 26,500 hectares of arabica. However, the coffee price in 2001 dropped at the lowest price, therefore

the planted area is gradually decreased through two main causes (i) the strategy of government to cut down the robusta acreage, and (ii) the response of coffee growers to the market signal.

For the first case, the government has suggested that it would like to reduce the total planted area about 100 thousand hectares over the next seven years in an attempt to rationalize production with market demand. This includes a greater reduction in robusta acreage and an increase in arabica. Actually, most agree that it would be difficult to mandate such a reduction and, that ultimately, such decisions would be taken on an individual basis by farmers. There has been more success with the on- farm diversification to other crops than with the actual uprooting of coffee, although uprooting has happened to a limited extent, mostly in less productive areas or with older trees.

There is an evidence that market signals have reached farmers and impacted their decisions. The data on planted areas have shown a fairly close correlation to major price changes in the international markets. The data in table 2 sketches the figure below which compares data of planted coffee areas with the average export price in 1990-2003 periods. It demonstrates the extent in which the price movements may have been the separate causes.

In the 1990-2000 periods, this occurred without government control of coffee acreage, caused for further expansion of the planted area. The farmers' response signal to the price can be investigated in terms of credit. Vietnamese banks report that after the 1994 price spike, the 1995/96 planting year resulted in the highest-ever borrowing for new plantations. When prices picked up again in 1997, there was a renewed expansion as well.

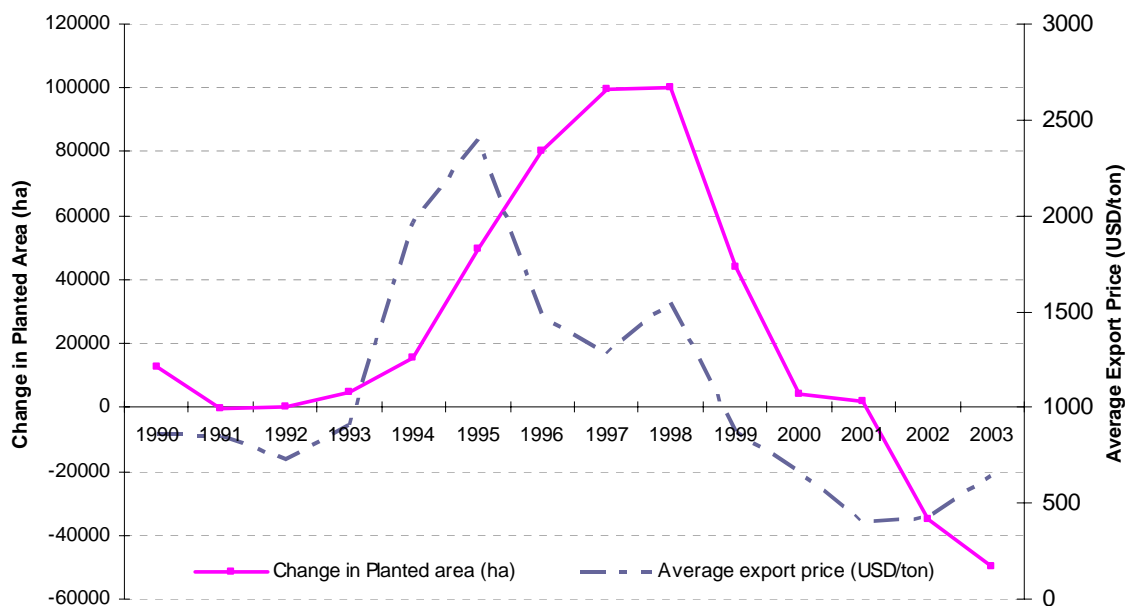


Figure 3 Changes in Planted Area and Robusta Coffee Price

Source: Data provided by VICOFA (2005)

In 2001, the status of Vietnam coffee industry was worse-off, this harvested season gained at highest production meanwhile the coffee price was lowest. The shrink price made losses for both coffee growers and exporters.

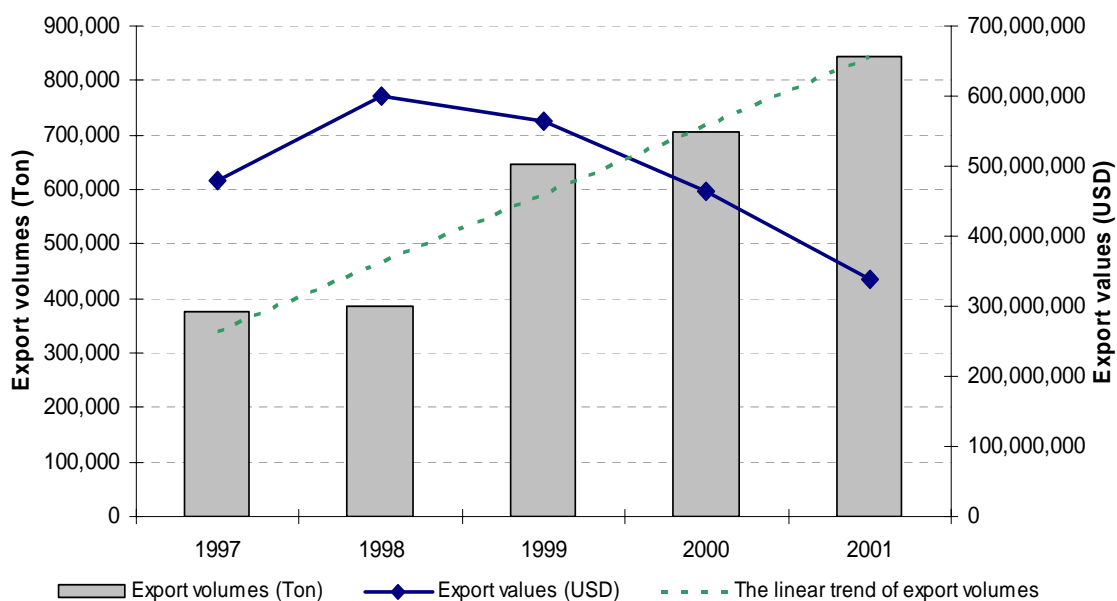


Figure 4 Vietnamese Coffee Export Volumes and Values

Source: Data provided by VICOFA (2005)

Therefore, it has resulted in an effective end to most new plantings. On the other hand, the charge on the irrigation water in the Central Highlands was so high that many coffee growers abandoned their coffee farms. Some coffee farmers chop down their coffee trees to grow other crops. However, no data on the chopped coffee area is available (USDA, 2001).

Production Technology

Robusta coffee's production is characterized by the attempt to pursue an intensive high- input strategy. This character has not derived from the government policy or industry strategy, it has been predominated for all coffee growers, both large and small. Only those farmers who lack resources or access to credit fail to apply considerable quantities of fertilizer. Coffee growers are heavy reliance on inputs has successfully raised output yields to extraordinarily high levels (WB, 2004).

In the Central Highlands, where has a favourable climate and soil condition for growing robusta coffee, has led to high yield levels. Average yield of the region is around two tons per hectare. This dramatic yield level is attached with an effort of farmers to apply highly intensive cultivation, which is characterized by the following:

- Eliminating the shadowed-trees to help robusta trees gains more radiated from the sun, this process will improve the yield;
- Condensing the tree space. Most of farmers are favorable to grow tree space at 3 times 3 meter for a density of 1,110 bushes per hectare;
- Increasing maximum the water quantity for irrigating in the dry season. It normally needs 650 liters per tree for one time irrigated. Each irrigation time takes from 7-10 days;
- Highly applying fertilizers, especially the chemical fertilizer varieties.

Table 3 The Difference of Production Technology in Producing Robusta Coffee between Brazil and Vietnam

Items	Units	Brazil	Vietnam
Tree density	Trees/ha	4,000	1,100 - 1,300
Size of farms	Ha	5 - 10 ha, maximum 10,000 ha	1 - 2 ha, maximum 10 ha
Ways of cultivation		Using highly mechanized, harvesting machinery, irrigation facilities...	Intensive cultivation with high level of fertilizers
Average green yield	kg/ha	950 to 1,400	1,400 to 2,000

Source: Kotecha (2003)

Farm Size

The vast majority of Vietnamese coffee farms are small scale. According to the result of the agricultural census in 2001 - General Statistics Office - attempted to capture national data on farm size. This investigation indicated that there are approximately 85 percent of all coffee farms are smaller than two hectares. This farm-size is the same with Indonesian robusta farm-size, but it is lower than Brazilian robusta farm-size with on average 10 hectare per farm.

Table 4 Size of Household Coffee Production Areas in the Central Highlands

	Size Distribution of coffee households (% of total farms)					
	<0.2 ha	0.2-0.5 ha	0.5-1 ha	1-2 ha	2-3 ha	>3 ha
All Central Highlands	10.6	26.1	30.9	24.1	5.7	2.7
Kon Tum Province	26.2	25.7	21.8	18.9	4.8	2.7
Dak Lak Province	5.6	2.1	32.2	25.4	5.0	2.7
Gia Lai Province	14.4	28.8	27.8	21.7	4.9	2.5
Lam Dong Province	9.7	26.6	31.5	23.5	5.8	3.1

Source: Result of the agricultural census 2001 (GSO, 2003)

In the decade 1990s - during the favorable coffee price period - many small farmers focused exclusively on single crops such as coffee. By 2001, when coffee market downturn, a part of farmers learned that this is risky in the absence of other sources of income or livelihood. Presently, the common trend is an increasing number

of small farmers for at least some on- farm diversification into complementary crops that can also be marketed.

Yield and Production Cost

Yields

As mentioned above, robusta coffees grow healthily in the Central Highlands due to the fertile basalt soil together with the intensive cultivation that caused to gain highly yield per hectare. The average yields around two tons per hectare compare very favourably with average African and Indonesian robusta yields of 0.25 to 0.35 ton per hectare, and Indian and Brazilian robusta of about 1 to 1.8 ton per hectare (Kotecha, 2003).

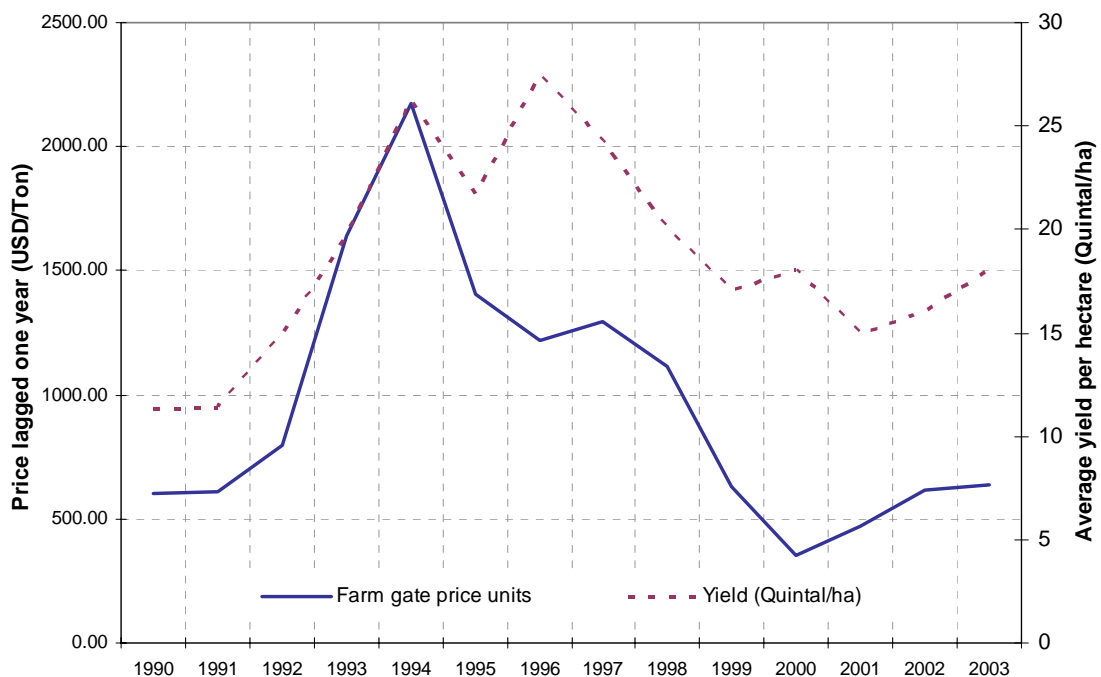


Figure 5 Farm Gate Price Units and Impact on Yield of Robusta Mature Trees

Source: Data provided by GSO (2005)

However, robusta yield in Central Highlands is not stable. Figure 5 shows an illustrative indication of how yields on mature trees behave relative to the likely money that a farmer has available from one season to pay for inputs in the next, given

the generally low level of access to credit. The yield elasticity calculation will be presented in chapter IV, however, the line draws in graph suggests that a period of low prices in which inputs are withdrawn could lead to the types of productivity drops.

Production Costs

Production costs are dominated by fertilizers. The amount of fertilizer used by coffee farmers increases according to the age of the plant and also depends on farmers' incomes and the coffee price. Production costs also include pesticides and irrigation, and depend on the quality of land, amount of available water, and cultivation practices, and among other factors.

Table 5 Production Cost of Coffee Household Yielding Two Tons per Hectare in the 2002 - 2003 Crop

Items	<i>Input uses</i>		Price (VND)	<i>Value</i>	
	Quantity	Units		(VND)	Share (%)
Fertilizers				2,579,500	35
SA	350	kg	1,600	560,000	
Urea	285	kg	2,700	769,500	
Super-phosphate	750	kg	1,000	750,000	
Potassium	250	kg	2,000	500,000	
Chemical				160,000	2
Insecticide	2	liter	30,000	60,000	
Pesticide	2	kg	50,000	100,000	
Irrigation				691,900	9
Dieses oils	185	liter	3,500	647,500	
Lubricant oils	5.55	liter	8,000	44,400	
Labor				3,975,000	54
Weeded Grass	75	may day	15,000	1,125,000	
Put down fertilizers	40	man day	15,000	600,000	
Prune off branches	15	man day	15,000	225,000	
Prevention of diseases	9	man day	15,000	135,000	
Irrigation	54	man day	15,000	810,000	
Harvested	60	man day	15,000	900,000	
Others	12	man day	15,000	180,000	
Total cost (VND)				7,406,400	100
Exchange rate (USD/VND)				15,800	
Total cost (USD)				468.76	

Source: Author's calculation based on data from coffee farm visited, Daklak, 2005.

Table 5 presents an illustration of the breakdown of production cost of coffee household. For the level of inputs quoted, the farmer expected to get two tons per hectare, would cost 469 USD per hectare or 234.4 USD per ton. This production cost is lower than Brazilian robusta production cost. Lewin. *et al* (2004) studied production of robusta coffee in Brazil, this study indicated that production cost averages about 91 Reals per 60 kilogram, or about 440 USD per ton (3.45 Reals equals 1 USD) for the 2002 – 2003 crop in Espirito Santo region - A primary region of robusta production in Brazil.

The Public Services

Research and Extension Services

The Extension services were centrally controlled by MARD, with primary decisions made at the national level, and the information, training, and policy then passed down through the provincial, and to the district level. These services are now more centralized to three main areas: the first area is the agricultural extension such as guiding the plant technique which encourages farmer to apply new seeds with the high yield; or the coffee diseases treatment to help farmer identifying the type of disease and how to use the exact pesticide to remedy coffee trees; the second area is farm level post-harvest technology which pays more attention to develop low-cost methods for drying and storing coffee in order to avoid problems of mold, and uneven drying; the third area is for research on water resource - this is a public activity that is implemented by the Eakmat Coffee Research Institute. The diffusing activities on market information and policy are also attached in the task of the agriculture extension center in each province. However, this activity seems to be working as a pilot model in the only Daklak province recently.

Extension in the Central Highlands has been particularly problematic, especially where policies strongly encourage sedentary or fixed cultivation and discourage the traditional nomadic cultural practices. Extension centers for these areas often have an inadequate understanding of local production methods and often lack regular contact with their “clients”. Although government has attempted to strengthen

these services, in minority areas, the communication and infrastructure links to these district-level extension services are often underdeveloped (WB, 2004).

Credit Services

The main formal source of credit for coffee growers is the Vietnamese Bank of Agriculture and Rural Development (VBARD), which is wholly owned by the state. Compared with agriculture extension, the formal credit service were most useful to the farmer. Since the year 2000 the coffee price was very volatile, almost coffee growers were approached the credit sources. They used the loan to apply for investing production process, even for their live in the year that coffee price downturn.

In period of 2001-2004, government continued intervention, particularly in the credit market, provided a valuable service to the coffee grower. It was estimated that there are nearly 170 million USD in open loans to coffee growers with at least 25 percent classed as non-performing (WB, 2004). It could actually slow the negative impacts of the painful adjustment that farmers will inevitably face.

Coffee Processing and Marketing

Coffee Processing

Coffee processing can be divided into two parts. Primary processing involves the conversion of harvested coffee cherries into green bean. Secondary processing involves the transformation of green beans into final consumer products such as roasted beans, ground coffee, and soluble coffee. In Central Highlands the primary processing has done by farmer through the drying method, the second processing has mostly done by wholesalers and exporters.

Farmers in Central Highlands are most preferred the drying method due to it is simple and saving cost. The drying may be done by spreading the cherries out in the sun for 5 - 10 days until the moisture of cherries reduce to 10-15 percent. After drying, hulling machines are used to removing the husk, leaving the green bean. This

process is normally spent about 40 to 60 man-days for one hectare harvested and it costs about 7 -11 percents of production cost (see table 5).

Marketing Channel

Most households sell their dry-processed bean to private middlemen. The dried cherries have been then delivered to state and private processors mainly for cleaning, sorting and grading. A number of processing companies have recently been equipped with advanced technology and facilities to sustain the capacity of 150-200,000 tons of coffee beans. Products made by these companies have higher quality and better appearance. However, there still exist hundreds of small and outdated processing plants, emerging as the main challenge especially when quality standards are higher in the world market. Most of these enterprises use dry processing technology chain with lower processing cost (VND 148,000/ton (or 10 USD/ton) against VND 670,000/ton (45.3 USD/ton) in case of using wet technology) but producing much lower and uneven quality (Chi, 2003).

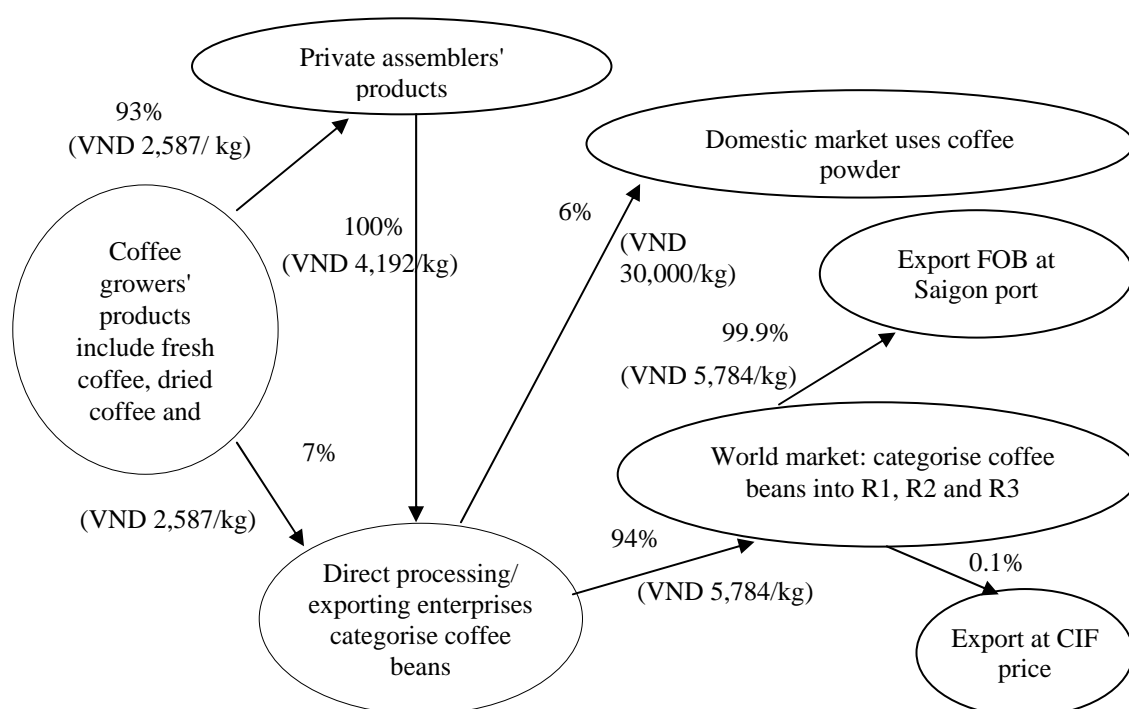


Figure 6 Coffee Commodity Chain in Dak Lak Province in 2001

Source: ICARD (2002)

From processing companies, coffee has been transported to two sources. Firstly, coffee powder or instant coffee has been sold in local markets to domestic traders (wholesalers and retailers). Second source is the international markets through private and state exporters. Before 1999, private exporters were not allowed to take part in this link. Just since 1999, the appearance of private exporters has shrunk state sector (Duyen, 2003). The commodity chain value of coffee sector will be presented more clearly, in the case of Dak Lak province, the biggest coffee producing region of Vietnam.

The Structure of Vietnam Coffee Industry

In the period before 1999, the liberalization in coffee industry took place just in fields of production and processing only, coffee-exporting activity in Vietnam was confined to state owned enterprises (SOEs)¹. Until 1999, private sector firms have been permitted to engage in the export of coffee.

Since 1999, private firms have been permitted to engage in coffee exports. Assemblers can take part into coffee market without the license of the SOEs. This participation of private sector in coffee exports has negatively impacted, to some extent, on the state-owned and state licensed cartel that existed prior to the liberalization of export marketing channels. There are currently over 80 organizations (both government and private) involved in the coffee collection and export (Frontenay and Leung, 2002). The current development of the coffee system is mapped in the Figure 7.

¹ Before 1988, producers of exportable goods were forced to sell to a specified export agency, and in coffee industry, the only one organisation permitted to export was Vinacafe. In 1989, coffee producers were allowed to sell products to some SOEs or provincially-managed companies licensed for export by Vinacafe. Quotas controlled coffee export. In 1990, licensing system was tightened. Coffee export was confined to Vicofa (Vietnam Coffee Association) members. In 1995, export quotas were lifted for coffee, but SOEs still monopolized coffee export until 1999. Since then, private sector firms have been permitted to engage in exporting coffee.

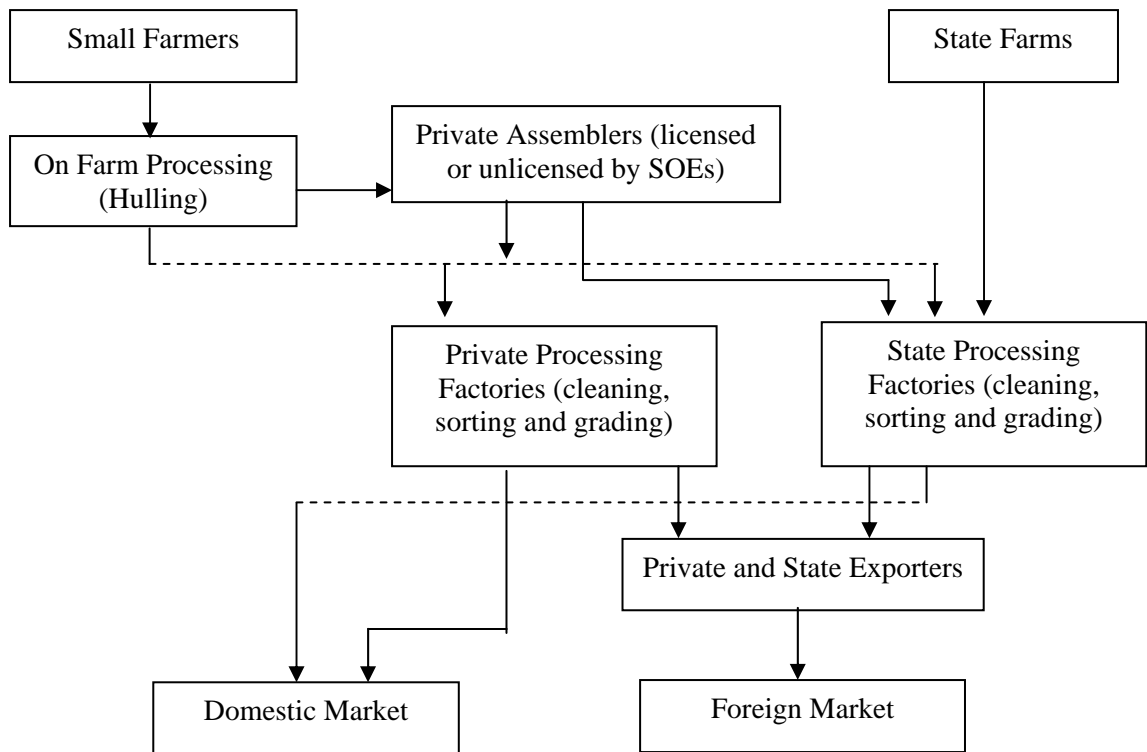


Figure 7 Coffee Marketing System in Vietnam

Source: Frontenay and Leung (2002)

CHAPTER III

RESEARCH METHODOLOGY

This chapter is discussed the different methodologies that pursued in developing the study. It consists of three parts. The first part deals with the analytical framework in which theoretical discussion on the supply function, supply response relation, and price elasticity of supply are provided. The second part presents an empirical framework, which shows the acreage, yield, and supply response model together with analyzing the factor affecting the supply of Vietnam robusta coffee industry. Lastly, the statistical procedure for estimation of the supply response parameters is described.

Analytical Framework

The nature of agricultural supply is more diverse than the nature of agricultural demand. Unlike the latter which is primarily determined by purely economic factors, the theory of supply expresses producers' response to both economic and non-economic determinants. These non-economic determinants include ecological, technological, institutional and uncertainty. It is, therefore, necessary to give a theoretical discussion of the concepts that are basic in the understanding of the supply phenomenon.

Theoretical Basic of Supply Function, Response Relation and Price Elasticity

Theoretically, a supply function expresses the relationship of the quantity of a commodity offered for sale at various prices, holding other factors constant. It can also be derived from the knowledge of the underlying input - output relationship or cost function of a firm, where producers seek to maximize profit under constraint.

A supply curve is defined only within the context of a competitive structure where sellers are price takers and therefore cannot influence the price in the market. A producer, assumed to be a profit maximizer, employs factors up to the point where the

cost of last unit of input is equal to the value of the added output. Profits are maximized by equating the marginal cost and marginal revenue.

In terms of cost relationships, the supply curve is defined as the marginal cost curve over the range where marginal cost is rising and exceeds (or equals) average cost. The quantity supplied is zero for lower product prices that is less than the ordinate of the marginal cost and the average cost curves. It implies that a firm will cease producing a commodity if its price is not high enough to cover the average variable costs of production.

The market supply curve is defined as the relationship between price and aggregate quantity offered for sale by all producers within a given region or country (Tomek and Robinson, 1990). Under normal circumstance it is positively sloped. The additional output which producer intends to provide at higher prices depends on the time allowed for adjustment.

The implicit functional relationship of supply can be expressed as:

$$Q_s = f(P, P_i, P_0, T, N, E, C)$$

This function represents the relationship existing between the quantity of supply (Q_s) and its factors affecting supply of which output price (P), input prices (P_i), prices of alternative commodities using the same inputs (P_0), technology (T), number of firm (N), expectation (E), and capacity of plant or number of acres (C).

From this, it can be seen that the level of production of any given product will theoretically depend on (i) the price of the product in question, (ii) the price of the products competing for the same inputs, and (iii) the price of inputs. Since the above mentioned condition are derived from a certain set of output and input prices and a given production function and since the production function depends on the level of technology, it can be concluded that the level of production function of a product will implicitly also depend on the technology. Another non-economic factor, weather, will also influence the production relationship in any given cropping year. Differently stated, the theory of supply expresses a general response of producers to a number of

causal determinants such as (i) economic, (ii) ecological, (iii) technological, (iv) institutional and (v) uncertainty.

The market supply of a product is a positively sloping function of the price of the product while each of the prices of the inputs, the prices of competing products, and the technology are the shifters of the market supply function.

An increase (decrease) of each of the price of the input will shift the market supply curve to the left (right), denoting less (more) output will be supplied in the market at the same price. An increase (decrease) of the price of competing crop will shift the market supply curve of the product to the left (right), again denoting less (more) output will be supplied in the market at the same price. Alternatively, a supply curve is positively sloping. The higher the price, the bigger the quantity of a commodity that would be made available in the market on two premises. Firstly, the shift will be along the same supply curve (either upward or downward); secondly, the shift leads to a new supply curve (either outward or inward). The former is a response to changes in prices holding the other determinants constant whereas the latter is a response to changes in prices and other determinants.

Thus, an important distinction that can be drawn between a parallel shift in the supply curve and a structural change. In the static supply function, the quantity supplied depends only on the output price holding the other factors constant. Changes in any other factor results lead to a parallel shift in the supply. On the other hand, a structural change results from a change in the parameters or a change in the form of the relationship. Strictly speaking, only two categories of variables would qualify as supply shifters. These are price of input and price of commodities competing in production. Other variables often included as independent variables in the supply analyses are either structural or quasi-structural in nature.

Another concept that is worthy to note and is vital in understanding the structure of agriculture as well as a basic for policy decisions is the price elasticity of supply.

The price elasticity of supply describes the responsiveness of the quantity supplied to changes in price, other factors held constant. The coefficient of the elasticity of supply expresses the percentage change in the quantity supplied as a result of a percentage change in price. Algebraically:

$$E_s = \frac{\% \Delta Q}{\% \Delta P} = \frac{\Delta Q/Q}{\Delta P/P} = \frac{\Delta Q}{\Delta P} \frac{P}{Q}$$

Where Q refers to the quantity supplied and P refers to price. Since an increase in quantity is normally associated with a rise in price, the sign of the coefficient usually is positive. If the percentage change in quantity is large than the corresponding percentage change in price, the response is regarded to be elastic since the coefficient is greater than one. Conversely, if the percentage change in quantity is less than the corresponding percentage change in price, the response is said to be inelastic. The coefficient is between the range of zero and one. If there is no quantity response to a price change, hence it is a zero elasticity which means that the supply is fixed.

A large number of statistical analyses are in quandary in the estimation of short-run and long-run elasticities. The concept is that in the short run, most or all factors of production are fixed while, as time passes, successively more of these restrictions are removed. Thus, it is believed that the short-run elasticity of supply for an individual firm is always less than or equal to the long run elasticity of supply.

Economists have stressed for some time the difference between a long-run and short-run elasticity of supply. They have noted this difference significantly on the supply side than on the demand side for reasons that a producer is more pruned to more price uncertainty than a consumer. Thus, the time taken to adjust the production plans for that matter involving capital expenditures is clearly important and should be considered.

Another aspect of supply is supply response. Agricultural commodities, generally, are more responsive to a given change in price in the long run. In a very short run, once the crop is harvested, the supply function is a vertical line.

Supply function and supply response relation are two concepts which are often used synonymously. A distinction is some times made between the traditional supply function of economic theory and a response relation. The traditional supply curve specifies a price-quantity relation, all other factors held constant. The response relation is more general; it specifies the changes in quantity supplied in response to changes in price and other determinants. Thus, the response may involve both movements along a supply curve and shift in the supply curve (Tomek and Robinson, 1990).

The response concept is based on the hypothesis that when price changes, there are likely to be correlated change in supply shifters. A hypothetical response relation is shown in the figure 8. At a price P_1 , producers offer an output of Q_1 , but as the price increase to P_2 , output expands along the diagonal between S_1 and S_2 , ultimately reaching Q_2 . We call as a response path with a price increase (AB). If price thereafter decline to P_3 , output declines along the new supply curve S_2 , resulting in the production of Q_3 , or response path with a subsequent price decrease (BC).

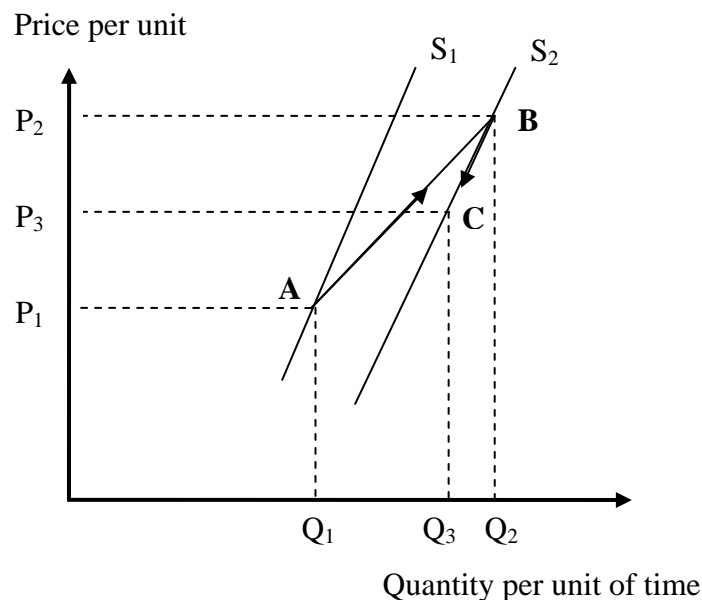


Figure 8 Hypothetical Supply Response Paths

Source: Tomek and Robinson (1990)

Consequently, an increase in price can be expected to have two effects. First, it will cause farmers to increase output along static curve; and second, it will lead them to shift to new supply curve.

Statistical Model for Estimation of Supply Response Parameters

The supply response relation of any commodity derives from profit maximization of a producing unit subject to the production function constraints. Thus, from the economic theory and with the results of previous studies, supply of a particular commodity depends on the price of the stated commodity; prices of alternative commodities; price of inputs in the production process; ecological, technological and institutional factors. The static supply relationship is generally formulated as:

$$Q_t = f(P_{ot}, P_{st}, P_{it}) X_{1t}, \dots, X_{kt}$$

Where: Q_t = quantity supplied in period t
 P_{ot} = price of commodity in period t
 P_{st} = prices of substitute commodities in period t
 P_{it} = price of inputs in the production process
 X_{1t}, \dots, X_{kt} = other non-economic determinants such as institutional and technological factors

For example, give a statistical model of an actual output for a specific crop. This equation consists of the output, price of the crop that represents relation to the costs of cropping and marketing, and climatic factors like rainfall. Thus, the relationship can be written as:

$$Q_t = \beta_0 + \beta_1 P_{ct} + \beta_2 R_t + U_t$$

Where: Q_t = the actual output of the crop in year t
 P_{ct} = producer price of the crop in year t
 R_t = amount of rainfall in year t
 U_t = error term
 β_0 is intercept of equation and β_1, β_2 are parameter coefficients.

The equation above consists of the dependent variable (Q_t) and explanatory variables such as price of the crop ($P_{c,t}$) and amount of rainfall (R_t). The functional form can be either linear or double logarithms, even exponential or semi-logarithmic model.

In the case of the double logarithmic model though it has a simple computation in determining the elasticity, the elasticity is equal to the corresponding coefficient estimate which remains to be constant over the range of data, but its limitations can be detected by checking the dependent and independent variables. The dependent variable will become zero if any independent variable is zero in the equation.

As in the semi-logarithmic model, the dependent variable does not become zero even if a factor is zero. However its main drawback is that the rate of a change of the dependent variable with respect to change in the independent variable increases at high independent levels.

The elasticity in these models can be defined as:

$$\begin{aligned}
 E_p &= \beta_1/Q \cdot Q/P = \beta_1/P && \text{for semi-log} \\
 E_p &= \beta_1 Q/P \cdot P/Q = \beta_1 && \text{for double log} \\
 E_p &= \beta \bar{P} / \bar{Q} && \text{for linear}
 \end{aligned}$$

The specifications of supply response models for perennial crops like coffee differ considerably from those of annual crops. First, there is a long time gap between planting and first output. Second, a single planting produces continuous output. Finally, the yield of the crop increases from the first output and eventually declines. On the other hand, annual crops are short-maturing and one planting produces only one output.

Empirical Framework

The supply response functions for robusta coffee in Vietnam are estimated by using the supply functions by Bateman. The model of acreage response describes the forces that motivate coffee growers to plant robusta coffees; whereas, the model of

yield response investigates the factors affecting the crop supply; lastly, model of aggregate supply response presents the output relationship which links the output harvested to area planted.

The Acreage Response Model

The major determinant of the expected long-run profitability of growing coffee is the farmer's expectations with regard to the pattern of future price. It is based on assumption that yield and cost expectations are not major influences in determining area planted. Yield patterns have changed slowly over time while cost fluctuations have been directly related to change in coffee price. Thus the relationship between planting and the farmer's price expectation is formulated as follows:

$$Sc_t = a_0 + a_1Pc_t^* + a_2Pp_t^* + U_t \quad (1)$$

Where: Sc_t = the number of hectares planted coffee in year t
 Pc_t^* = expected farm gate price of coffee in year t (VND/kg)
 Pp_t^* = expected farm gate price of pepper in year t (VND/kg)
 U_t = error term
 a_0 = intercept of the equation, a_1 , a_2 are parameter coefficients

Since expected prices cannot be observed, they need to be represented in terms of observable variables. The adaptive price expectation model assumes that the expected price at time t is equal to last expected price period plus an adjustment factor which is proportional to the difference between the actual price received and the expected producer price in period t.

The expected prices can then be expressed as:

$$Pc_t^* = Pc_{t-1}^* + \beta(Pc_t - Pc_{t-1}^*) \quad (2)$$

$$Pp_t^* = Pp_{t-1}^* + \beta(Pp_t - Pp_{t-1}^*) \quad (3)$$

Where: β = coefficient of adjustment having a value range of $0 < \beta < 1$

Rearranging the equation (2) and (3) gives:

$$Pc_t^* - Pc_{t-1}^* = \beta(Pc_t - Pc_{t-1}^*) \quad (4)$$

$$Pp_t^* - Pp_{t-1}^* = \beta(Pp_t - Pp_{t-1}) \quad (5)$$

Combining equation (1), (4) and (5) yields the estimating equation (see appendix 1)

$$Sc_t = a_0\beta + a_1\beta Pc_t + a_2\beta Pp_t + (1-\beta)Sc_{t-1} + V_t \quad (6)$$

Where:
 Pc_t = average robusta bean farm gate price (VND/kg)
 Pp_t = average pepper farm gate price (VND/kg)
 Sc_{t-1} = the robusta area planted in the last year (hectare)
 V_t is error term [$V_t = U_t - (1 - \beta)U_{t-1}$]

The Yield Response Model

A number of factors can affect the yield of the given crop. The specification used for modeling the yield equation per unit area assumes conditions as made in the output supply function, which can be expressed as:

$$Y_t^* = a_0 + a_1P_{t-1} + a_2F_{t-1} + a_3R_{t-1} + U_t \quad (7)$$

Where:

Y_t^* is desired yield per unit area in year t
 P_{t-1} is price of robusta coffee in the last year
 F_{t-1} is fertilizer price in the last year
 R_{t-1} is amount of rainfall in the last year
 U_t is error term
 a_0 is intercept of equation; a_1 , a_2 , and a_3 are parameter coefficients

Given the formulation of yield adjustment model as postulated by Nerlove:

$$Y_t - Y_{t-1} = \beta(Y_t^* - Y_{t-1}) \quad (8)$$

Where: β represents the coefficient of adjustment.

Substituting equation (7) into (8), yields:

$$Y_t - Y_{t-1} = \beta(a_0 + a_1P_{t-1} + a_2F_{t-1} + a_3R_{t-1} + U_t - Y_{t-1})$$

Rearranging this equation, the result as:

$$Y_t = a_0\beta + a_1\beta P_{t-1} + a_2\beta F_{t-1} + a_3\beta R_{t-1} + (1-\beta)Y_{t-1} + \beta U_t \quad (9)$$

Let, $a_0\beta = c_0$; $a_1\beta = c_2$; $a_2\beta = c_2$; $a_3\beta = c_3$; $(1-\beta) = c_4$ $\beta U_t = V_t$

Then, equation (9) becomes:

$$Y_t = c_0 + c_1P_{t-1} + c_2F_{t-1} + c_3R_{t-1} + c_4Y_{t-1} + V_t \quad (10)$$

Applying this model to the case's robusta crop, the model of yield equation to identify the yield response of robusta coffee in Vietnam is given as:

$$Y_t = b_0 + b_1P_{t-1} + b_2Y_{t-1} + b_3F_{t-1} + b_4R_{t-1} + b_5I_{t-1} + b_6L_{t-1} + V_t \quad (11)$$

Where: Y_t = robusta coffee yield per hectare in year t (quintal/ha)

P_{t-1} = average robusta bean farm gate price (VND/kg)

Y_{t-1} = robusta coffee yield per hectare in year t-1 (quintal/ha)

F_{t-1} = price of fertilizer in year t-1 (VND/kg)

R_{t-1} = amount of rainfall in year t-1 (mm/year)

I_{t-1} = irrigation fee in year t-1 (VND/hour)

L_{t-1} = Labor wage rate in year t-1 (VND/man day)

The Aggregate Supply Response Model

The output relationship model is developed by combining the acreage and yield response model. It starts by defining the potential output Q_t^* of robusta in terms of the planted area and potential yield per hectare.

$$Q_t^* = \sum_{i=k}^{20} (Y_i S_{t-i}) \quad (12)$$

Where:

Q_t^* = the potential output of robusta in year t (ton)

Y_i = the potential yield per hectare of robusta planted in year t-i (quintal/ha)

S_{t-i} = the planted area in year t-i (ha)

k = the age at which coffee trees first begin to bear cherry ($k=3$) (year)

The equation above is given a specific form of the information that known about the pattern of yield over the life cycle of the robusta coffee and acreage. It implies that both potential yield and the acreage planted also influence crop

production. This equation assumes that yield per hectare is zero prior to year k , and then output per hectare remains constant throughout the bearing period from the k^{th} years to the 20th year.

Equation (12) refers to potential output in the year of harvest. In order to determine what actual yield will be, it is necessary to introduce the effects of climatic factors. It has been hypothesized, for instance, that April to July is a very important climatic determinant of main crop yield. The importance of rainfall during this period is related to the annual bearing cycle of robusta coffee.

The possibility also exists that not all robusta coffee produced in year t will be harvested. Affecting factors for example rainfall, farm gate price in the last year, which represents the money to which farmers have available to pay for inputs in the current year, in relation to the cost of cropping and marketing, may affect the actual harvest. Thus, we can express as:

$$Q_t = a_0 + a_1 P_{c_{t-1}} + a_2 Z_t \quad (13)$$

Where:

Q_t = the amount of robusta coffee harvested in year t (ton)

$P_{c_{t-1}}$ = average robusta bean farm gate price in last year (VND/kg)

Z_t = other variables representing ecological, technological, or other non-economic factors.

Combining the output relationship model and the actual supply model, the aggregate supply response model is thus obtained as:

$$Q_t = a_0 + a_1 \sum_{i=k}^{20} (Y_i \cdot S_{c_{t-i}}) + a_2 P_{c_{t-1}} + a_3 Z_t \quad (14)$$

Since the potential yield and the planted area of robusta also influence coffee production, substituting equation (12) into equation (14) will give:

$$Q_t = a_0 + a_1 Q_t^* + a_2 P_{c_{t-1}} + a_3 Z_t + U_t \quad (0 < a_1 < 1) \quad (15)$$

Estimation Procedures

This study has used the double logarithmic method which is curvilinear in original observations and becomes linear in the parameters when expressed in logarithmic terms. An attractive feature of the model is that the elasticities are equal to the corresponding coefficient estimates which remain constant over the range data.

The proposed models belong to the autoregressive model, therefore, it firstly was necessary to detect serial correlation and remedy it through the method of Durbin h test, then the statistical procedure of ordinary least square (OLS) has been used to derive the estimates of the coefficients of independent variables which explain the variations in quantity supplied. All estimated equations were then subject to the following test:

- Sign of the coefficients in relation to the dependent variables; and
- Level of significance such as T-test, F-test, R^2

CHAPTER IV

RESULT AND DISCUSSION

This chapter presents the empirical results of the study on robusta coffee supply response in Vietnam, together with the related information regarding the numerical results and principal economic implication of the parameter estimates.

The supply equation for the response relation of robusta coffee that was described in the previous chapter was estimated only in the Central Highlands of Vietnam where is a special region of robusta coffee varieties.

The coefficients of the explanatory variables were derived by using the ordinary least square method in double logarithmic form. It is accompanied by the estimated standard error of regression; calculated t-values with two-tailed test which describe the significance of the explanatory variables; the multiple coefficient of determination (R^2), which explains how the independent variables affects the variation of the explained variable; the F-statistics, which helps determine the acceptance or rejection of the null hypothesis that there is no significant relationship among the variables in the equation; and the Durbin-Watson statistics that help determine whether serial correlation exist in the time series data.

The short-run and long-run price elasticities are also discussed in the acreage and yield response model. The short-run elasticities are equal to the corresponding estimated coefficients of the regression output, while the long-run price elasticity is calculated by dividing the short-run elasticity by the coefficient of adjustment. The latter, on the other hand, is defined as one minus the coefficient of the lagged area in the case of acreage response equation and one minus the coefficient of the lagged yield for the case of yield response equation.

Other aspect that is worthy of examination with regard to the supply response relation after deriving the coefficients of the parameters in an identified equation is the price elasticity of aggregate supply. This elasticity can be detected directly from

the estimated coefficient of the supply response equation. Three formulations were used to describe the supply response function of robusta coffee in Vietnam. They are the acreage, yield, and the aggregate supply response model.

The Acreage Response Model

Model of Acreage Response

In the acreage response model, the dependent variable that was used in the estimation was the robusta area planted (Sc_t). The independent variables used were the following: the average farm gate price of robusta coffee bean (Pc_t), the average farm gate price of pepper (Pp_t) and the lagged index of robusta area planted (Sc_{t-1}). Selections of variables were made after a careful analysis that was conducted as regards to variables which reflect the realistic response relation as clearly defined in the previous chapter. The estimated equation that adapted Bateman's model is given as follows:

$$\ln Sc_t = -1.76 + 0.26 \ln Pc_t - 0.09 \ln Pp_t + (1-1.03) \ln Sc_{t-1}$$

Table 6 The Original Estimation of Robusta Coffee Acreage Equation in the Central Highlands of Vietnam, 1990-2004

Variable	Coefficient	T-Statistic
Constant term	-1.756168	-0.689424
Price of robusta coffee	0.255573	0.971505
Price of pepper	-0.090569	-1.769238*
Lagged planted area of robusta coffee	1.030875	12.03543**

R-squared	: 0.999953
Adjusted R-squared	: 0.999939
Standard error of regression	: 0.133955
Durbin - Watson statistics	: 0.823045
F-value	: 71.69243**

* Significant at 90 percent

** Significant at 99 percent

The statistical finding, as presented in table 6, shows that all of the coefficients of the exogenous variable, except the coefficient of the lagged planted area variable, have right sign. The multiple coefficient of determination (R^2) is high, with value is 0.99 and it indicates that around 99 percent of variation in the area planted to robusta coffee in the current year is explained by these variables. The relationship between the dependent variable and the independent variable as found to be significant as shown by the high values of the computed F ratio. However, sign of the estimated coefficients variable of area planted was not consistent with economic principles, and the coefficient variable of coffee price also was not statistically significant in explaining the changes in variation of robusta area planted. The estimated Durbin - Watson d is 0.82, which is lower than 2. The d value indicated that we may be encountered with the serial correlation in our time series data.

The most appropriate equation was selected after carrying out several alternative trial equations. The area planted equation for robusta in Vietnam is followed the Nerlovian form and given as follows:

$$\ln Sc_t = -1.3 + 0.28 \ln Pc_{t-1} + 0.91 \ln Sc_{t-1} \quad (16)$$

Table 7 Estimation of Robusta Coffee Acreage Equation in the Central Highlands of Vietnam, 1990-2004

Variable	Coefficient	T-Statistic
Constant term	-1.328124	-1.225298
Price of robusta coffee	0.281262	2.398733*
Lagged planted area of robusta coffee	0.912278	15.25113**

R-squared	: 0.962933
Adjusted R-squared	: 0.956194
Standard error of regression	: 0.154855
Durbin - Watson statistics	: 1.320680
F-value	: 142.8818**

* Significant at 95 percent

** Significant at 99 percent

Equation (16) indicated that the area planted to robusta coffee in current year is a function of lagged of robusta price and its area planted in last year. The coefficients of multiple determination (R^2) are high enough, with value is 0.96. The relationship between the dependent variable and the independent variable as found to be significant as show by the high values of the computed F ratio. Therefore, the equation reveals that 96 percents of variation in the acreage response can be explained by the two variables, the lagged price of coffee, and lagged planted area. Coefficients of these variables were highly significant in explaining the changes in variation of robusta acreage. The estimated Durbin - Watson d is 1.32, which is small to the critical value at 2. It suggests that the Durbin - Watson statistic of 1.32 does not allow a decision to be made regarding the presence of autocorrelation among the residuals.

The positive sign of the coefficient of the robusta price is consistent with the empirical observation that area planted moves in the same direction as price change. An increase (decrease) in price of robusta will lead to a corresponding increase (decrease) in acreage for the current year. The estimated coefficient of the lagged planted area implies that one percent increase in area planted in last year will lead to 0.91 percent increase in the area plant for current year. This also indicates that the acreage to robusta is evenly increasing every year.

The Price Elasticity of Acreage

The short-run elasticity can be seen directly from the estimated coefficients of equation (16). The short-run elasticity of area planted with respect to the lagged price is 0.28, which is inelastic, being less than one. It implies that farmers are not much response to changes in price of robusta in the short run. A small percentage change in price of robusta will cause a smaller change in the planted area. In this case, one percent increase in price will increase the area by only 0.28 percent. This is because the expansion is relative fixed and constrained in the short-run, especially for the case perennial crop as coffee.

The long-run elasticity is calculated simply by dividing the short-run elasticity by the coefficient of adjustment that is one minus the coefficient of the lagged planted

area, which is 0.09. Thus, the long run elasticity of area planted with respect to price is 0.31. This can be read as inelastic. It means that one percent increase in the lagged price of robusta coffee will lead to 0.31 percent increase in area planted for the current year.

The Yield Response Model

Model of Yield Response

In the yield response model, the dependent variable was the yield of robusta coffee (Y_t). The independent variables used were the price of robusta (P_{t-1}), yield of robusta in last year (Y_{t-1}), price of fertilizer in last year (F_{t-1}), irrigation fee in last year (Ir_{t-1}), labor wage rate in last year (L_{t-1}), and amount of rainfall (R_{t-1}) in last year. The original model that proposed in the methodology is given as follows:

$$\ln Y_t = -8.3 + 0.4 \ln P_{t-1} + 0.5 \ln Y_{t-1} + 0.7 \ln F_{t-1} + 0.8 \ln Ir_{t-1} - 1.2 \ln L_{t-1} + 0.6 \ln R_{t-1}$$

Table 8 The Original Estimation of Robusta Coffee Yield Equation in the Central Highlands of Vietnam, 1990-2004

Variable	Coefficient	T-Statistic
Constant term	-8.261547	-2.035920*
Lagged price of robusta coffee	0.440777	1.490284
Lagged yield of robusta coffee	0.531715	1.879797
Lagged price of fertilizer	0.682036	1.604454
Lagged irrigation fee	0.838610	0.926471
Lagged labor wage rate	-1.201445	-1.258242
Lagged amount of rainfall	0.634448	1.424061

R-squared	: 0.797011
Adjusted R-squared	: 0.623020
Standard error of regression	: 0.168239
Durbin - Watson statistics	: 2.225911
F-value	: 4.580760*
* Significant at 95 percent	

The statistical finding has indicated that none of these estimated coefficients are statistically significant. Therefore, it suggested that we should more investigate in this equation.

The same process of selection was used with that of the acreage response model. After carrying out several alternative trial equations, and using the weighted least square method to correct for the heteroskedasticity, the final equation that gives the best estimates to the yield response model for robusta in Vietnam was found as follows:

$$\ln Y_t = -3.24 + 0.11 \ln P_{c,t-1} + 0.84 \ln Y_{t-1} - 0.37 \ln L_{t-1} + 0.85 \ln R_{t-1} \quad (17)$$

Table 9 The Estimation of Robusta Coffee Yield Equation in the Central Highlands of Vietnam, 1990-2004

Variable	Coefficient	T-Statistic
Constant term	-3.236835	-1.369739
Lagged price of robusta coffee	0.110695	0.793119
Lagged yield of robusta coffee	0.843746	4.275228*
Lagged labor wage rate	-0.366319	-1.999475**
Lagged amount of rainfall	0.845026	2.036305**

R-squared	: 0.965212
Adjusted R-squared	: 0.949750
Standard error of regression	: 0.160975
Durbin - Watson statistics	: 1.298623
F-value	: 7.084250**

* Significant at 99 percent

** Significant at 90 percent

The statistical results of the empirical estimation of yield equation (equation 17) show that around 96 percent of the variation in robusta coffee yield per hectare is explained by the lagged price of the crop, lagged yield, lagged labor wage rate, and amount of rainfall in the last year. This is indicated by the multiple coefficient of

determination (table 9). It is associated with a high enough F-statistic coefficient of 7.08. The T-statistic of the lagged yield of robusta coffee is significant at 99 percent while the lagged of labor wage rate and lagged amount of rainfall are both significant at 90 percent.

The above estimations show the significant effects of the explanatory variables on the yield per hectare equation. The T-statistic of the lagged price of robusta coffee is quite low (significant at 56 percent), but was retained in the equation following the rule that if the variables are logical parts of the model, they should not be dropped on stringent statistical grounds (Tomek and Robinson, 1990).

The positive sign of the coefficient of lagged price is consistent with economic theory. The yield per hectare moves in the same direction as the change in price. An increase or decrease in the lagged price of robusta coffee will lead to a similar increase or decrease in the yield for the current year.

The negative sign of the coefficient of the lagged labor wage rate is also consistent with economic principles. This implies that one percent increase in the lagged labor wage rate will lead to 0.37 percent decrease in yield per hectare for the current year. The primary reason is that farmers will optimize the use of this input. Thus, higher price of this input will tend to reduce the yield of robusta coffee per hectare.

The Durbin - Watson statistic of 1.53, which is small when compared with the critical value at 2, does not allow a decision to be made regarding the presence of autocorrelation among the residual.

The Price Elasticity of Yield

The short-run elasticity of robusta yield with respect to price is 0.11, implying that one percent increases in its price will induce the yield for the current year to increase by 0.11 percent. This price elasticity is considered inelastic since it is less than one. The change in price causes less than proportionate change in yield per hectare.

The long-run price elasticity of yield per hectare is more varied than the short-run. This was due to the small value of the calculated coefficient of adjustment (1-0.84). After dividing the short-run elasticity to the coefficient of adjustment, the long-run elasticity of yield equals 0.69.

The price elasticity of yield per hectare is smaller in the short-run than in the long-run. However, they are both found to be inelastic. The yield elasticity in the long-run is corresponding with the fact that the yield level of Vietnamese coffee is gradual improvement with the great achievement of two tons per hectare in the present.

The Aggregate Supply Response Model

It differs from the annual crop that robusta coffee is perennial crops in which the trees need one stage for planting before becoming the trees bearing. Adopting the Bateman's model, the aggregate supply will be employed with the potential production term appears in section below.

Model of Aggregate Supply Response

The appropriate equation was selected after carrying out several alternative trial equations. The supply equation for robusta coffee in Vietnam is given as follows:

$$\ln Q_t = -13.47 + 0.83 \ln Q_t^* + 0.44 \ln P_{c_{t-1}} + 1.34 \ln R_{t-1} \quad (18)$$

Where the dependent variable was the production of robusta coffee (Q_t), the independent variable used were the potential output of the crop (Q_t^*), its lagged price ($P_{c_{t-1}}$) and the amount of rainfall (R_{t-1}) in the last year. The lagged rainfall variable was selected due to the natural condition of Central Highlands; it suggested that April through July rainfall was the relevant statistic for R_{t-1} .

The above equation reveals that 93 percents of variation in the coffee supply can be explained by three variables, Q_t^* , $P_{c_{t-1}}$, and R_{t-1} . The coefficients of these variables turn out to be highly significant in explaining the changes in robusta supply

(table 10). The coefficient variable of potential output is statistically significant at 99 percent and coefficient variables of the lagged price and lagged amount of rainfall are both significant at 95 percent. However, the Durbin Watson coefficient equals 1.52, which is small and it may have a positive serial correlation.

Table 10 The Estimation of Aggregate Supply Equation of Robusta Coffee in the Central Highlands of Vietnam, 1990-2004

Variable	Coefficient	T-Statistic
Constant term	-13.47240	-4.453706*
Potential output of robusta coffee	0.826084	4.878229*
Lagged price of robusta coffee	0.442374	2.213615**
Lagged amount of rainfall	1.335088	2.360064**

R-squared	: 0.932280
Adjusted R-squared	: 0.911964
Standard error of regression	: 0.257961
Durbin - Watson statistics	: 1.517709
F-value	: 45.88902*
* Significant at 99 percent	
** Significant at 95 percent	

The Aggregate Supply Elasticity

The other aspect that is worthy of examination with regard to the supply response relation after deriving the coefficients of the parameters in the identified equation is the aggregate elasticity of supply.

The above equation in form of double logarithmic has a simple computation in determining the elasticity, the elasticity is equal to the corresponding coefficient estimates which remains to be constant over the range of data, but its limitation can be detected by checking the dependent and independent variables. In other words, the dependent variable will become zero if any independent variable is zero in the equation.

The price elasticity can be seen directly from the estimated coefficients of equation (3). The elasticity of aggregate robusta supply with respect to lagged its price is 0.44, implying that one percent increase in the lagged robusta price will induce the supply for the current year to increase by 0.44 percent. This price elasticity in the aggregate supply equation is considered inelastic since it less than one. However, the finding of aggregate supply elasticity, which equals 0.44, is much meaningful in the actual of Vietnam robusta coffee industry. Because the coffee price change could be caused the shock of the robusta production, especially with the wide robusta area in the Central Highlands.

Table 11 Estimated Output Elasticities of Robusta Coffee Production in the Central Highlands of Vietnam, 1990 - 2004

Item	Short-run elasticity	Long-run elasticity	Aggregate elasticity
Acreage	0.28	0.31	-
Yield	0.11	0.69	-
Production	-	-	0.44

Source: Author calculation

Factors Affecting Robusta Production

The empirical estimates of this study have confirmed the hypothesis that coffee growers are responsive to price in planning their production. The derived elasticity of planted area are 0.28 in short-run and 0.31 in the long-run, hence it indicated that coffee growers respond positive to price changes. Yet other factors can be equally important to substantiate this contention.

It has been noted that the coffee supply response is related to a number of variables aside from price. These factors can influence the coffee growers' decision to produce robusta instead of other crops. They can be divided into two major components (i) other economic factors aside from price, and (ii) non-economic factors.

Other Economic Factors Aside from Price

(a) *The behavior of coffee growers to adjust their production to the signal of market:* Evidently, Vietnam just opened the market to the economy since the year 1990, therefore, coffee growers have a little experience to adjust their production to the signal of market, it was true in the 1990s - during the favourable price period - many coffee growers focused exclusively on single crop such as robusta coffee, the growing of robusta acreage reached on average 23.9 percent per year. By 2001, when coffee market downturn, a part of coffee growers learned that this was risky in the absence of other crops diversification.

(b) *Income Stability:* As mentioned in the previous section, the vast majority of Vietnamese coffee farms are small scale around one to two hectares, and they are much dependent on single robusta crop. Therefore, the farmer's response to coffee price is faced by many constraints to maintain income stability or livelihood.

(c) *Marketability:* Robusta bean can be stored over a year thus it makes sense in coffee growers' decision to plant coffee rather than other crops. Other crops such as pepper, rubber, cashew-nut, and cocoa can be grown healthily in the Central Highlands and its product are also stored as coffee. However, some of these crops such as cashew-nut, cocoa, fruit trees are not economic due to they need much labor for tending or have no market output; rubber is needs long time for planting and also a big capital; pepper is economical crop however it is a risky crop because of the diseases.

(c) *Costly:* Under the natural condition, robusta coffee production is more tolerant to adverse weather condition than other crops. However, most of coffee growers in Central Highland are intensive cultivation with the high level of fertilizer application and irrigation with expectation to reach high yield and production. Therefore, robusta production become expensively due to input costs are much tightly correlated to the yield and production.

Non-Economic Factors

(a) *Adverse Weather Condition*: Central Highlands region has two main seasons of which rainy season from April to September and dry season for the rest of months. If a year has a small rainfall, then it is not only affected directly to the yield of tree but also reduced the ground water source. In this case, the yield will be reduced or increased production cost due to the growers exploit ground water for irrigating. Whereas, rain appears during the harvested time, then it also affected to the production and bean quality. Air humidity is also affected to the coffee bean during the stored time.

(b) *Pest and Diseases*: Because of the intensive cultivation, robusta coffee in the Central Highlands are easy vulnerable when the season appeared pest and disease. Its impacts are not only affected the health of tree, but also caused on reducing yield, production, and quality of coffee bean.

Government Intervention and Coffee Industry in Vietnam

For the aggregate supply equation above, it should included policy variable and time trend variable in equation to measure what are the government interventions on the Vietnam coffee industry as well as technology improvements in coffee production. However, because of the limited time series data, the factors affecting coffee supply such as policy, technology improvement cannot be detected directly from aggregate supply equation. Hence, the study uses the nominal protection coefficient and revealed comparative advantages to investigate the government interventions on the coffee industry.

The nominal protection coefficients (NPC) for Vietnamese coffee are calculated by using domestic prices and border prices. Both domestic prices and border prices are annual averages, provided by the GSO. The revealed comparative advantages (RCA) are also calculated by using the annual ratio of Vietnamese coffee export value and world coffee export value over the annual ratio of Vietnam total

agro-products export and world total agro-products export. The results are presented in the table below.

Table 12 Nominal Protection Coefficients (NPC) and Revealed Comparative Advantage (RCA) of Vietnam Robusta Coffee Industry

	Vietnam				World		RCA	NPC
	Coffee export values	Total agro-products export values	Domestic coffee price	FOB coffee price	Coffee export values	Total agro-products export values		
	(Mil.\$)	(Mil.\$)	(\$/ton)	(\$/ton)	(Mil.\$)	(Mil.\$)	(%)	
1990	59.16	1,106.00	776.01	861.14	6,680.87	4,261,900	34.12	0.90
1991	65.44	1,089.00	601.08	852.04	5,841.19	4,394,800	45.21	0.71
1992	63.86	1,276.10	611.57	727.79	5,339.18	4,711,800	44.16	0.84
1993	113.00	1,444.40	796.63	909.09	6,580.16	4,719,000	56.11	0.88
1994	320.00	1,948.10	1,642.04	1,960.78	14,341.75	5,283,700	60.52	0.84
1995	533.52	2,521.10	2,173.32	2,393.56	14,206.67	6,293,300	93.75	0.91
1996	366.20	3,068.30	1,404.24	1,473.64	10,649.83	6,629,600	74.30	0.95
1997	479.12	3,238.50	1,217.98	1,275.60	10,661.60	6,896,900	95.70	0.95
1998	600.70	3,323.70	1,297.93	1,551.39	11,783.45	6,787,300	104.10	0.84
1999	563.40	3,688.70	1,117.24	871.60	9,471.99	7,026,900	113.31	1.28
2000	464.34	4,197.50	629.00	658.36	6,343.12	7,824,600	136.46	0.96
2001	338.09	4,413.30	351.00	400.37	3,669.10	7,567,700	158.01	0.88
2002	300.33	4,616.00	470.00	427.81	3,430.60	7,936,000	150.51	1.10

Source: Data is calculated from the source of GSO and FAO (2004)

Research into the extend and effects of government interventions within the coffee industry in Vietnam revealed that the industry was freely developed under the neglected government policy and it was also improved the comparative advantage in the 1990-2002 periods.

In table 12, nearly all items of NPC coefficient have all values less than one. Theoretically, coffee growers and processors are taxed and consumers subsidized. However, the trend of NPC has propensity to ward but they are less than one, except

NPC in 1999 and 2002. It is true with situation of Vietnam coffee industry at that time. As mentioned in the previous section, the coffee plantation area in Vietnam has rapidly expanded during the 1990-2000 periods without any government controls. The NPC for 1999 and 2002 may be the results of the export promotion policy, namely export rewards and credit support for coffee exports in 1999, and the public stockholding policy took place in the middle of 2001.

The revealed comparative advantage coefficients have positive trend which reflect the gradual improvement of the comparative advantage of the industry. It is consistent with the effort of Vietnamese coffee growers on the intensive cultivation, which was analyzed in the previous section.

CHAPTER V

SUMMARY AND CONCLUSION

This study is an attempt to estimate the robusta coffee supply and analyze factors affecting the crop production in the country. Its framework is designed to provide a comprehensive assessment of the Vietnam robusta industry with an analysis on the supply aspect. Supply in this study has been defined as the aggregate supply of the local production in the Central Highlands for the given crop years. Its basic hypothesis used in the analysis is that coffee growers are responsive to price in planning their production.

Three basic models were considered and believed to give a deeper analysis about the supply response relations. As stated earlier, these are the acreage, yield, and aggregate supply response relations. The former response relation describes the forces that motivate farmers to plant their robusta coffee, and the latter response relation links the planted area to supply.

The importance of robusta coffee in Vietnam economy as discussed in chapter I was described both economic factors and non-economic factors situations which are very influential to the robusta coffee industry development.

As for supply aspect, coffee growers meet several economic and non-economic factors which give a dent to their coffee production venture. As a result, the expansion of robusta areas has occurred without government control. Thus, in turn, it has made some advantage and disadvantage to the development of robusta industry.

Chapter II presented the situation of Vietnam coffee industry and evolution of robusta supply, the historic perspective of Vietnamese coffee industry, and then highlighted the evolution of coffee supply through the description of key factors that affect to the industry such as the planted area, production and technology, farm size, yield, production cost, and the structure of the coffee industry.

This study is an attempt to provide a deeper insight into the supply aspect of robusta coffee in Vietnam. Supply is defined within the context of this study as the aggregate local production. It also regards that the main objective of the study is being set forth.

Summary of Empirical Findings

The robusta supply response in Vietnam is determined by three basic components, the acreage response, yield response, and aggregate supply response function. The acreage of the crop is positively correlated to its own lagged price and lagged planted area. Around 96 percents of variation in the planted area is explained jointly by these two explanatory variables.

The yield per hectare is also positively correlated to the lagged price of coffee, lagged amount of rainfall, lagged labor wage rate, and lagged yield. About 96 percent of variation in the crop yield per hectare is explained by these variables.

The estimate of aggregate supply elasticity of robusta coffee with respect to its lagged price is found to be generally low. The price elasticity is 0.44 and inelastic due to it is less than one. This implies that one percentage change in price causes a less than proportionate percentage change in the aggregate supply.

Though the aggregate supply elasticity of robusta coffee in Vietnam is found to be inelastic, coffee growers are responsive to change in price. While they respond positively to price, other factors are to be considered in explaining the variation of robusta coffee supply. However, there are no official statistics on coffee production costs; these variables such as fertilizer price, irrigation fee, and labor wage rate were employed from the previous survey and collected by author, therefore they are not statistically significant in analysis robusta coffee supply. It may cause of limited data, or time series data for those variables which are not accurate due to the data took from survey with long interval time.

Conclusion

The first objective of the study has been found through the estimate of supply function of Vietnam robusta coffee industry and its elasticities. The finding bring out meaning of the expansion of area planted and improvement of the crop yield through the impact of price on the planted area and yield in the 1990 - 2004 period. As a result, the work on specification of robusta coffee supply response will benefit the public sector in planning not only on coffee industry, but also on other crop industries.

The second objective has been investigated through the aforementioned factors influence the farm's decision to produce robusta coffee. Through farmers are influenced by price, it appears that non-economic factors are not to be left out in explaining the farmer's behavior.

Although the previous studies have no investigation on supply elasticity of robusta coffee in Vietnam, the crop supply elasticity with respect to its price is relatively corresponding to the industry situation. The supply elasticity is 0.44 that demonstrate the character and problematic industry, which set forth initially in the study.

Policy Recommendation

Policy recommendations have already been given out by some previous studies, especially ICARD - Oxfam Hong Kong research on “The impact of the global coffee trade on Dak Lak province, Vietnam: Analysis and policy recommendations”. These recommendations include improving the market information system, reducing the area planted to coffee, diversifying production and implementing a temporary storage policy for coffee. In view of the foregoing issues and development, some suggestions are given out.

- Since the unplanned supply and world coffee crisis in the past, the Vietnam coffee industry has learnt that it should be improved in the planning acreage and marketing system. Therefore, coffee acreage is stable in the near future, so policy makers should

be concentrated on how to improve yield and quality of coffee bean in the supply aspect.

- Recommend coffee growers relocated in unfavourable area for coffee farming shift towards other crops and diversify crops in the coffee acreage. This will help farmers to avoid the risk when coffee price go down, or encounter an adverse weather.

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APPENDIX

Appendix Table 1 Derivation of the Acreage Response Equation

The relationship between planting and the farmer's price expectation is as follows:

$$S_t = a_0 + a_1 C_t^* + a_2 P_t^* \quad (1)$$

Where: S_t = the number of hectares planted coffee in year t
 C_t^* = expected farm gate price of coffee in year t (VND/kg)
 P_t^* = expected real producer price of pepper crop (VND/kg)

Since expected prices cannot be observed, they need to be represented in terms of observable variables. The adaptive price expectation model assumes that the expected price at time t is equal to last expected price period plus an adjustment factor which is proportional to the difference between the actual price received and the expected producer price in period t.

The expected prices can then be expressed as:

$$C_t^* = C_{t-1}^* + \beta(C_t - C_{t-1}^*) \quad (2)$$

$$P_t^* = P_{t-1}^* + \beta(P_t - P_{t-1}^*) \quad (3)$$

Where: β = coefficient of adjustment having a value range of $0 < \beta < 1$

Rearranging the equation (2) and (3) gives:

$$C_t^* - C_{t-1}^* = \beta(C_t - C_{t-1}^*) \quad (4)$$

$$P_t^* - P_{t-1}^* = \beta(P_t - P_{t-1}^*) \quad (5)$$

From equation (1) we have:

$$C_t^* = \frac{S_t - a_0 - a_2 P_t^*}{a_1} \quad (6)$$

$$C_{t-1}^* = \frac{S_{t-1} - a_0 - a_2 P_{t-1}^*}{a_1} \quad (7)$$

$$P_t^* = \frac{S_t - a_0 - a_1 C_t^*}{a_2} \quad (8)$$

$$P_{t-1}^* = S_{t-1} - a_0 - a_1 C_{t-1}^* \quad (9)$$

Substitute equation (6) and (7) into equation (4) gives:

$$\frac{S_t - a_0 - a_2 P_t^*}{a_1} - \frac{S_{t-1} - a_0 - a_2 P_{t-1}^*}{a_1} = \beta \left(C_t - \frac{S_{t-1} - a_0 - a_2 P_{t-1}^*}{a_1} \right)$$

$$\Leftrightarrow S_t - a_0 - a_2 P_t^* - S_{t-1} + a_0 + a_2 P_{t-1}^* = a_1 \beta C_t - \beta S_{t-1} + a_0 \beta + a_2 \beta P_{t-1}^*$$

$$\Leftrightarrow S_t = a_0 \beta + a_1 \beta C_t + a_2 P_t^* + a_2 (\beta - 1) P_{t-1}^* + (1 - \beta) S_{t-1} \quad (10)$$

Substitute equation (8) and (9) into (5) and do the same, yields:

$$S_t = a_0 \beta + a_2 \beta P_t + a_1 C_t^* + a_1 (\beta - 1) C_{t-1}^* + (1 - \beta) S_{t-1} \quad (11)$$

From equation (10):

$$P_t^* = \frac{S_t - a_0 \beta - a_1 \beta C_t - a_2 (\beta - 1) P_{t-1}^* - (\beta - 1) S_{t-1}}{a_2} \quad (12)$$

From equation (11):

$$C_t^* = \frac{S_t - a_0 \beta - a_2 \beta P_t - a_1 (\beta - 1) C_{t-1}^* - (\beta - 1) S_{t-1}}{a_1} \quad (13)$$

Therefore:

$$\begin{aligned} S_t &= a_0 + 2S_t - 2a_0 \beta - a_1 \beta C_t - a_2 \beta P_t - 2(1 - \beta) S_{t-1} - a_2 (\beta - 1) P_{t-1}^* - a_1 (\beta - 1) C_{t-1}^* \\ &= -a_0 + 2a_0 \beta + a_1 \beta C_t + a_2 \beta P_t + 2(1 - \beta) S_{t-1} + a_2 (\beta - 1) P_{t-1}^* + a_1 (\beta - 1) C_{t-1}^* \end{aligned} \quad (14)$$

From equation (8), we also have:

$$a_2 P_t^* = S_t - a_0 - a_1 C_t^*$$

Substitute into equation (14), yields:

$$\begin{aligned} S_t &= -a_0 + 2a_0 \beta + a_1 \beta C_t + a_2 \beta P_t + 2(1 - \beta) S_{t-1} + (\beta - 1) S_{t-1} - a_0 (\beta - 1) - a_1 (\beta - 1) C_{t-1}^* + a_1 (\beta - 1) C_{t-1}^* \\ &= -a_0 + 2a_0 \beta + a_1 \beta C_t + a_2 \beta P_t + 2S_{t-1} - 2\beta S_{t-1} + \beta S_{t-1} - S_{t-1} - a_0 \beta + a_0 \end{aligned}$$

Hence,

$$S_t = a_0 \beta + a_1 \beta C_t + a_2 \beta P_t + (1 - \beta) S_{t-1} \quad (15)$$

Appendix Table 2 Data Used in Model

Y	Sc _t	Y _t	Q _t	Q _t *	Pc _t	Pp _t	F _t	L _t	Ir _t	R _t
1990	85,656	11.7	56,355	1079910	3389	8220	1913	5000	2300	1194.50
1991	80,899	11.3	62,934	1354870	5751	9980	2200	7000	2500	1136.50
1992	73,806	11.4	84,085	1403340	7419	7780	2350	8500	2800	1435.25
1993	75,246	14.9	107,341	1276274	8139	9600	1700	9000	4000	1481.5
1994	96,043	19.7	154,053	1593710	8952	1750	2240	11700	5000	1481.75
1995	147,449	26.3	180,415	1941098	8850	21080	2870	12500	5000	1401.5
1996	206,593	21.7	269,527	1632838	5340	18500	2780	13000	5520	1724.75
1997	275,926	27.4	362,090	2631578	8819	29700	2357	18000	7000	1461.25
1998	293,906	24.3	364,072	3583011	11529	52000	2039	20000	8000	1491.25
1999	324,388	20.0	486,178	4131860	15052	51500	1496	20000	8000	1623.5
2000	468,649	17.0	689,851	4690742	9707	40500	2130	25000	10000	2401.25
2001	477,600	18.0	761,700	5290308	4825	26350	2334.0	25000	12000	1916.25
2002	448,500	15.0	634,600	4865820	6500	14700	2336.0	28000	12000	1763.25
2003	440,357	16.0	686,510	7498384	9550	17975	2992.0	32000	12000	1862.84
2004	437,758	18.0	768,489	8596800	8932	18750	3877.0	35000	15000	1910.47

Where:

Sc_t = robusta area planted (ha)

Y_t = Yield per hectare (quintal/ha)

Pc_t = average farm gate coffee price (VND/kg)

Q_t = robusta production (ton)

Q_t* = The potential output (ton)

F_t = price of Ure's fertilizer (VND/kg)

Ir_t = irrigation fee in year t (VND/hour)

R_t = amount of rainfall given year (mm)

Pp_t = average farm gate pepper price (VND/kg)

L_t = Labor wage rate in year t (VND/day)

Appendix Table 3 Trial Estimation of Acreage Response Equation of Robusta
Coffee, the Central Highlands, Vietnam, 1990-2004

Variable	Coefficient	Std. Error	T-value
Constant term	-0.999232	1.07408	-0.954005
Lagged two years price of robusta coffee	0.316126	0.120606	2.621149
Lagged price of pepper	-0.040891	0.064690	-0.632113
Lagged planted robusta coffee	0.894547	0.080244	11.14788 ^(*)

R-squared : 0.967252
Standard error of regression : 0.148092
Durbin - Watson statistics : 1.600963
F-value : 88.60984
(*) Significant at 99 percent

Appendix Table 4 Trial Estimation of Acreage Response Equation of Robusta
Coffee, the Central Highlands, Vietnam, 1990-2004

Variable	Coefficient	Std. Error	T-value
Constant term	0.178912	1.719222	0.104066
Price of robusta coffee	0.049165	0.180109	0.272974
Price of pepper	0.080043	0.078648	1.017737
Lagged planted robusta coffee	0.894479	0.088508	10.10625 ^(*)

R-squared : 0.950570
Standard error of regression : 0.187554
Durbin – Watson statistics : 1.052914
F-value : 64.10220
(*) Significant at 99 percent

Appendix Table 5 Trial Estimation of Yield Response Equation of Robusta Coffee, the Central Highlands, Vietnam, 1990-2004

Variable	Coefficient	Std. Error	T-value
Constant term	-8.637372	3.771464	-2.290190 ^(**)
Price of robusta coffee	0.425726	0.150841	2.822339 ^(**)
Lagged yield of robusta coffee	0.839540	0.150633	5.573423 ^(*)
Price of fertilizer	0.345438	0.159997	2.159029 ^(***)
Irrigation fee	0.340256	0.631895	0.538469
Labor wage rate	-0.938429	0.586746	-1.599379
Lagged amount of rainfall	1.185740	0.543053	2.183469 ^(***)

R-squared : 0.863065

Standard error of regression : 0.129331

Durbin - Watson statistics : 1.897499

F-value : 8.403668

(*) Significant at 99 percent

(**) Significant at 95 percent

(***) Significant at 94 percent

Appendix Table 6 Trial Estimation of Yield Response Equation of Robusta Coffee, the Central Highlands, Vietnam, 1990-2004

Variable	Coefficient	Std. Error	T-value
Constant term	-0.749699	2.484216	-0.301785
Price of robusta coffee	0.059945	0.161655	0.370821
Lagged yield of robusta coffee	0.691491	0.191457	3.611728 ^(**)
Price of fertilizer	0.038240	0.190699	0.200527
Lagged amount of rainfall	0.111053	0.290771	0.381927
R-squared	0.640662		
Standard error of regression	0.187389		
Durbin - Watson statistics	1.473194		
F-value	4.457235		

(**) Significant at 95 percent

Appendix Table 7 Trial Estimation of Aggregate Supply Response Equation of Robusta Coffee, the Central Highlands, Vietnam, 1990-2004

Variable	Coefficient	Std. Error	T-value
Constant term	-6.812075	7.030461	-0.968937
Potential production of robusta coffee	0.155194	0.390854	0.397063
Lagged price of robusta coffee	0.344382	0.322567	1.067631 ^(****)
Lagged price of fertilizer	0.086627	0.506577	0.171005
Lagged irrigation fee	1.018997	0.846084	1.204368 ^(***)
Lagged labor wage rate	0.002483	1.210734	0.002051
Lagged amount of rainfall	0.609731	0.556979	1.094710 ^(****)

R-squared : 0.967372

Standard error of regression : 0.214015

Durbin - Watson statistics : 1.593903

F-value : 34.58943

(***) Significant at 73 percent

(****) Significant at 60 percent