EMPIRICAL EVIDENCES FROM A COFFEE PARADOX: AN EXPORT SUPPLY/PRICE ASYMMETRY APPROACH

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export supply model, coffee paradox, elasticity of transmission, price asymmetry, price equation, profit equation

Abstract
This paper aims to determine the solidity of the notion of the "coffee paradox" using annual data from 1977 to 2007. In the confines of an export supply model, we analyze the effects of export coffee price on export volume. Price and profit equation are used to determine the effects of market power on export coffee price and measure changes in the retail and export price. We also estimate the elasticity of transmission and price asymmetry as a means of verifying the "coffee paradox." Ordinary Least Square (OLS), Instrumental Variables (IV), and simultaneous equation with Seemingly Unrelated Regressions (SUR) methods of econometric analysis are employed. Empirical results suggest that the world coffee market is characterized by "coffee paradox" due to different changes between retail and export prices of coffee, and that it is the existence of market power in importing countries that is the main contributor to the condition of price asymmetry.

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1. Introduction

Approximately 2.5 billion cups of coffee are consumed each day around the world, and this rate of consumption ranks coffee as the fifth most actively traded commodity in the world (ICO[1], 2005). In the past several decades, the international coffee market has undergone major changes which include, in particular, a shift in general policy setting, including volatile prices and varying production levels. Figure 1 indicates that export volumes of coffee and the differences between export prices and retail prices of coffee have gradually increased since 1977.

In light of these occurrences, some have argued within the world of coffee for the existence of a so called "coffee paradox[2]," characterized by a "coffee boom" in coffee consuming countries, a widening gap between producer and consumer prices, and a "coffee crisis" in producing countries (Morisset, 1997; Krivonos, 2004; Daviron and Ponte, 2006; and Pierre, 2007). Pierre (2007) makes reference to this paradox and claims that there were at least three different explanations for the coffee paradox. They include: 1) oversupply; 2) reconstruction and concentration within the world coffee market; and 3) the existence of price asymmetry in the transmission of price changes.

The main objectives of this paper are to: 1) determine an export supply model for coffee in order to obtain an estimate of price elasticity 2) determine the existence of market power and 3) explore empirical evidence related to the existence of a coffee paradox in terms of elasticity of transmission and price asymmetry between the export and domestic price of coffee. To accomplish these objectives, this paper is organized as follows. First, a review of the pertinent literature is conducted. Second, data and methodology specifications, including the export supply model, price equation, and profit equation, are discussed. Third, a cointegration test is utilized to examine the annual data.

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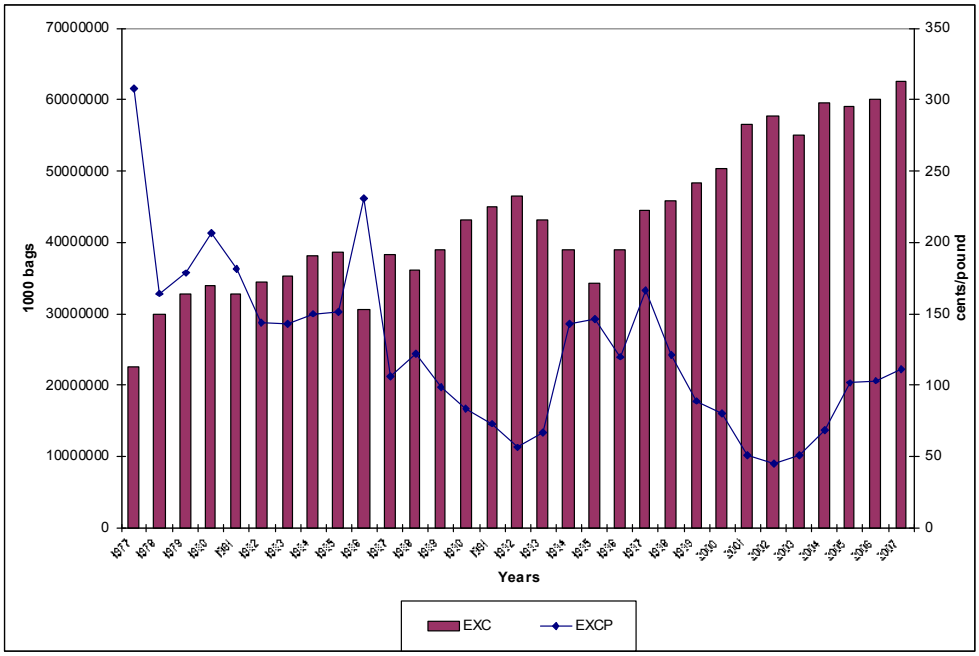
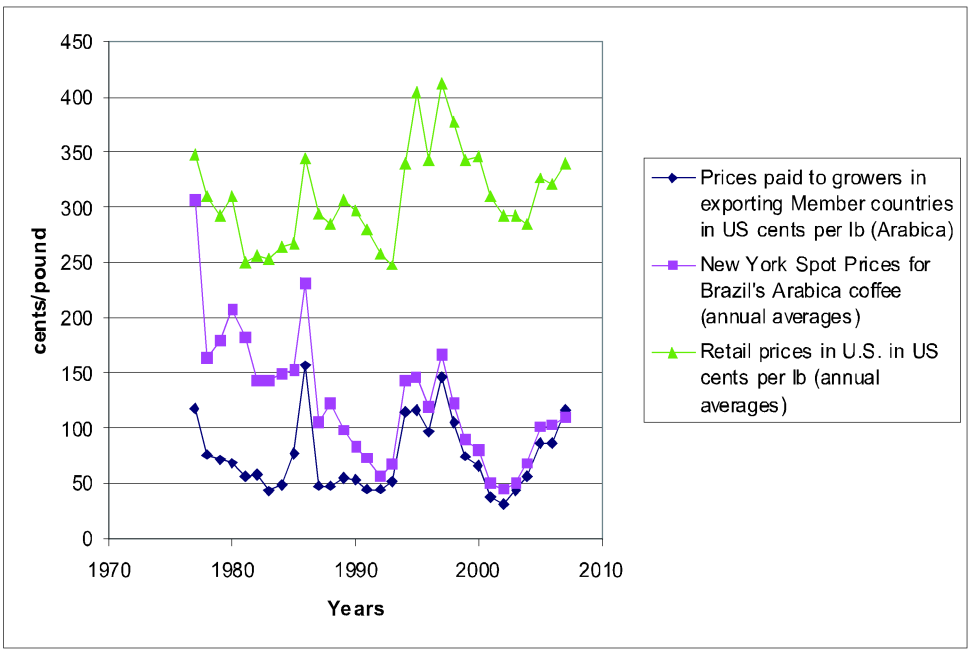
[1] International Coffee Organization

[2] 'coffee paradox' or 'coffee crisis' is characterized by a special feature as follows: Increase of export volume contributes to decrease of export coffee price (see Figure 1). However, decrease of export coffee price causes increase of retail coffee price in importing countries. Therefore, this situation contributes to the depression of coffee producer and profit structure. That is, 'coffee paradox' defines that the differences between export coffee price and retail coffee price are gradually increased.

FIGURE 1. Trends in the World Coffee Market





Note: *EXC* and *EXCP* denote export coffee volume and export coffee price, respectively.
Source: ICO

Ordinary Least Square (OLS) is then used to estimates the export supply function. Analysis is also conducted using Instrumental Variable (IV) models to examine the impact of exogenous variables on export coffee prices, and Seemingly Unrelated Regression (SUR) in the case of simultaneous equations. The empirical results of our specified export supply model show how the exporting price affects both the export quantity and economic growth, and also help to determine the existence of market power. The price/profit equations empirically establish evidence for the elasticity of transmission and price asymmetry. Finally, a summary and conclusion are presented along with suggestions for future study.

2. Review of Literature

An extensive literature has evolved in the past decades using economic theory to analyze the relationships of trade, economic growth, and market power. This section outlines recent studies concerning exporting countries, including empirical analyses, structural economic analysis of trade and economic growth.

First, in order to construct the export supply model, we extend the work of Bahmani-Oskooee and Ltaifa (1992). Bahmani-Oskooee and Ltaifa (1992) examined the effects of exchange rate on the aggregate exports of 67 developed countries using cross-sectional data. They used an export supply function[3] in terms of capturing the exchange rate effect on trade. Therefore, in this paper, we organize an export supply function in the world coffee market and apply for the export price elasticity to measure the profit equation.

Second, several previous papers have investigated the world coffee market, paying particular respect to producer prices and price transmission. Karp and Perloff (1993) estimated the degree of competitiveness and the adjustment paths of two largest exporters. Krivonos (2004) analyzed the impact of coffee sector reforms and considered evidence for which reforms increased the share of producer prices in the world price of coffee. Pierre (2007) sought to determine the main source of the coffee crisis and the coffee paradox within

[3] Basic export supply model is as follows: Export quantity=f(export price, total production, GDP, exchange rate).

fair trade coffee.

Several other previous papers determined the existence of asymmetry in price transmission. Kinnucan and Forker (1987) estimated the asymmetric relationships between changes in the farm level price of milk and changes in the retail prices of major diary products. Mundlak and Larson (1992) analyzed the relationship between domestic prices and world prices of agricultural commodities and showed how world prices are transmitted to domestic prices. Mohanty et al. (1995) investigated price asymmetry in the international wheat market and tested the speed of price adjustments based on Houck (1977).

Based on previous papers, this analysis will estimate the extended export supply model, focusing on the exchange rate and economic growth, to determine the elasticity of transmission and to test for price asymmetry using time lags based on the workings of Boyd and Brorsen (1988) and Mohanty et al. (1995).

3. Data and Modeling

3.1. Data

The data for this analysis is obtained from the USDA and the International Coffee Organization (ICO), and includes variables such as export volume, production, and consumption of coffee[4]. The World Bank database contains variables such as real gross domestic product (GDP). Price databases are also obtained from the ICO. The time period covered ranges from 1976/1977 through 2006/2007.[5] The specific explanations and definitions of estimated variables are shown in Table 1.

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[4] See APPENDIX A.

[5] The Augment Dickey-Fuller test results are APPENDIX B.

TABLE 1. The Definitions of Variables

Variables	Definitions
EXC	Total coffee export quantity (1000 bags) Source: USDA World Markets and Trade (2008) and International Coffee Organization Note: 1 bag=60 kg=132.276 pounds
EXCP	Export coffee price (cents per pound) Source: USDA World Markets and Trade (2008) and International Coffee Organization Note: New York Spot Prices for Brazil's Arabica Coffee
TPC	Total coffee production (1000 bags) Source: USDA World Markets and Trade (2008) and International Coffee Organization
EX GDP	Exporting countries' real gross domestic product (U.S. dollars) Source: The World Bank Database
ER	Real exchange rates for Reals/U.S. dollar Source: USDA Note: The Reals is the Brazilian currency unit.
CIF/FOB	Ratio of Cost Insurance and Freight (CIF) to Free On Board (FOB) Source: International Coffee Organization Note: CIF prices and FOB prices are based on retail prices in importing countries and New York Spot Prices for Brazil's Arabica Coffee, respectively.
OIL	Annual average U.S. crude oil price (U.S. dollars/ton) Source: Financial Trend Forecaster (www.inflationdata.com)
TEAP	Tea prices (U.S. dollars/kg) Source: FAO Tea Composite Price and ITC annual Bulletin
GP	The prices paid to growers in exporting member countries for Arabica (cents per pound) Source: International Coffee Organization
RCP	Retail prices in importing Member countries (cents per pound) Source: International Coffee Organization
EX CR4	Exporting countries' concentration ratio four
IM CR4	Importing countries'concentration ratio four
EXTP	Total exportable production of exporting members (1000 bags) Source: International Coffee Organization Note: Total exportable production indicates the total production less domestic consumption in producing countries.
Inventory	Inventories of green coffee in importing Member countries (1000 bags) Source: International Coffee Organization

3.2. Empirical Models

3.2.1. Market Power and Export Supply Function for the World Coffee Market

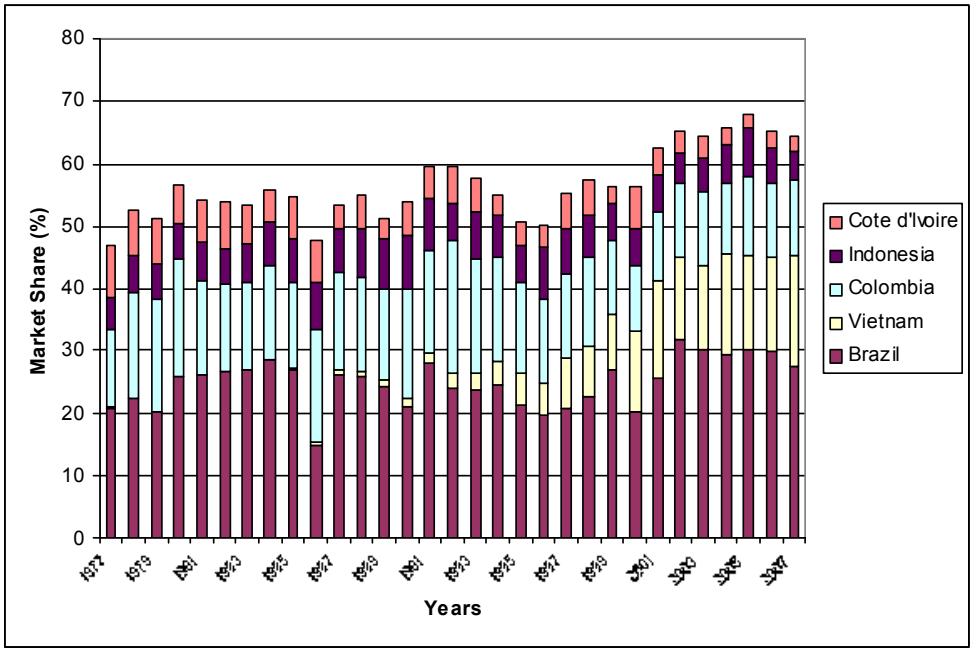
Major exporting/importing countries of coffee are shown in Table 2. Major coffee exporting countries are Brazil, Colombia, Vietnam, Indonesia, and Cote d'lvoire and major coffee importing countries are the United States, Germany, France, and Italy. Figures 2 and 3 indicate the market share and concentration ratio 4 (CR4) based on export/import coffee volume, respectively. On major coffee exporting countries in 2007, Brazil accounted for about 27% of the total world coffee market, Vietnam 17%, and Columbia 12%. The CR4 share for major exporting countries has gradually increased to over 0.4 since 1977. On major importing countries in 2007, the United States accounted for about 24% of the total world coffee market, Germany 19%, Italy 7.5%, and France 6%. The CR4 share for major importing countries has increased to over 0.6 since the 1990s. This implies that the major exporting/importing countries have experienced an increase in market power based on the CR4. However, this does not imply that market power exists in the international coffee market because CR4 shares for exporting/importing countries are ambiguous. Therefore, this study proposes to test the hypothesis that market concentration ratio for exporting/importing countries raises market price, and investigates the relationship between CR4 of exporting/importing countries and coffee.

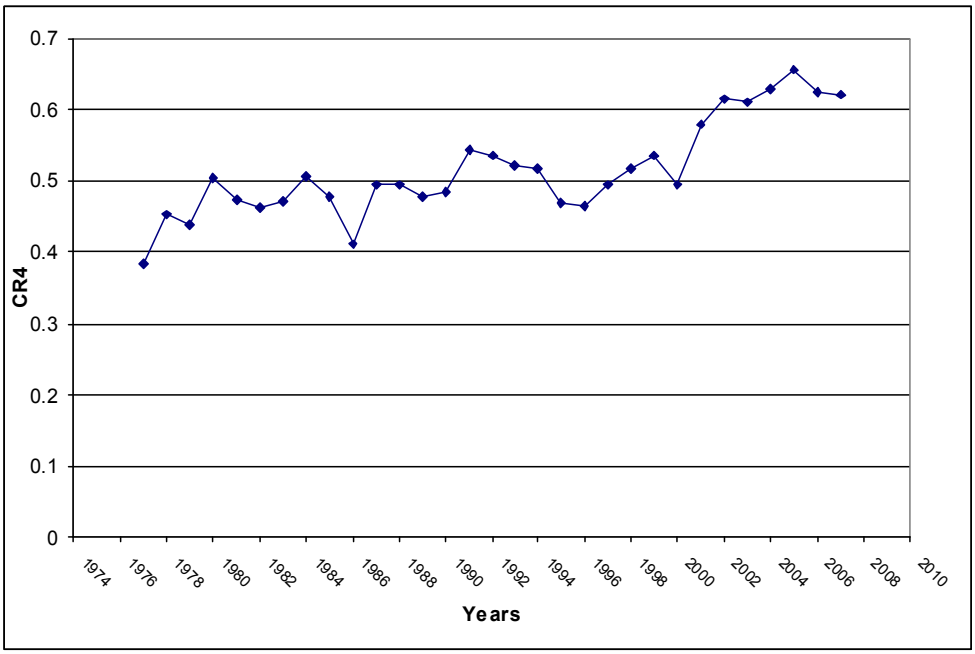
TABLE 2. Exporting/Importing Countries for the World Coffee Market

Major Exporting Countries	Major Importing Countries
Brazil	The U.S.
Colombia	Germany
Vietnam	France
Indonesia	Italy
Cote d'lvoire	Japan

Note: This table is based on the total export/import volumes from 1977 through 2007

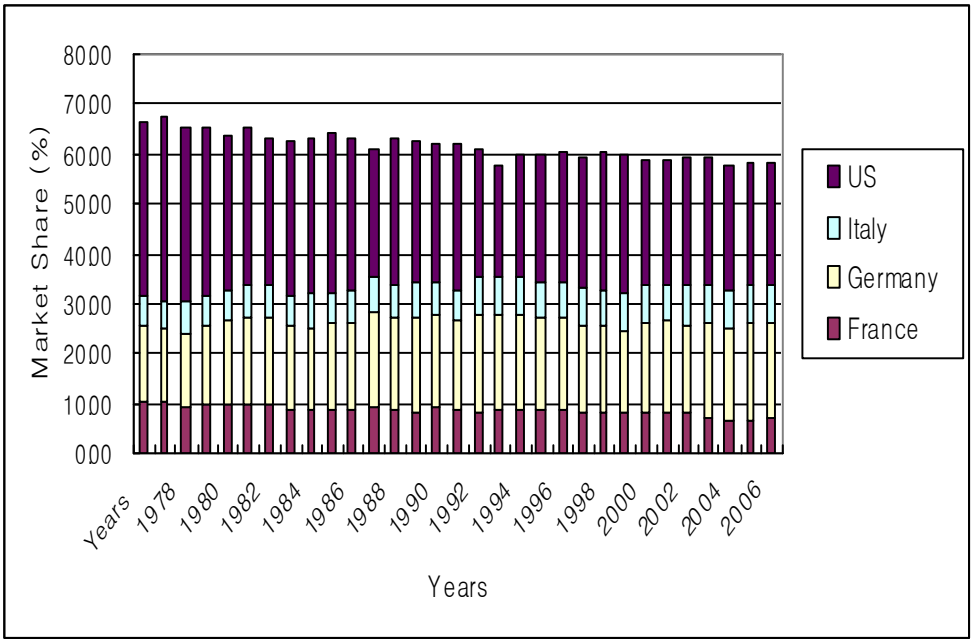
FIGURE 2. Market Share and Concentration Ratio 4 for the World Coffee Market (Major Exporting Countries)

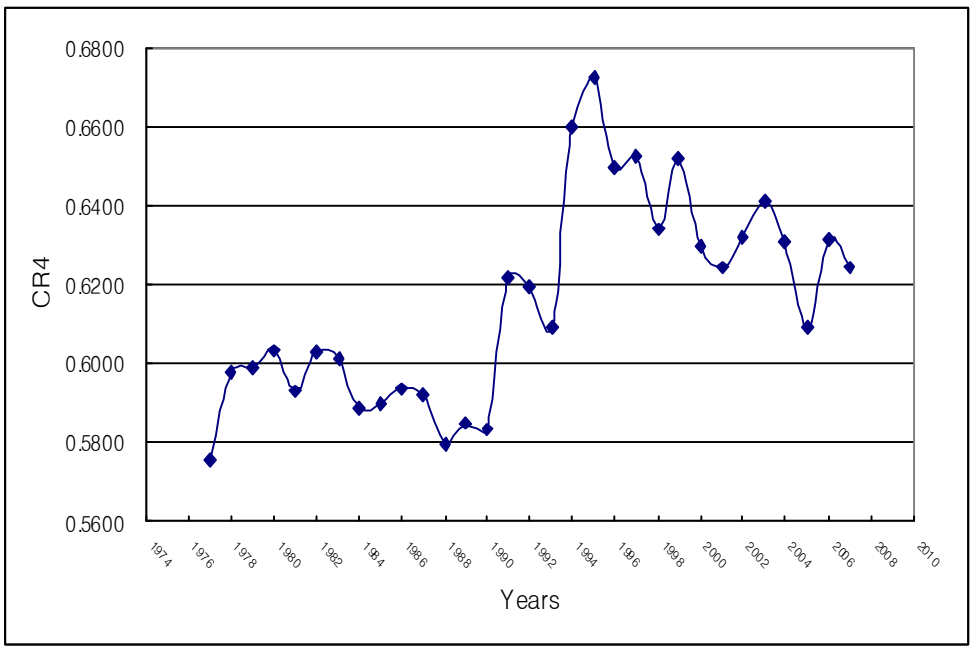




Note: CR4 is based on major exporting countries' volume.

FIGURE 3. Market Share and Concentration Ratio 4 for the World Coffee Market (Major Importing Countries)





Note: CR4 is based on major importing countries' volume.

First, this paper analyzes the existence of market power in the world coffee market using the *Lerner* index. The *Lerner* index is defined as follows:

$$Lerner\,index\,of\,monopoly\,power = \frac{P - MC}{P} \tag{1}$$

where P is export price and MC is the marginal cost of production of the product. However, the *Lerner* index of monopoly power requires the ability to measure marginal cost but this is not easily done. Moreover, price must refer to a constant quality unit since difference in quality implies change in real price (Clarkson and Miller, 1982). Therefore, we use another equation instead of the marginal cost as follows:

$$\frac{P - MC}{P} = \frac{1}{|\eta|}\,^{6} \tag{2}$$

where η is export price elasticity[7] for coffee exporting countries. This equation is equally useful to measure the degree of monopoly. Although the concentration ratio seems to be a useful measure of monopoly power, it has a serious shortcoming. Monopoly power is a function not only of a firm's market share, but also of potential supply from either existing firms or firms that could enter the industry. Samuelson (1965) mentioned that the monopoly power of that one firm could be zero if the potential supply elasticity were sufficiently large. In other words, a price that yields monopoly profits in this situation will cause the existing monopoly to be deluged by new entrants or expansion by existing marginal firms in the industry.

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[6] Basic Lerner Index equation is as follows: Lerner Index= $\frac{P}{\varepsilon} = \frac{}{\varepsilon_M + \eta}$ where ε is the firm's price elasticity of demand, MS is the market share, ε_M is the market price elasticity of demand, and η is the supply elasticity faced by importing countries. Cole (1991) argued that this relates the Lerner Index of monopoly power to market share, but has as a critical argument the supply elasticity of the competitive firms. Therefore, in this paper, we focus on the relationship between the Lerner Index and supply elasticity even if price elasticity of demand is not zero.

[7] $\eta = \frac{dQ}{dP}\frac{P}{Q}$ where P is export price and Q is export volume.

In order to estimate of export price elasticity (η) in exporting countries, we extend the work of Bahmani-Oskooee and Ltaifa (1990) which formulated the effects of real exchange rate on export volume with respect to the export supply function. Based on the basic export supply model, we construct an empirical model of which export coffee quantity is affected by export coffee price, total production, exporting countries' GDP, and exchange rate. The empirical model is as follows:

$$Log\sum_{i=1}^{5}(EXC_{it}) = a_0 + a_1 Log(EXCP_t) + a_2 Log\sum_{i=1}^{5}(TPC_{it}) + a_3 Log\sum_{i=1}^{5}(EX\,GDP_{it}) + a_4 Log(ER_t) + \varepsilon_{1t} \quad (3)$$

where EXC_{it} is aggregated export coffee volume for exporting countries i in period t $EXCP_t$ represents export coffee price in period t TPC_{it} represents aggregated production volume for exporting country i in period t $EX\,GDP_{it}$ represents aggregated real gross domestic product (GDP) of exporting country i in period t ER_t represents real Brazil Real/U.S.$ exchange rate and υ_{1t} is an error term.

The value of a_1 indicates export price elasticity for exporting countries. The expected signs of a_i are positive in terms of the traditional export supply model in which production, price, and exchange rate have positive effects on export volume.

3.2.2. Price Equation

In order to analyze the impacts of other factors affecting export coffee price, we assume the price equation with export coffee price as the dependent variable, with explanatory variables of CIF/FOB, CR4, tea prices, GP, and export coffee volume as follows:

$$\begin{aligned} Log(EXCP_t) = {} & b_0 + b_1 Log(CIF/FOB_t) + b_2 Log(EX\,CR4_t) \\ & + b_3 Log(TEAP_t) + b_4 Log(GP_t) + b_5 Log\sum_{i=1}^{5}(EXC_{it}) + \varepsilon_{2t} \end{aligned} \quad (4)$$

where CIF/FOB_t represents the ratio of CIF to FOB prices in period t $EX\,CR4_t$ represents the concentration ratio of four for exporting countries in period t $TEAP_t$ represents export tea price in period t GP_t represents prices paid to grow-

ers in exporting member countries for Arabica and $\bar{\varepsilon}_{4t}$ is an error term. Equation (4) will use the sub-equation under the export supply model (Equation (3)) for using Instrumental Variable/Generalized Method Moments (IV/GMM). Export coffee price is considered as an endogenous variable.

3.2.3. Marginal Cost and Profit Equation

Based on Equation (2), we obtain the marginal cost as follows:

$$MC_t = \frac{P_t(\eta - 1)}{\eta} \tag{5}$$[8]

From Equation (3), we obtain the estimated result of export price elasticity using OLS and SUR procedure, and then determine the marginal cost for exporting countries in period *t*. Thus, we re-estimate the marginal cost for using production in period *t* as follows:

$$MC_t = c_0 + c_1 TPC_t \tag{6}$$

where *MC* is the marginal cost for coffee exporting countries and *TPC* is production volume.

Using the estimated results of the marginal cost function, we obtain the total cost function using through the integration of Equation (6) with respect to total production quantity of coffee in period *t*. Total production cost function in period *t* is as follows:

$$\int MC_t d(TPC_t) = c_0 \times TCP_t + c_1 \int TPC_t d(TPC_t) \tag{7}$$[9]

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[8] In Table 3, we obtain the estimated coefficient of export coffee price. Especially in Equation (6), we utilize the export price elasticity (−0.1457) based on the OLS robust.

[9] This paper ignores arbitrary constant of integration.
The estimated results and graphs of marginal cost and profit are shown in APPENDIX C.
In this paper, we use the estimated results of cost equation in terms of APPENDIX C.

And therefore

$$TC_t = c_0 \times TPC_t + \frac{c_1}{2} \times (TPC_t)^2 \tag{8}$$

where TC is total cost in exporting countries.

The general profit function is defined as follows:

$$\Pr ofit_t = (\Pr ice_t \times Quantity_t) - (Total\ Cost_t) \tag{9}$$

Using Equations (8) and (9), we obtain the coffee exporting countries' profit equation. Also, we focus on the relationships between profit and price asymmetry with respect to empirical analysis[10]. In order to construct the empirical model, we assume the profit equation, the profit of which is based on the transportation cost (such as oil price), retail/export coffee price difference, and the prices paid to growers in exporting countries. The empirical profit equation is defined as follows:

$$Log(\Pr ofit_t) = e_0 + e_1 Log(OIL_t) + e_2 Log(RCP_t - EXCP_t) + e_2 Log(GP_t) + \varepsilon_{3t} \tag{10}$$

In this paper, we use Equation (10) as the profit equation to determine price asymmetry between retail and export prices for coffee.

3.2.4. Elasticity of Transmission and Price Asymmetry

One reason the world coffee market exhibits a dramatic response to fluctuation

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[10] Daviron and Ponte (2005, page 220) argued that a part of the solution to the commodity problem entails embedding symbolic quality attributes into commodity production. That is, once coffee is blended and roasted, it is sold to consumers under a brand name with essentially no further information on its material quality. This implies that roasters use brand reputation as a proxy for variance in material quality (Daviron and Ponte, 2005, page 220). In other words, this means that a higher price doesn't necessarily buy a better coffee. Therefore, they mentioned that roasters have complete information on material quality when they buy coffee, and they release next to no information on material quality to their clients (Daviron and Ponte, 2005, page 220).

in retail and export prices is the asymmetric response of domestic consumer prices to a change in world prices (Morisset, 1997). Morisset (1997) analyzed the relationships between variations in world and domestic prices in extending the work of Mundalck and Larson (1992). This paper is based on the work of Morisset (1997) and included the relationships between retail prices and the prices paid to growers in exporting member countries of Arabica coffee.

In order to estimate the retail price adjustment, we construct Equation (11) in which retail price (*RCP*) is affected by related price factors (export price, exchange rate, retail price of t-1 period, and producers' price). The general model of retail price adjustment is estimated as follows:

$$Log(RCP_t) = \alpha_0 + \alpha_1 Log(EXCP_t) + \alpha_2 Log(ER_t) + \alpha_3 Log(RCP_{t-1}) + \alpha_4 Log(GP_t) + \varepsilon_{4t} \qquad (11)$$

The coefficients α_1 *and* α_2 [11] are the elasticity of changes in the retail prices with respect to the changes in the export price and the prices paid to growers in exporting member countries of Arabica, respectively, and are analyzed as the elasticity of transmission. Using Equation (11), we show that there exists a significant and positive relationship between these two prices and that this relationship is asymmetric.

To test for price asymmetry, we follow the works of Boyd and Brorsen (1998) and Mohanty et al. (1995). They analyze the static asymmetry for Houck's model. In this paper, we construct a Vector Autoregressive (VAR) model which is based on *RCP* with an explanatory variable, and *EXCP*, *GP*, (*RCP-EXCP*), and (*RCP-GP*) with dependent variables. And we selected optimal lag variables based on the AIC (Akaike Information Crieterion), SBIC (Schwartz Bayesian Information Criterion), and HQIC (Hannan-Quinn Information Criterion). The structure model on which this paper is based can be written as:

[11] If $\alpha_1 = 1$ *and* $\alpha_2 = 1$, there is perfect correlation within commodity prices.

$$\begin{aligned} Log(RCP_t) = {} & \beta_0 + \beta_1 Log(EXCP_t) + \beta_2 Log(EXCP_{t-1}) + \beta_3 Log(EXCP_{t-2}) + \beta_4 Log(GP_t) \\ & + \beta_5 Log(GP_{t-1}) + \beta_6 Log(GP_{t-2}) \\ & + \gamma_1 Log(RCP_t - EXCP_t) + \gamma_2 Log(RCP_{t-1} - EXCP_{t-1}) + \gamma_3 Log(RCP_{t-2} - EXCP_{t-2}) \\ & + \delta_1 Log(RCP_t - GP_t) + \delta_2 Log(RCP_{t-1} - GP_{t-1}) + \delta_3 Log(RCP_{t-2} - GP_{t-2}) + \varepsilon_{5t} \end{aligned} \quad (12)^{12}$$

This analysis tests two asymmetric hypotheses (Boyd and Brorsen, 1988). The first test is that the speed of adjustment of export coffee price (*EXCP*) and the prices paid to grower (*GP*) is the same for retail prices (*RCP*) increase, and the second test is that total effects of export coffee price (*EXCP*) and the prices paid to grower (*GP*) changes are the same for retail prices (*RCP*) increasing changes as follows:

(*Test* 1)

$$H_0 : \gamma_1 = \gamma_2 = \gamma_3 = \delta_1 = \delta_2 = \delta_3 \quad ^{13}$$

(*Test* 2)

$$H_0 : \sum_{i=1}^{3} \gamma_i = \sum_{i=1}^{3} \delta_i$$

Kinnucan and Forker (1987) and Balke, et al. (1998) indicate that market power is the main factor for the asymmetric response in price changes. This study analyzes the impacts of concentration ratio or market power within export/import countries on different changes between retail coffee price and export coffee price.[14] It also investigates the impacts of the supply side with respect to exportable production in exporting countries and inventory in importing countries on the difference changes of retail and export coffee prices as follows:

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[12] The optimal lags of VAR model are selected by the minimum values of AIC, SBIC, and HQIC. In Equation (12), the optimal lags of *EXCP*, *GP*, (*RCP-EXCP*), and (*RCP-GP*) are "2", respectively.

[13] Both hypotheses can be tested by the restriction using F-test

[14] Kelton and Weiss (1989, page 41) proposed to test the basic hypothesis which held that concentration ratio raises price. They constructed a price equation that includes explanatory (price) and dependent (CR4) variables. They found strong evidence that rising concentration does tend to lead to price rises. However, Marion and Geithman (1995) investigated the hypothesis that packer monopsony power had a significant negative effect on cattle prices during the 1971-86 period. They found that cattle prices are negatively affected by increased packer concentration ratio.

$$Log(RCP_t - EXCP_t) = \pi_0 + \pi_1 Log(EX\ CR4_t) + \pi_2 Log(IM\ CR4_t) + \pi_3 Log(EXTP_t) + \pi_4 Log(Inventory_t) + \varepsilon_{6t} \quad (13)^{15}$$

where $EXTP_t$ represents total exportable production of exporting members in period t $Inventory_t$ represents inventories of green coffee in importing member countries in period t and ε_{6t} is an error term. Using Equation (13), we can investigate the source of price asymmetry including exporting/importing countries' market power, total production volume, and inventory.

3.3. Cointegration Tests

Given annual data, we pre-test for stationarity and the existence of a cointegration vector prior to specification of the model. In each OLS and simultaneous equations, we obtain the results of Engle-Granger (EG)[16] test which estimates a unit root test on the residual from the regression model. The null hypothesis of this test is that the residuals are non-stationary. With respect to results from both the OLS and simultaneous equations, we conclude that the residuals are stationary, which means that the dependent variables and explanatory variables of each regression model are cointegrated. Also, we call the estimated equation the static relationship function and interpret it as long run parameters (Greene, 1990).

3.4. Instrumental Variables (IV) and Seemingly Unrelated Regression (SUR)

Instrumental variables (IV) can be used to produce a consistent estimator of a parameter when the explanatory variables are correlated with the error terms (Greene, 1990). Baum and Schaffer (2003) also discussed IV estimation in the broader context of the Generalized Method of Moments (GMM) procedure.

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15 Also, APPENDIX D investigates the relationships between export coffee price/retail prices and CR4 for exporting/importing countries, respectively.

16 See Engle and Granger (1987)

The Breusch-Pagan, Hansen, and Anderson statistics are standard tests for detecting the presence of heteroskedasticity in an OLS model in terms of processing the IV and GMM. We test for over-identification using the *Hansen J-test*. The resulting test statistics show that over-identification is not a problem in the equation. We also test the validity of any instruments using the *Anderson* test. This test has a null hypothesis that the instruments are uncorrelated with the error term. In terms of the results, all cases reject the null hypothesis. Thus, we conclude that at least one instrument variable is not correlated with the random errors. If the instrument variables are not exogenous, then the IV procedure is not consistent and there is doubt as to the validity of the instrument. The *Breusch-Pagan* test illustrates that this equation has a heteroskedasticity problem in terms of rejecting the null hypothesis. Therefore, this equation is estimated with IV/GMM procedure due to the existence of autocorrelation.

The Seemingly Unrelated Regression (SUR) was developed by Zellner (1962) as a procedure for analyzing a system of multiple equations. An econometric model may contain multiple equations which are independent of each other on the surface. Especially, a set of equations that may be related not because they interact but because their error terms are related (Greene, 1990). Therefore, this paper investigates several sub-equations to analyze the simultaneous equations whose dependent variables are determined by the simultaneous interaction of several relationships.

4. Estimation and Results

4.1. Results for Estimated Export Supply Model

Table 3 displays the estimated results of the export supply model (Equation (3)). Because of problems with heteroskedasticity, we use the robust OLS and generalized method of moments (GMM). The coefficients of export coffee price on export coffee volume are −0.1457, −0.1636, and −0.1395 with statistically significance in the robust OLS, IV/GMM, and SUR models, respectively. This implies that the changes of export coffee price respond inelastic on the export coffee volume. Applying Equation (2), the inelasticity of export price on export volume causes to exist of market power in exporting countries. Also, a

1% change in export coffee price decreases exported coffee volume by less than 1%. In the general export supply model, the relationships between export volume and export price are positive in sign while the results of this paper are not positive because there are negative trends for export volume and export price (see Figure 1). That is, exporting countries tend to increase their exporting volumes even if export prices decrease. This causes decreased profit in exporting countries and a "coffee crisis" for producers.

The effects of economic growth, the exchange rate, and production on export volume are positive statistically significant and less than one. This implies that increases in economic growth, the exchange rate, and production cause export volume to increase.

TABLE 3. Estimated Results of Export Supply Model

Explanatory Variables	OLS robust	IV/GMM	SUR
Intercepts	4.6423*** (7.45)	4.7543*** (7.44)	4.5662*** (9.26)
Log(EXCP)	−0.1457*** (−4.01)	−0.1636*** (−4.39)	−0.1395*** (−3.20)
Log(EX GDP)	0.1594*** (2.82)	0.1619*** (2.92)	0.164*** (3.99)
Log(ER)	0.1196** (2.51)	0.0983** (2.20)	0.1196** (2.13)
Log(TPC)	0.2919** (2.29)	0.27** (2.14)	0.2937** (2.68)
R-square	0.9033	0.9022	0.9032
Observations	31	31	31
F-test	69.60***	72.88***	72.58***
Engle-Granger	−0.5297** (−2.27)	−0.5092** (−2.21)	−0.5254** (−2.28)
Anderson	−	97.546*** p-value: 0.000	−
Hansen	−	2.542 p-value: 0.471	−

Note: Dependent variable is Log(EXC). t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

4.2. Results for Estimated Price Equation

Table 4 presents the results of price equations for both robust OLS and SUR models. The effects of the CIF/FOB ratio on the export coffee price are negative and statistically significant. The CIF/FOB ratio serves as a proxy for the transportation costs between exporting and importing countries. However, the negative effects of the CIF/FOB ratio on the export coffee price implies that an increase in transportation cost decreases the export coffee price and increases the difference between exporting and importing country coffee prices.

The concentration ratios for major exporting countries have positive effects on the export coffee price but are statistically insignificant. Thus, the market power of exporting countries does not influence the export coffee price.

In addition, tea prices (considering tea as a coffee substitute) have positive and statistically significant effects on the export coffee price. Increases in the tea price act to increase coffee price.

TABLE 4. Estimated Results of Price Equation

Explanatory Variables	OLS Robust	SUR
Intercepts	3.6604***	3.4157***
	(3.18)	(2.99)
Log(CIF/FOB)	−0.6337***	−0.6464***
	(−8.70)	(−7.61)
Log(EX CR4)	0.195	0.207
	(0.98)	(0.95)
Log(TEAP)	0.1751*	0.1849**
	(1.96)	(2.07)
Log(GP)	0.3733***	0.3706***
	(9.69)	(9.33)
Log(EXC)	−0.3391*	−0.3098*
	(−2.04)	(−1.76)
R-square	0.9822	0.9821
Observations	31	31
F-test	331.70***	342.75***
Engle-Granger	−1.0146***	−0.5254**
	(−4.93)	(−2.28)

Note: Dependent variable is Log(EXCP). t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

The effects of prices paid to growers in exporting countries for Arabica are to increase export coffee price with statistical significance. The increase of export coffee volume negatively affects the export coffee price. These two results imply that the increase of prices paid to growers corresponds with the increase of export prices, but the increase of export volume results in decreased export prices. According to recent trends (see Figure 1), prices paid to growers in exporting countries have gradually decreased, while export coffee volume has increased since 1977. Thus, the export coffee price has gradually decreased due to a decrease in producers' prices and an increase in export volumes.

4.3. Results for the Profit Equation

The estimated results of Equation (10) are as follows:

$$Log(\mathrm{Pr}ofit_t) = -7.2864 - 0.0717Log(OIL_t) - 0.3195Log(RCP_t - EXCP_t) + 0.1033Log(GP_t)$$
$$(36.19)^{***} \quad (-1.43) \qquad (-5.28)^{***} \qquad (2.64)^{**}$$
$$R^2 = 0.6731 \quad F(3,27) = 21.63 \quad Observations = 31 \quad Engle = Granger = -0.8109^{***} \quad (-2.81)$$

Note: t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

According to robust OLS for the profit equation, the elasticity of the difference between retail and export coffee price on profit in exporting countries is −0.3195 with statistical significance. This means that the difference between retail and export coffee price negatively affects the exporting countries' profit. As the difference between two prices increases, the exporting country's profits decrease. However, the increase in producers' received prices cause an increase in profit for exporting countries. Therefore, the differences between retail and export price are one of the main factors contributing to a reduction in exporting countries' profit.

4.4. Results for Elasticity of Transmission and Price Asymmetry

The estimated elasticity of transmission indicates a positive and statistically significant relationship between export coffee price and retail price as follows:

$$Log(RCP_t) = 0.5563 + 0.1576Log(EXCP_t) + 0.1552Log(ER_t) + 0.6398Log(RCP_{t-1}) + 0.2475Log(GP_t)$$
$$(1.70) \quad (3.29)*** \quad (3.00)*** \quad (4.99)*** \quad (5.31)***$$
$$R^2 = 0.5339 \quad F(4,25) = 24.73 \quad Observations = 30 \quad Engle = Granger = -1.2488***(-4.18)$$

Note: t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

The coefficient of *EXCP* is the elasticity of world coffee prices on retail coffee prices, and is analyzed here as the elasticity of transmission. The estimated value of *EXCP* is 0.1576 and implies that variations in world prices are inelastically transmitted to retail price. That is, a one percentage change of world coffee price changes retail coffee price by 0.1576%. And the estimated results of price asymmetry (Equation (12)) and tests for hypotheses are as follows:

$$\begin{aligned} Log(RCP_t) &= 0.3894 - 0.1401Log(EXCP_t) - 0.0661Log(EXCP_{t-1}) + 0.0989Log(EXCP_{t-2}) \\ &\quad (1.86)* \quad (-1.39) \quad (-1.04) \quad (1.36) \\ &\quad + 0.347Log(GP_t) + 0.016Log(GP_{t-1}) - 0.0475Log(GP_{t-2}) \\ &\quad (4.26)*** \quad (0.49) \quad (-1.02) \\ &\quad - 0.1425Log(RCP_t - EXCP_t) - 0.0057Log(RCP_{t-1} - EXCP_{t-1}) + 0.0322Log(RCP_{t-2} - EXCP_{t-2}) \\ &\quad (-1.36) \quad (-0.10) \quad (1.33) \\ &\quad + 1.0494Log(RCP_t - GP_t) - 0.1084Log(RCP_{t-1} - GP_{t-1}) - 0.0971Log(RCP_{t-2} - GP_{t-2}) \\ &\quad (5.43)*** \quad (-0.91) \quad (-1.16) \end{aligned} \qquad 17$$
$$R^2 = 0.9820 \quad F(12,16) = 259.49 \quad Observations = 29 \quad Engle = Granger = -1.061***(-4.22)$$

Note: t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

The estimated coefficient of the prices paid to grower (GP) is 0.347 with statistical significance. That is, a 1% change of GP affects the increase of retail price by 0.347%. And the estimated coefficient of the difference between RCP and GP is 1.049 with statistical significance and this implies that the increasing of the difference between retail price and the prices paid to grower has

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[17] Test 1 and 2 results are F(1.16)=25.61 with p-value=0.0001 and F(1.16)=17.91 with p-value=0.0006, respectively. Although this study follows the work of Boyd and Brorsen (1988) to analyze the elasticity of transmission and price asymmetry in the estimated results of equations (11) and (12), the relationships between retail price and export coffee price are ambiguous. However, this study focuses on the relationships between the difference of coffee prices (based on export/import coffee prices) and market concentrations of exporting/importing countries.

contribute to the increase of retail price. Therefore, the asymmetry of retail price and the prices paid to grower is a main factor which influences the increase of retail price.

The first test is to determine whether the speed of adjustment for both *EXCP* and *GP* is the same as for an increase in *RCP*. The second test is to ascertain whether the total effects of *EXCP* and *GP* changes are the same for *RCP* increasing changes.

The first asymmetry hypothesis is tested by determining whether there is a significant difference between *EXCP* and *RCP*, and *GP* and *RCP* changes. An F-test rejects the hypothesis that these coefficients are equal. The second asymmetry hypothesis is whether there is a significant difference between the sum of the coefficients of *EXCP* and *GP* changes. The F-test rejects the null hypothesis. Therefore, empirical evidence supports the hypothesis that export coffee price and the price paid to growers in exporting countries respond asymmetrically to changes in retail coffee price.

4.5. The Reason for Price Asymmetry

Balke et al. (1998) mentioned that the reasons for price asymmetry are market power, search cost, and inventories in importing countries. To analyze the causes of price asymmetry, this analysis used a simple regression model with the logarithm of differences for retail and export coffee price as the dependent variable and with selling/buying power, exportable production, and inventory in importing countries as explanatory (independent) variables. The estimated results are written as:

$$Log(RCP_t - EXCP_t) = \underset{}{-1.4808} \underset{(-0.77)}{-0.0785 Log(EX\,CR4_t)} \underset{(-0.09)}{+5.7315 Log(IM\,CR4_t)} \underset{(2.71)**}{+0.4458 Log(EXTP_t)} \underset{(1.35)}{} + \underset{(0.54)}{0.1077 Log(Inventory_t)}$$

$$R^2 = 0.5953 \quad F(4,26) = 9.56 \quad Observations = 31 \quad Engle - Granger = -0.6443**(-2.66)$$

Note: t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

The estimated coefficient of importing country CR4 of 5.7315 is statistically significant. This implies that the change in importing countries' buying power has a positive influence on price differences. The estimated values of exportable production in exporting countries and inventory in importing countries are positive in sign but are not statistically significant. That is, the supply side of the world coffee market is not the main factor which brings about changes in retail and export coffee prices. Therefore, with the evidence of price asymmetry, we conclude that importing countries' market power in the world coffee market affects the price asymmetry for both retail and export coffee prices.

5. Summary and Conclusions

The main purpose of this analysis was to estimate an export supply model for the world coffee market, and to examine empirical evidences for the coffee paradox in terms of price/profit equations and price asymmetry. Using annual crop data from 1977 to 2007, the main findings are as follows:

First, coffee exporting countries have market power in terms of relationship between export coffee price and export volume. Export coffee price and export volume have a negative relationship. This explains the phenomenon when the export coffee price has decreased even though export volume has increased.

Second, an increased margin between export and retail coffee prices has contributed to the decrease in profit amongst exporting countries. Increased export coffee price has a positive effect on the retail price. Moreover, the variation in export prices is imperfectly transmitted to the retail price.

Third, the phenomenon of price asymmetry exists in the world coffee market, and price asymmetry is a main factor which contributes to lower profits in exporting countries. The market power of importing country is a major factor contributing to price asymmetry.

In conclusion, the world coffee market is characterized by a "coffee paradox" based on these empirical results. Inconsistent changes in both retail and export coffee prices, resulting from price asymmetry, have served to decreased profit in exporting countries. Price asymmetry, which is influenced by buying power, is the main piece of evidence supporting the existence of the

coffee paradox.

In future research, reconstruction and concentration movements, which may exist in the world coffee market and result in hidden market power within importing countries, should be investigated. This paper suggests that the buying power of importing countries is the main factor contributing to the existence of price asymmetry. However, Pierre (2007) argued that at the trader level the top three companies (Neumann, Volcafe, and Ecom) control approximately 45% of the total coffee market, and Philip Morris, Nestle, Sara Lee, and Procter and Gamble control approximately 69% of the coffee market at the roaster level. Thus, analysis should be conducted to determine the existence of hidden market power within the world coffee market, and verify resulting price asymmetries.

APPENDIX A. Descriptive Data

Variables	Observations	Mean	Std	Min	Max
Log(EXC)	31	7.6203	0.1068	7.3523	7.7961
Log(EXCP)	31	2.0497	0.2048	1.654	2.488
Log(TPC)	31	4.7442	0.1052	4.5356	4.9204
Log(EX GDP)	31	11.7875	0.2339	11.3465	12.2212
Log(ER)	31	0.105	0.1588	−0.1625	0.419
Log(CIF/FOB)	31	0.4367	0.1986	0.0525	0.8118
Log(OIL)	31	1.5873	0.2009	1.1959	1.9898
Log(TEAP)	31	2.66	0.1276	2.4894	2.8873
Log(GP)	31	1.8318	0.1818	1.4899	2.1923
Log(RCP)	31	2.4865	0.0591	2.3929	2.6139
Log(EX CR4)	31	−0.2914	0.0557	−0.4143	−0.1825
Log(IM CR4)	31	−0.2111	0.0182	−0.2397	−0.1723
Log(EXTP)	31	4.624	0.1121	4.3881	4.8152
Log(Inventory)	31	3.8805	0.1721	3.605	4.1245

Note: Definitions of estimated variables are the same in Table 1.

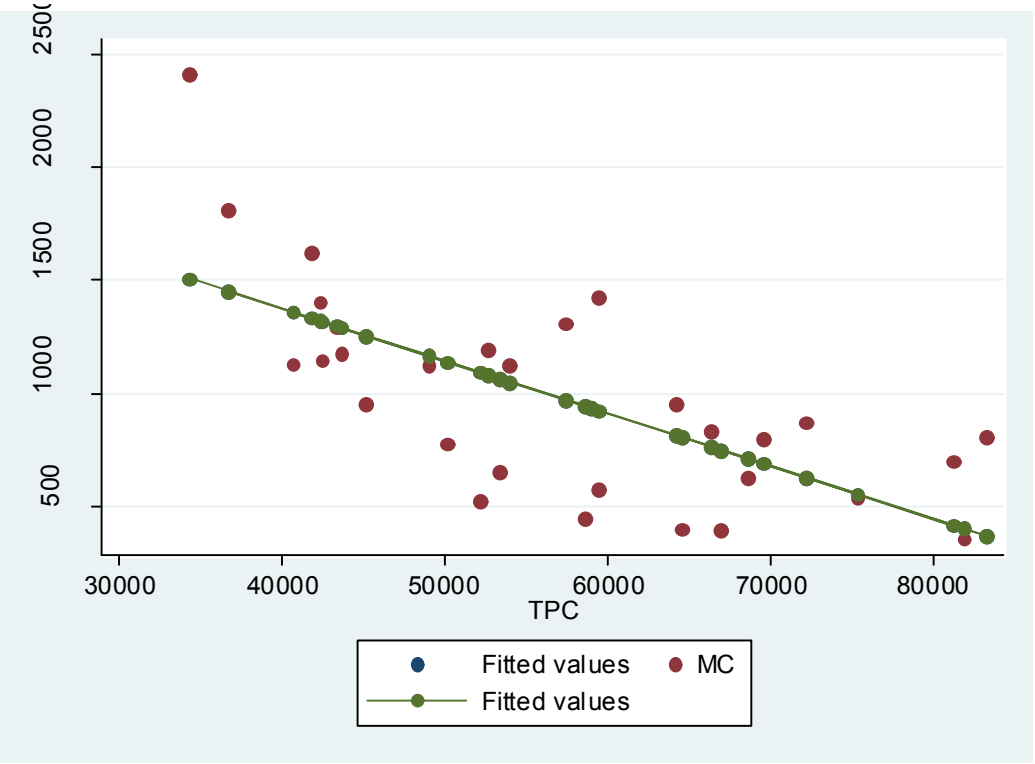
APPENDIX B. Results of Unit Root Test

The unit root test determines the order of integration for those variables that are under consideration. The measure employed for testing the order of integration is known as the Augment Dickey-Fuller (ADF) test. This procedure's statistic rejects the null hypothesis of non-stationarity of all the variables, when first difference variables are used. With respect to the results, we can interpret these parameters as long-run parameters (see Greene, 1990, page 650). The ADF test results are as follows:

Variables	ADF in Levels Lag(0)		ADF First Differences Lag(0)	
	Without Trend	With Trend	Without Trend	With Trend
Log(EXC)	−0.2941** (−2.65)	−0.4024** (−2.60)	−1.035*** (−5.57)	−1.0523*** (−5.67)
Log(EXCP)	−0.2941** (−2.65)	−0.4024** (−2.60)	−1.035*** (−5.57)	−1.0523*** (−5.67)
Log(TPC)	−0.4917*** (−3.25)	−1.3205*** (−7.40)	−1.7223*** (−13.09)	−1.7226*** (−12.85)
Log(EX GDP)	−0.306** (−2.23)	−0.2343* (−1.91)	−0.5591*** (−3.20)	−0.5538*** (−3.11)
Log(ER)	−0.1324* (−1.78)	−0.1948* (−1.81)	−0.6426*** (−3.52)	−0.6675*** (−3.60)
Log(CIF/FOB)	−0.1922** (−2.17)	−0.3331** (−2.17)	−1.0442*** (−5.98)	−1.0628*** (−5.79)
Log(OIL)	−0.1244* (−1.88)	−0.9362* (−1.82)	−0.9188*** (−4.79)	−0.9573*** (−4.89)
Log(TEAP)	−0.1463* (−1.92)	−0.2241* (−1.85)	−1.258*** (−6.75)	−1.3071*** (−7.00)
Log(GP)	−0.4455*** (−2.84)	−0.4386*** (−2.78)	−1.0168*** (−5.36)	−1.032*** (−5.33)
Log(RCP)	−0.3967** (−2.65)	−0.4326*** (−3.15)	−1.673*** (−6.22)	−1.1744*** (−6.14)
Log(EX CR4)	−0.2463** (−2.25)	−0.6065*** (−3.61)	−1.23*** (−7.18)	−1.2493*** (−7.03)
Log(IM CR4)	−0.1586** (−2.23)	−0.8673*** (−4.52)	−1.4162*** (−8.30)	−1.423*** (−8.72)
Log(EXTP)	−0.7267*** (−4.33)	−1.3471*** (−7.69)	−1.7234*** (−13.15)	−1.7244*** (−12.92)
Log(Inventory)	−0.1635** (−2.34)	−0.3046** (−2.21)	−0.8295*** (−4.52)	−0.8279*** (−4.44)

Notes: Definitions of estimated variables are the same in Table 1. t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

APPENDIX C. Estimated Results of Marginal Cost and Profit in Exporting Countries

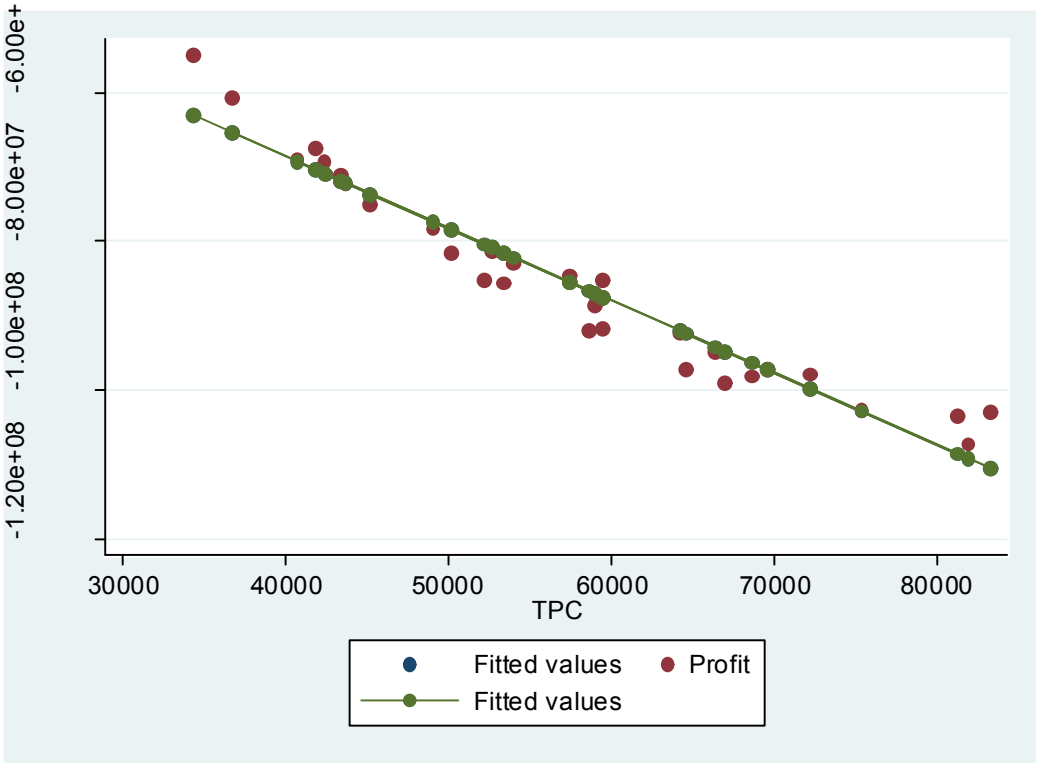


Note: This graph is based on the estimated results of marginal cost as follows:

$$MC_t = 2307.971 - 0.0232TPC_t$$
$$(8.73)^{***} \quad (-5.16)^{***}$$

$R^2 = 0.4790 \quad F(1,29) = 20.32 \quad Observations = 31 \quad Engle = Granger = -0.485^{**}(-2.46)$

APPENDIX C. Continued



Note: This graph is based on the estimated results of profit as follows:

$$\Pr ofit_t = (-2.98e+07) - 969.8708 TPC_t$$
$$(-8.46)^{***} \quad (-15.81)^{***}$$

$R^2 = 0.9384 \quad F(1,29) = 249.91 \quad Observations = 31 \quad Engle = Granger = -0.5359^{**}(-2.35)$

APPENDIX D.

Following up the works of Kelton and Weiss (1989) and Marion and Geithman(1995), this study investigates the relationships between export coffee prices/retail prices and CR4 for exporting/importing countries, respectively. We assume that coffee prices are affected by CR4 and inventory, and the simple log-log models are organized as follows:

$$Log(EXCP)=f(Log(EXCR4),\ Log(IMCR4),\ Log(Inventory))$$
$$Log(RCP)=f(Log(EXCR4),\ Log(IMCR4),\ Log(Inventory))$$

The OLS results of the simple log-log models are as follows:

$$Log(EXCP_t) = 3.3647 + 0.1569Log(EXCR4_t) - 1.6419Log(IMCR4_t) - 0.4707Log(Inventory_t)$$
$$(3.20)^{***}\quad (0.10)\qquad\qquad (-2.70)^{**}\qquad\qquad (-1.30)$$
$$R^2 = 0.6081$$

$$Log(RCP_t) = 2.8331 - 0.142Log(EXCR4_t) + 1.2282Log(IMCR4_t) - 0.0331Log(Inventory_t)$$
$$(6.22)^{***}\quad (-0.54)\qquad\qquad (2.86)^{**}\qquad\qquad (-0.37)$$
$$R^2 = 0.6187$$

Note: t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level. Definitions of estimated variables are the same in Table 1.

In the estimated results, importing countries' CR4 on export coffee price has a negative effect with statistical significance. However, importing countries' CR4 on retail coffee price has a positive effect with statistical significance. This implies that major coffee importing countries' market power affects the exporting/importing coffee prices rather than exporting countries' market power or supply sides.

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