International Journal of Innovative Research and Scientific Studies, 7(3) 2024, pages:1248-1267

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Enhancing Indonesian coffee trade: Strategies for navigating and reducing trade barriers

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Abstract

This study scrutinizes the intricate relationship between production technology advancements and price reactions in the Robusta and Arabica commodities and their collective influence on profitability exploring the relationship between market and policy dynamics and the coffee industry in Indonesia. This study delves into the intricate interplay between market dynamics, policy interventions and technological advancements within the Robusta and Arabica coffee commodities in Indonesia. It employs a historical simulation to scrutinize the multifaceted relationship between production technology advancements, price reactions and their collective influence on the profitability of coffee cultivation in the region from 2008 to 2020. Our research reveals a striking discrepancy between the expansion of coffee cultivation due to technological progress and the delayed price reactions within the Indonesian coffee industry. The industry faces challenges in translating these advancements into immediate profitability for growers despite significant strides in production technology. The study further dissects the role of governmental interventions, such as subsidies in shaping production outcomes and market responses. High bank interest rates emerge as a significant hindrance to industry growth, exacerbating the profitability dilemma faced by coffee growers. Furthermore, the export price elasticity of Robusta coffee exhibits limitations, raising questions about the industry's ability to harness its potential in global markets despite increased production volumes. Our findings underscore the industry's acute sensitivity to policy alterations highlighting the urgent need for strategic reforms targeting high bank interest rates and the expansion of market opportunities. We advocate for comprehensive research efforts that encompass a broader spectrum of variables to yield deeper insights into the complexities of the Indonesian coffee sector.

Keywords: Agricultural policy, Arabica coffee, Historical simulation, Indonesian coffee industry, Market dynamics, Price responsiveness, Robusta coffee.

DOI: 10.53894/ijirss.v7i3.3231
Funding: This study received no specific financial support.
History: Received: 15 November 2023/**Revised:** 6 February 2024/**Accepted:** 28 February 2024/**Published:** 31 May 2024

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Played significant roles in the research process, S.N.L. and A.A.R.D.L.; conceptualizing the study leading the data collection process and conducting the primary analysis of the data, S.N.L.; contributed extensively to the development of the methodology assisted in data analysis, and played a key role in drafting and revising the manuscript, A.A.R.D.L. Both authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Institutional Review Board Statement: Not applicable.
Publisher: Innovative Research Publishing

1. Introduction

The convergence of global trade and the cultivation of coffee give rise to a multifaceted fabric of economic, social and political elements. The global trade in coffee which has been widely examined by Nguyen, et al. [1] with respect to its production implications illustrates the phenomenon of economies of scale. This topic has been further investigated by Harvey, et al. [2]. These economies have practical significance as they facilitate the expansion of export markets for countries leading to an increase in foreign exchange revenues. This is a significant factor for economic growth as emphasized by Da Silveira, et al. [3].

Nevertheless, the implementation of protectionist policies, including export taxes, import tariffs, quotas and subsidies, often poses a significant obstacle to the aforementioned economic expansion. Mundell [4] elucidates the adverse consequences of these regulations which hinder the unrestricted exchange of goods and services and introduce notable inefficiencies such as the suboptimal allocation of labor resources. The present discussion prompts inquiries of a crucial nature regarding the most effective approaches to trade involvement within the coffee industry.

On the other hand, trade liberalization is proposed as a significant catalyst capable of enhancing trade conditions and addressing market imbalances. The studies conducted by Tao and Song [5] provide evidence of the possibility of trade liberalization in attaining the 'law of one price' across various markets. This concept is considered crucial for establishing a well-functioning global market, as affirmed by Kharaishvili and Gechbaia [6]. According to Sharifi et al., the aforementioned change is supposed to promote realignment from manual labor-intensive industries to capital investment-intensive ones which will impact the flow of financial resources [7].

The prevailing academic consensus holds that the implementation of taxes and tariffs with the aim of rectifying domestic market flaws is regarded as incorrect in its approach to enhancing economic growth. According to Laksana [8] there have been recent criticisms suggesting that these tactics are detrimental as they have negative effects on both home economies and global welfare. This position presents a critique of established economic doctrines and advocates for a thorough reassessment of trade policy within the coffee industry.

The objective of this study is to examine the intricacies of global trade and its ramifications for the coffee sector. The central topic of this analysis pertains to the influence of protectionist trade policies and the transition towards trade liberalization on the global coffee trade. The study places emphasis on the agreements made during the Uruguay round of negotiations. The topic at hand holds great significance due to the prominent role of the coffee industry in the economies of numerous developing nations and its large impact on worldwide trade.

A notable deficiency persists in the form of a comprehensive examination of the precise trade obligations undertaken within the coffee sector throughout the Uruguay Round despite the existence of a substantial body of research pertaining to coffee production and trade policy. Prior research conducted by Luig [9] has offered valuable insights into the subject matter, although a comprehensive examination of this crucial juncture in trade history remains incomplete. This study aims to address this knowledge gap by proposing that a thorough comprehension of these commitments is crucial for understanding the present and future dynamics of the coffee business.

The significance of this research is underscored by the prominence of the coffee business. This study seeks to provide insights into the relationship between trade policy and the coffee sector with the objective of offering valuable information to policymakers, industry stakeholders and academics regarding the consequences of trade liberalization. This study aims to provide insights into the potential optimization of trade policy to effectively bolster the growth and stability of the coffee sector. It endeavors to contribute to the establishment of a more equitable and efficient global trading system.

This study explores two primary research questions. Firstly, it examines how policy changes impact Indonesia's Robusta coffee industry focusing on production advancements and price responses. Secondly, it investigates the roles of internal factors, including technological advancements, government interventions and bank interest rates in shaping the industry's profitability and responsiveness. These questions are essential for understanding the dynamics of the coffee industry in Indonesia and for identifying strategies to enhance its growth and resilience.

This paper is structured into several key sections. It begins with an introduction that introduces the context and significance of Indonesia's Robusta coffee industry and outlines the research questions. The literature review section delves into previous studies and theoretical frameworks relevant to the coffee industry, trade policies and market dynamics. In the methodology section, the historical simulation approach used for the study covering 2008-2020 is described. The results section presents the findings, including the impacts of policy changes and internal factors on the industry. This is followed by the discussion which interprets the results and examines their implications. Finally, the paper concludes with a section on conclusion and recommendations summarizing the key findings and suggesting areas for future research.

2 Literature Review

2.1. Trade Liberalization and Its Implications for the Global Coffee Industry

The promotion of trade liberalization has been widely advocated as a means to achieve more self-reliance in agricultural products especially in developing countries. The topic under consideration which holds significant importance in the realm of global economic policy has been subject to thorough examination by Mary [10], Farrell, et al. [11] and Wainaina and Gültekin [12]. The aforementioned investigations have shed light on the extensive advantages associated with the reduction of trade barriers highlighting their favorable relationship with agricultural productivity and the attainment of national self-reliance.

There is a lack of in-depth analysis of the coffee commodity in relation to trade liberalization despite a great deal of academic research on the topic. The lack of attention given to coffee's economic importance and unique market dynamics in existing literature indicates a notable research gap [13]. The distinct characteristics of supply chain dynamics, price volatility and labor practices in the coffee production industry require a customized analytical approach.

The Uruguay Round, a significant landmark in trade talks had a huge impact on worldwide agricultural policies [14]. Nevertheless, the ensuing discussion has rarely explored the direct consequences of this phenomenon on the coffee business which plays a crucial role in the economies of numerous developing countries [15, 16]. Conducting a more comprehensive analysis of the findings of the round could provide significant and invaluable insights into the present condition and prospective trajectory of the global coffee market.

Furthermore, extensive documentation exists regarding the wider implications of trade liberalization, including the flow of resources and the advancement of basic industries in emerging nations [17]. Nevertheless, the simultaneous lack of progress in secondary and tertiary sectors which frequently remain in their early stages indicates an intricate and diverse influence of liberalization measures, warranting a more detailed investigation.

In the specific context of Indonesia, research conducted by Bonar titled "Econometric Model of the Indonesian Hardwood Product Industry: A Policy Simulation Analysis" has provided insights into the consequences of tariffs imposed on timber exports. However, there is a scarcity of comparable studies that specifically examine the thriving coffee industry in Indonesia. It is imperative to conduct econometric research to provide valuable insights for policy-making and the development of competitive strategies considering Indonesia's prominent position as a major producer of Robusta and Arabica coffee.

Econometric models play a crucial role in comprehending the impacts of trade policies. The Armington model used by Meiri, et al. [18] posits that countries that import coffee exhibit sensitivity to fluctuations in demand factors. The significance of strategic policy formulation for nations involved in coffee exports is highlighted by this level of response.

The subject at hand necessitates acknowledging the crucial role of Indonesia as a prominent coffee grower making substantial contributions to the worldwide export market. The international competitiveness of a nation is reliant upon its response to trade liberalization which aims to create a fair and balanced trading environment by eliminating distortions in trade.

The application of econometric modeling to analyze the impact of price variables on the Indonesian coffee industry, employing equations similar to those proposed by Cagan's Adaptive Expectation Model provides a robust approach to forecasting and comprehending market dynamics [19, 20]. This methodology enables the anticipation of planting acreage responses based on projected prices rather than current prices taking into account the inherent uncertainty of future market situations.

2.2. Econometric Modelling and the Competitiveness of the Coffee Industry

The econometric analysis of the Indonesian coffee sector and its global counterpart relies on assessing the competitive position of Indonesian coffee in both home and international markets. The response of the area under consideration to changes in the price variable within a certain year as observed in a study analyzing supply response can be summarized as follows:

$$A^*_t = a_o + a_1 P_t + u_t \quad (1)$$

$$A_t - A_{t-1} = \mu\,(A^*_t - A_{t-1}),\ 0 < \mu \leq 1 \quad (2)$$

By substituting Equation 1 into Equation 2 it is obtained.

$$A_t = b_o + b_1 P_t + b_2 A_{t-1} \quad (3)$$

On Value $b_o = \mu a_o, b_1 = \mu a_1 \; dan \; b_2 = 1_{-\mu.}$

The adaptive expectation model proposed by Cagan is deemed more suitable due to its conceptual foundation rooted in the consideration of uncertainty surrounding future prices [21]. The hypothesis posits that the quantity of planted acreage in period t (At) is not contingent upon the current price but rather on the anticipated price in period t (P*t). The model employed is as follows:

$$A_t = a_o + a_1 P^*_t + u_t \quad (4)$$

The expected price expectations are approached through the following adaptive postulates:

$$P^*_t - P^*_{t-1} = \gamma(P_t - P^*_{t-1}), 0 < \gamma \leq 1 \quad (5)$$

On value

P*t = Expected price this year.

P*t-1 = Price expectations in the past year.

Pt = Actual price in the year.

γ = Coefficient of expectation.

Changes in the expected price in the period t (P*t – P*t-1) are the difference between the actual price (Pt) and the expected price in the previous period (P*t-1). Equations can be written as follows:

$$P^*_t = P^*_{t-1} + \gamma(P_t - P^*_{t-1}) \quad (6)$$

By the transformation of Equation 4 to obtain the P*t which is then made in the form of a lag of one period, it is obtained.

$$P^*_t = -a_o/a_1 + 1/a_1\, A_t - 1/a_1\, u_t \quad (7)$$

$$P^*_{t-1} = -a_o/a_1 + 1/a_1\, A_{t-1} - 1/a_1\, u_{t-1}$$

Equation 5 was obtained by substituting them from Equations 7 and 8.

$$(-a_o/a_1 + 1/a_1\, A_t - 1/a_1\, u_t) - (-a_o/a_1 + 1/a_1\, A_{t-1} - 1/a_1\, u_{t-1}) \quad (8)$$
$$= \gamma[P_t - (-a_o/a_1 + 1/a_1\, A_{t-1} - 1/a_1\, u_{t-1})]$$
$$\text{Or } A_t = (\gamma a_o) + (\gamma a_1) P_t + (1-\gamma) A_{t-1} + [\mu_t - (1-\gamma)\,\mu_{t-1}]$$

In simple terms, the formula can be written as follows:

$$A_t = b_o + b_1 P_t + b_2 A_{t-1} + \varepsilon_t$$

On value, $b_o = \gamma a_o, b_1 = \gamma a_1, b_2 = 1 - \gamma dan\ \varepsilon_t = \mu_t - (1-\gamma)\,\mu_{t-1.}$ (9)

Since the variable Pt can be replaced with Pt-1 in the adaptive expectation model because the price expectation (P) formed for the t period is often unknown, the available information is used, namely the price in the previous period (Pt-1). So the similarity of expectation behavior becomes:

$$A_t = b_o + b_1 P_{t-1} + b_2 A_{t-1} + \varepsilon_t \quad (10)$$
$$A_t = F(P_{t,} PBS_{t,} SB_{t,} UP_{t,} T, A_{t-1}) \quad (11)$$

On value
At = Area of coffee plants in the year to t.
Pt = Coffee price in the year to t.
PBSt = Price of substitution goods in year to t.
SBt = Bank interest rate in the year to t.
UPt = Wage rate in the year to t.
T = Time trend.
At-1 = Acreage in the previous year.
The production side is convex towards the point of origin.

$$Q = Q(A, L, Z,) \quad (12)$$

On value :
Q = Numbers of marginal coffee production from acreage factors.
A = Area of plants producing.
L = Use of labor.
Z = Other factors of production.

Production factors (A, L and Z) are endogenous changes. In contrast, coffee prices (PQ) and price factors (area of Plant Price (PA), use of Labor Price (PL), other factor Production Price (PZ)) are exogenous changes. Therefore, the demand function of the factor can be formulated as follows:

$$A^D = A(P^Q, P^A, P^L, P^Z) \quad (13)$$
$$L^D = L(P^Q, P^L, P^A, P^Z) \quad (14)$$
$$Z^D = Z(P^Q, P^Z, P^A, P^L) \quad (15)$$

On values A^D, L^D and Z^D, each is the demand for land, labor and other factors. By substituting the demand function factors 13, 14 and 15 to the production function 16, the coffee supply function in a given year (QSt) can be formulated as follows:

$$Q^S t = f(P^Q t, P^A t, P^L t, P^Z t) \quad (16)$$

In addition to the price factor of the commodity and the price of production factors, the supply of a commodity is also determined by the cost of factors of production, the purpose of the enterprise, the level of technology, taxes, subsidies, price expectations and other changes. Thus, the coffee offering by producers can be formulated in the form of functions as follows:

$$Q^S t = f(P^Q t, P^S t, P^F t, P^* t, Zt) \quad (17)$$

On value
QSt = Number of coffee offers in year t.
PQt = Price of coffee in year t.
PSt = Price of alternative commodity coffee in year t.
PFt = Price factor-factor of production in year t.
P*t = Expected coffee price in year t.
Zt = Other factors affecting coffee supply in year t.

3. Materials and Methods

The method used in this study involves analyzing time series from 2008 to 2020 through simultaneous structural equations and the two-stage least squares (2SLS) estimation method. This approach allows for the examination of multiple interrelated variables over time. The use of 2SLS is particularly significant as it helps to address potential endogeneity issues ensuring more reliable and valid estimates. This differs from past studies in that it combines a comprehensive time-series analysis with a sophisticated econometric technique providing a more nuanced understanding of the dynamic interplay between policy changes, internal factors and their impacts on Indonesia's Robusta coffee industry.

This study used 12 years of time series from 2008 to 2020. The data was focused on different aspects of coffee including the type of plantation, type of coffee and the main exporting and importing countries. The data was analyzed using simultaneous structural equations and the two-stage least squares (2SLS) estimation method. The specific model formula used is as follows:

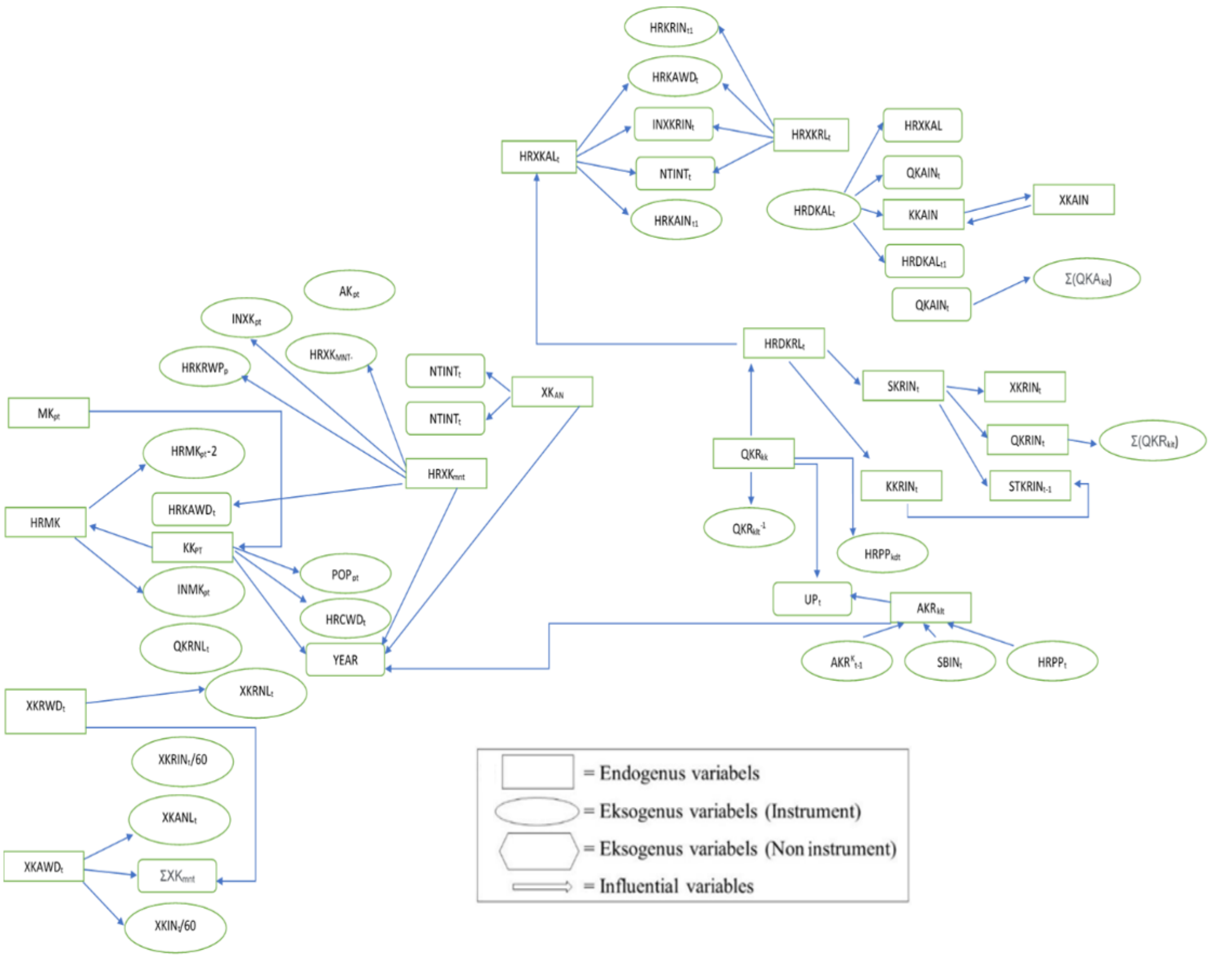

Figure 1.
Simulant scheme.

Figure 1: Dynamics of Indonesia's Robusta coffee industry: A structural model with 2SLS estimation (2008-2020).

Information
AMKR = Robusta Coffee Producing Area.
PBSt = Large Plantations in Sumatra.
PBJt = Large Plantations in Java.
PRSt = Smallholder Plantations in Sumatra.
PBLt = Large Plantations Outside Java and Sumatra.
PRLt = Smallholder Plantations Outside Java and Sumatra.
AMKR= Robusta Coffee Producing Area.
PBSt= Large Plantations in Sumatra.
PRJt= People's Plantations in Java.
PRlt = Smallholder Plantations Outside Java and Sumatra.
QKR = Robusta Coffee Production.
PBSt = Large Plantations in Sumatra.
Xka = Arabica Coffee Export.
BRt= Brazil in the year to-t.
CLt= Columbia in the year to t.
CKt= Costarika in the year to-t.
GLt= Guatemala in the year to-t.
MCt= Mexico in the year to-t.
HRXKA= Arabica Coffee Export Price.
BRt= Brazil in the year to-t.
CL= Columbia in the year to-t.
CKt= Costarika in the year to-t.
GLt= Guatemala in the year to-t.
MCt= Mexico in the year to-t.
IAt= India in the year to-t.
HRMK = Coffee Import Price.

GRt= German in the year to-t.
ITt = Italy in the year to-t.
Ukt = United Kingdom in the year to-t.
Ast = USA in the year to-t.
JP = Japan in the year to-t.
BLt = Dutch in the year to -t.
HRDKL = Domestic Real Assets of Arabica Coffee Outside Java and Sumatra.
HRPPJT = Real Fertilizer Assets on Java Island in year t.
SBINT = Bank Indonesia interest rate in year T.
AKA = Arabic coffee area.
AKCL = Real Colombian coffee year 1.
AKCL1 = Columbia coffee area lags 1 year.
HRXKAGt = Rill price of Guatemala Arabica coffee exports in year t.
AKGLt = Guatemala coffee area.
NTMCt = Mexico exchange rate in year t.
AKMCt = Mexico coffee area in the year t.
AKIAt = INDIAN Arabica coffee area in year t Indian exchange rate in year t.
XKAINT = Indonesian Arabic coffee exports in year.
XKRINt = Indonesia's Robusta coffee exports in year t.
NTINt = The exchange rate of the Indonesian rupiah against the Us dollar in year t.
INXKRINt = Indonesian Robusta coffee export price intervention (%).
QKAWDt = World Arabica coffee production in year t (thousand tons).
QKRWDt = World Robusta coffee production in year t (thousand tons).
QKRNLt = Robusta coffee production in other countries in year t (thousand tons).
QKANLt = Arabica coffee production in other countries in year t (thousand tons).
HRKRWDt = World price of Robusta coffee (cents US dollars per Lb).
HRKAWDt = World price of Arabica coffee (US dollar cents per Lb).
INXKRINt = Indonesian Robusta coffee export price intervention (%).
INXKAINt = Indonesian Arabica export price intervention (%).
MKWDt = World coffee imports (Robusta + Arabica) in year t (tons).
MKNLt = Imports of coffee from other countries (Robusta + Arabica) in the t-th year (tons).
XKRWDt = World Robusta coffee exports in year t (tons).
XKAWDt = World Arabica coffee exports in year t (tons).
XKANLt = Coffee exports from other countries in year t (tons).
KKRINt = Demand for Indonesian Robusta coffee in year t (thousand tons).
KKAINt = Indonesian Arabica coffee demand in year t (thousand tons).
XKRINt = Indonesian Robusta coffee exports in year t (thousand tons).
XKAINt = Indonesian Arabica coffee exports in year t (thousand tons).
HRDKRIt = Domestic price of Indonesian Robusta coffee (Rp/Kg).
HRDKAIt = Domestic price of Indonesian Arabica coffee (Rp/Kg).
SKRINt = Domestic supply of Robusta coffee (thousand tonnes).
STKRINt-1 = Final stock of Robusta coffee (thousand tons).

4. Results

4.1. Multivariate Regression Analysis Outcomes

The results of our multivariate regression study provided valuable insights pertaining to six variables, namely AMKRPBSt, AMKRPBJt, AMKRPBLt, AMKRPRSt, AMKRPRJt and AMKRPRLt. The constant coefficients exhibited considerable variation among the models with AMKRPBSt and AMKRPBLt displaying negative constants (-0.07777 and -0.365, respectively). On the other hand, the AMKRPBJt exhibited a consistently positive value of 5.1514. The constants for AMKRPRSt, AMKRPRJt and AMKRPRLt were relatively greater indicating that each regression model had separate intercept values (see Table 1).

The AMKRPBSt model revealed a positive coefficient (0.0131) for the heart rate kinetics in response to training intensity (HRDKRIt/Upt) suggesting a direct association between the independent variable of training intensity and the dependent variable. The effect of the year was seen to have positive coefficients in many models. Among these models, the AMKRPRJt model displayed the most significant coefficient (3.379) indicating a notable influence that is reliant on time.

The coefficient of AMKRPBS1 in the AMKRPBSt model was found to be significant and positive (0.684876) suggesting a robust positive impact. This finding aligns with the results obtained from the AMKRPRSt model where a comparable positive effect was detected (0.674). The disparity in heart rate kinetics measurements (HRDKRIt2-HRDKRIt1) had beneficial impacts in the AMKRPBJt and AMKRPBLt models.

The HRPPJt variable exhibited a negative coefficient in both the AMKRPBJt and AMKRPRJt models with values of -0.0111 and -0.10196, respectively. This indicates an inverse relationship between HRPPJt and the dependent variables within these particular contexts. The SBINT variable demonstrated negative coefficients in many models with the AMKRPRSt model displaying the highest significant negative coefficient (-0.75521).

The coefficients for the third heart rate kinetics measurement (HRDKRIt3) in the AMKRPRJt and AMKRPRLt models were found to be positive but rather small (0.009 and 0.0024) suggesting a moderate positive trend. The variables AMKRPBL1 and AMKRPRL1 exhibited noteworthy coefficients in their respective models (0.75521 and 0.53) indicating substantial individual impacts on the dependent variables.

The overall fit of the model was deemed excellent as evidenced by the F-statistics ranging from 27.996 to 225.86. Additionally, the R-squared values indicated that the models were able to explain between 84% and 98% of the variability observed in the dependent variables. The considerable degree of explanatory capacity exhibited by our regression models serves as a testament to their resilience while also highlighting the substantial influence exerted by the incorporated variables on the observed results.

Table 1.
Sub-model of area and coffee production with aggregation of coffee types, plantation types and Indonesian territory.

Variables	AMKR*PBSt	AMKR*PBJt	AMKR*PBLt	AMKR*PRSt	AMKR*PRJt	AMKR*PRLt
CONTANTA	- 0.078	5.151	-0,365	18.164	56.468	8.785
HRDKRIt/Upt	0.013	-	-	-	-	-
YEAR	0.009	-	0.0846	-	-	3.379
AMKRPBS1	0.685	-	-	0.674	-	-
HRDKRIt2-HRDKRIt1	-	0.0011	0.00043	-	-	0.0061
HRPPJt	-	- 0.0111	-	-	-0.102	-
AMKR*PBJt	-	0.937	-	-	-	-
SBINT	-	-	-0.755	-0.196	-0.379	-0.151
HRDKRIt3	-	-	-	0.009	0.002	-
AMKR*PBLt	-	-	0.755	-	-	-
AMKR*PRLt	-	-	-	-	-	0.533
F-values and R-squared	F = 83.54 R^2 = 0.94	F = 27.996 R^2 = 0.84	F = 108.011 R^2 = 0.97	F = 225.86 R^2 = 0.98	F = 41.280 R^2 = 0.92	F = 128.314 R^2 =0.9716

4.2. Analysis of Variance Outcomes

The dataset was analyzed using regression analysis specifically focusing on six variables: QKRPBSt, QKRPBJt, QKRPBLt, QKRPRSt, QKRPRJt and QKRPRLt. This study yielded valuable and statistically significant findings. The constant terms (CONTANTA) exhibited substantial variation across each model with QKRPBSt, QKRPBLt and QKRPRLt displaying negative values. This indicates that when all predictors are at zero, the baseline levels of the dependent variables are lower. In contrast, the variable QKRPRSt had a positive constant value suggesting a greater intercept for the model (see Table 2).

The findings indicate that there was a small and positive impact on the dependent variable in the QKRPBSt, QKRPBJt, and QKRPBLt models as a result of the second heart rate kinetics response to training (HRDKRIt2). This suggests that with each unit rise in HRDKRIt2, there was a tiny increase in the dependent variable. Nevertheless, the QKRPRSt model exhibited a more significant impact.

The variable QKRPBSt1 exhibited a statistically significant positive effect in both the QKRPBSt and QKRPRSt models. This implies that previous values of the variable exert a lasting positive impact on its present value within these models.

The variable "YEAR" exhibited varying effects across the models with a particularly strong positive coefficient of 0.6006 in the QKRPBJt model. This finding underscores a consistent and significant temporal pattern within this specific model. The aforementioned phenomenon was similarly noted in the case of QKRPRLt although with a lesser degree of intensity.

The variable “Upt” exhibited heterogeneous impacts displaying a positive coefficient in the QKRPBJt model while demonstrating negative coefficients in the QKRPRJt and QKRPRLt models. These findings suggest a nuanced link that is contingent upon the unique circumstances of each model.

The variables AMKRPBJt and AMKRPRLt exhibited statistically significant positive coefficients in the models QKRPRJt and QKRPRLt, respectively, hence providing more evidence of the impact of these variables on their respective models.

The adequacy of the model fit was generally robust as evidenced by the F-statistic and R-squared values. The QKRPBLt model exhibited the greatest R-squared value (0.975) suggesting that the model has the ability to account for 97.5% of the variability seen in the dependent variable. The QKRPBJt model exhibited the lowest R-squared value (0.6969) indicating a higher degree of unexplained variability within the model. The F-statistics varied from 8.621 in the QKRPBJt model to 189.126 in the QKRPRLt model indicating the overall relevance of these models.

Table 2.
Regression coefficients and model fit statistics for predictive variables.

Variables	QKR*PBSt	QKR*PBJt	QKR*PBLt	QKR*PRSt	QKR*PRJt	QKR*PRLt
CONTANTA	-0.0164	-9.00262	-0.4894	11.668	-7.9272	-16.265
HRDKRIt2	0.000014	0.00077	0.00018	0.0123		
HRPPSt	-0.0004					
AMKRPBSt	0.294			0.3387		
YEAR	0.005	0.6006	0.061			1.7119
QKRPBSt1	0.35			0.369		
Upt		0.0017			- 0.0025	- 0.0039
AMKRPBJt		0.844			0.57579	
HRPPLt			-0.002			
AMKRPBLt			0.4037			
CONSTANTA						
HRDKRIt					0.00236	
QKRPRJt1					0.0991	
HRDKRIt1						0.0034
AMKRPRLt						0.384
F-values and R-squared	F = 27.491 R^2 = 0.9076	F= 8.621 R^2 = 0.6969	F = 145.896 R^2 =0.975	F = 45.264 R^2 = 09235	F = 13.999 R^2 = 0.7887	F = 189.126 R^2 = 0.9806

Sub Model of Indonesian Demand, Supply and Price Identities

Total Robusta coffee production

$$QKRINt = QKRPBSt + QKRPBJt + QKRPBLt + QKRPRSt + QKRPRJt + QKRPRLt$$

Total Indonesian Arabica production

$$QKAINt = QKAPBSt + QKAPBJt + QKAPBLt + QKAPRSt + QKAPRJt + QKAPRLt$$

Robusta coffee offers

$$SKRINt = QKRINt + STKRINt$$

Domestic demand for Robusta-type coffee

$$KKRINt = QKRINt - XKRINt - STKRINt$$

Domestic request for Arabica type coffee

$$KKAINt = QKAINt - XKAINt$$

4.3. Econometric Analysis of Indonesian Coffee Prices

Table 3 presents the findings of an econometric analysis that investigated the factors influencing domestic coffee pricing in Indonesia. The study used two distinct regression models to examine the variables associated with heart rate kinetics of commerce (HRDKRIt) and heart rate kinetics of agriculture (HRDKAIt).

According to the HRDKRIt model, the constant term was determined to be 364.745 which represents the baseline price of coffee in the absence of any other variables. The variable HRXKRIt which denotes the heart rate kinetics of exports, exhibited a positive coefficient of 0.051. This implies that an increase in the heart rate kinetics of exports is associated with a marginal rise in the domestic coffee price. On the other hand, the study conducted by SKRINt demonstrates the impact of market changes on domestic coffee prices revealing a negative correlation (-0.077) between sensitivity and price. This suggests that heightened sensitivity is associated with decreased pricing. The variable KKRINt which may indicate the level of domestic market demand exhibited a robust positive correlation with coffee prices (0.814). The variable HRDKRIt1 representing the heart rate kinetics of trading in the previous period exhibited a positive impact on the current price (0.596). This finding implies that there is a carry-over effect from past trade activity to current pricing.

It is important to note that the constant term in the HRDKAIt model which is intended to capture the agricultural factors influencing coffee prices showed a significantly higher value of 464.477. The coefficient for HRXKAIt had a positive value of 0.0596 suggesting a comparable link to HRXKRIt observed in the first model. This relationship implies that an increase in HRXKAIt is connected with a corresponding increase in domestic coffee costs. The KKAINt variable had a significantly positive coefficient (12.431) indicating a robust correlation between coffee prices and this agricultural indicator. The variable HRDKAIt1 exhibited a positive coefficient of 0.568 indicating a positive temporal effect comparable to that of HRDKRIt1 in the initial model.

The adequacy of the models was assessed by means of F-statistics and R-squared values. The HRDKRIt model exhibited a statistically significant F-statistic of 3.647 indicating a significant relationship between the independent variables and the dependent variable. Furthermore, the model accounted for 50% of the variability observed in domestic coffee prices as evidenced by an R-squared value of 0.50. On the other hand, it is worth noting that the HRDKAIt model exhibited a somewhat superior performance as evidenced by its F-statistic of 6.053 and R^2 value of 0.62 which account for 62% of the observed variation. The obtained values indicate that the model fits are moderate with the HRDKAIt model demonstrating slightly higher predictability of domestic coffee prices compared to the HRDKRIt model.

Table 3.
The domestic price of Indonesian coffee.

Variables	HRDKRIt	HRDKAIt
Constanta	364.745	464.477
HRXKRIt	0.051	-
SKRINt	- 0.077	-
KKRINt	0.814	-
HRDKRIt1	0.596	-
HRXKAIt	-	0.059
KKAINt	-	12.431
HRDKAIt1	-	0.568
Information	F =3.647 R^2 = 0.50	F =6.053 R^2 = 0.62

4.4. Determinants of Indonesia's Exports and Export Prices

The research investigated the exports and export prices of Indonesia by using six regression models. The objective was to determine the influence of several economic variables on the volume and price of exports. The findings are presented in Table 4. The HRDKRIt and HRDKAIt models which are believed to be indicative of export volume and agricultural exports indicate that the base price constants are 364.745 and 464.477, respectively. These values represent the initial price levels for Indonesian exports in these specific categories. The HRXKRIt variable exhibited a somewhat positive impact on HRDKRIt with a coefficient of 0.051. Simultaneously, it can be shown that HRDKAIt exhibited a marginal influence from HRXKAIt (0.0596) suggesting a minor rise in export prices in response to changes in these variables. The KKRINt and KKAINt variables exhibited notable positive impacts on their respective models with values of 0.814 and 12.431, respectively. These results suggest that these factors have considerable influence on export prices. The beneficial continuities from previous periods were also evidenced by the lagged effects of HRDKRIt1 and HRDKAIt1.

The XKRINt and XKAINt models exhibited significantly lower constants (27.624 and 2.586) respectively which may be associated with distinct export categories. The observed low effects of the lagged differences (HRXKRIt1-HRXKRIt and XKAINt1) indicate the presence of a consistent and steady trend throughout the course of time. The QKRINt and QKAINt coefficients demonstrated a favorable correlation with export volumes or prices.

The HRXKRIt and HRXKAIt models which pertain to the heart rate kinetics of exports and agriculture, respectively, exhibit negative constants (-578.700 and -251.108). This negative value implies a potential decrease in prices from the baseline assuming all other variables remain the same. The variables HRKRWDT and HRKAWDT exhibited noteworthy positive coefficients (9.0266 and 14.115) which may indicate the substantial influence of broader economic factors on export pricing. The presence of negative coefficients specifically -163.79 and -913.784 for the variables INXKRINt and INXKAINt could potentially suggest a correlation between export prices and international dynamics.

The explanatory capacities of the models exhibited variability with the HRXKRIt and HRXKAIt models demonstrating notable R-squared coefficients (0.9450 for both) implying that these models possess the ability to account for 94.50% of the fluctuations observed in the dependent variables. These findings indicate a robust alignment between the models and the heart rate kinetics variables as the latter provide a significant predictive capacity for the outcomes. In contrast, the HRDKRIt and HRDKAIt models had R-squared values of 0.50 and 0.62, respectively suggesting moderate levels of fit. These results imply that additional factors beyond the ones considered in the models may contribute to the determination of export volumes and prices.

Table 4.
A sub-model of Indonesia's exports and export prices.

Variables	HRDKRIt	HRDKAIt	XKRINt	XKAINt	HRXKRIt	HRXKAIt
Constanta	364.745	464.477	27.624	2.586	-578.700	-251.108
HRXKRIt	0.051					
SKRINt	- 0.077					
KKRINt	0.814					
HRDKRIt1	0.596	0.568				
HRXKAIt		0.059				
KKAINt		12.431				
HRXKRIt1-HRXKRIt			0.002	0.0000		
QKRINt			0.438			
XKA*INt1			0.364			
QKAINt				0.303		
XKA*INt1				0.374		
HRKRWDT					9.027	
INXKRINt					- 163.79	
NTINt					0.097	
HRXKRIT1					0.185	
HRKAWDT						14.115
INXKAINt						- 913.784
F-values and R-squared	F =3.647 R^2 = 0.50	F =6.053 R^2 = 0.62	F = 15.674 R^2 = 0.746	F =16.558 R^2 = 0.75	F = 64.485 R^2 = 0.945	F = 64.485 R^2 = 0.945

4.5. Econometric Modeling of Coffee Production in Major Exporting Countries

The regression analysis was conducted on six models to examine the factors that influence coffee output in the top coffee-exporting countries. These countries are represented by the variables QKABRt, QKACLt, QKACKt, QKAGLt, QKAMCt, and QKRIAt (see Table 5).

The QKABRt model which may be linked to coffee production in Brazil had a positive constant value (24.235) indicating the presence of a fundamental production level. The positive impact of the lagged difference between heart rate kinetics of Arabica coffee (HRXKABR1-HRXKABRt) and the current period's Arabica coffee production (AKBRt) on the model suggests that both historical patterns and present levels of Arabica coffee production cumulatively contribute to the outcome variable. The presence of a negative coefficient (-0.00129) for the variable HRCWDt suggests a potential relationship between an increase in coffee waste disposal and a modest decrease in coffee production.

The constant of the QKACLt model exhibited a negative value of -10.59 which could potentially indicate a deficiency in the levels of output. Nevertheless, the presence of positive coefficients in variables such as year, the lagged difference in heart rate kinetics of coffee leaf rust (HRXKACL1-HRXKACLt) and the preceding period's coffee leaf rust (QKACLt1) indicate a temporal rise in production and a possible gradual recuperation from the negative effects of leaf rust.

The QKACKt, QKAGLt and QKAMCt models exhibited a range of positive and negative constants and coefficients. The observed increase in production over time as indicated by the positive impact of the variable "year" across all models suggests a consistent increasing trend. Additionally, the variables "HRXKACKt", "AKCKt" and the lagged production variable "QKAGLt1" demonstrated a direct association with their respective coffee production outputs.

The QKRIAt model exhibited a small negative constant value of -0.9792. Nevertheless, the presence of positive coefficients for AKIAt (0.00991), NTIAt (0.116861) and the lagged variable HRXKRIAt (0.000927) indicates that despite an initial decrease, there are noteworthy variables contributing to the rise in coffee production.

The model fit statistics as evidenced by the F-statistic and R-squared values exhibited robustness across all models. The QKACKt model exhibited the greatest R-squared value (0.8668) indicating that it accounted for around 86.68% of the variance and implying a strong predictive capacity. Even though the model QKABRt has the lowest R-squared value of 0.6175, it nevertheless has a noteworthy ability to explain a substantial percentage of the variability in production. This suggests that the variables incorporated in the model are meaningful predictors.

Table 5.
Production sub-model of the world's leading coffee exporting countries.

Variables	QKABRt	QKACLt	QKACKt	QKAGLt	QKAMCt	QKRIAt
Constanta	24.235	-10.59	-0.332	0.381	1.516	-0.979
HRXKABR1-HRXKABRt	0.005					
AKBRt	0.001					
HRCWDt	-0.001					
YEAR		0.084	0.0655	0.098	0.0319	
HRXKACL1-HRXKACLt		0.044				
AKCLt		0.013				
QKACLt1		0.71				
HRXKACKt			0.001			
AKCKt			0.007			
HRXKAGLt				0.002		
AKGLt				0.003		
QKAGLt1				0.131		
HRKAWDt*NTMCt					0.009	
AKMCt					0.005	
AKIAt						0.099
HRXKRIAt						0.092
NTIAt						0.116
F-values and R-squared	F = 6.053 R^2 =0.617	F = 10.292 R^2 = 0.735	F = 34.715 R^2 = 0.866	F = 16.723 R^2 = 0.816	F = 15.121 R^2 = 0.739	F = 20.764 R^2 = 0.80

4.6. Export Dynamics of the Top Coffee-Exporting Countries

The examination of export sub-models about the primary coffee-exporting nations elucidated the diverse aspects that exert an influence on the quantities of coffee exports as presented in Table 6. A set of explanatory factors was used to test six models, each corresponding to a certain country. These models are designated by the variables XKABRt, XKACLt, XKACKt, XKAGLt, XKAMCt and XKRIAt.

The XKABRt model which is likely associated with Brazil demonstrates that the positive constant (2.8512) and the coefficient for QKABRt (0.530) signify a fundamental level of exports and a substantial influence of domestic production on export quantities. The coefficient for the interaction term (HRXKABR1-HRXKABRt)*NTBRt was found to be positive (0.00502) indicating that this factor has an additional effect on exports.

The XKACLt model which is connected to a country such as Colombia incorporates many variables to analyze the export levels. The positive constant (1.20760) represents the baseline level of exports. Additionally, the variables HRXKACL2 and QKACLt have a positive impact on export levels while the lagged variable XKACL1 indicates a sustained influence from earlier periods.

The XKACKt model demonstrated a consistent and relatively low constant value of 0.1003. Additionally, it revealed a positive coefficient for the variable (HRXKACKt - HRXKACK1) suggesting that alterations in this particular variable had a positive impact on export levels. QKACKt also exerted a direct influence on exports though to a lesser extent.

In the context of the XKAGLt model which can be associated with a nation such as Guatemala, it is noteworthy that despite the presence of a negative constant (-2.5036), the positive coefficients assigned to HRXKAGL1 and QKAGLt variables indicate the existence of other factors that contribute to the upward trend in exports.

In the XKAMCt model, the constant exhibited a little positive value (0.2272). Additionally, HRXKAMC2, QKAMCt, and NTMCt demonstrated positive contributions suggesting a potential relationship between these variables and the country's capacity to enhance its export activities.

The XKRIAt model which may pertain to Indonesia exhibits a negative constant (-1.216). However, the positive coefficients for HRXKRIAt, QKRIAt and NTIAt suggest that certain internal factors within the country are fostering the expansion of exports despite the initial negative baseline.

The model fit statistics demonstrated varying levels of predictive capability among the different models. The XKAGLt model demonstrated a notable R-squared value of 0.9282 indicating that about 92.82% of the variability in exports can be accounted for by the model. This finding suggests a strong level of fit between the model and the observed data. In contrast, the XKACLt, XKACKt and XKRIAt models exhibited much lower R-squared values (about 0.589) indicating a more moderate level of explanatory power.

Table 6.
Export sub-model of the leading exporting country of coffee.

Variables	XKABRt	XKACLt	XKACKt	XKAGLt	XKAMCt	XKRIAt
Constanta	2.851	1.207	0.103	-2.5036	0.2272	-1.216
QKABRt	0.530					
YEAR	0.886				0.0412	
(HRXKABR1-HRXKABRt)*NTBRt	0.005					
HRXKACL2		0.001				
QKACLt		0.589				
XKACL1		0.207				
(HRXKACKt - HRXKACK1)			0.002			
QKACKt			0.160	0.032		
XKAWDt			0.269			0.074
HRXKAGL1				0.002		
QKAGLt				0.099		
HRXKAMC2					0.001	
QKAMCt					0.390	
NTMCt					0.185	
HRXKRIAt						0.002
QKRIAt						0.093
NTIAt						0.029
F-values and R-squared	F = 6.053 R^2 = 0.617	F = 7.654 R^2 = 0.589	F = 7.617 R^2 = 0.588	F = 68.928 R^2 = 0.928	F = 11.597 R^2 = 0.755	F= 5.379 R^2 = 0.589

4.7. Determinants of Export Prices in Major Coffee-Exporting Countries

The regression models that were created to study the determinants of coffee export prices among the world's major coffee-exporting countries yielded significant insights into the various factors that influence export prices. The variables included in these models denote the coffee export prices of the corresponding nations specifically HRXKABRt, HRXKACLt, HRXKACKt, HRXKAGLt, HRXKAMCt and HRXKRIAt as presented in Table 7.

The presence of positive constants in all models indicates the existence of an inherent baseline export price for coffee. Among the models, HRXKABRt exhibits the lowest constant value (7.538) while HRXKRIAt demonstrates the greatest constant value (48.695). This observation may indicate intrinsic disparities in the fundamental export pricing of these nations.

The findings demonstrate a consistent positive relationship between the heart rate of world demand (HRKAWDt) and export prices of coffee across all models. The coefficients range from 0.648 to 0.8797 suggesting that an escalation in global demand is linked to a corresponding rise in coffee export prices from these nations.

The HRXKABRt model potentially pertaining to Brazil indicates that the international price index (INXKABRt) has a notable negative coefficient (-72.193). This finding implies that fluctuations in international prices exert a strong downward influence on export prices. A similar pattern was noted in the INXKACLt, INXKACKt, INXKAGLt, INXKAMCt, and INXKRIAt models for other nations whereby negative coefficients ranging from -120.92I to -156.14 were detected. This suggests that international indices have a significant influence on the determination of export prices.

The coefficient for the variable "year" had a positive value in both the HRXKABRt and HRXKACLt models, specifically 1.1682 and 0.339 respectively. This indicates a consistent upward trend in export prices on a yearly basis.

The positive impact of lagged variables specifically HRXKACL1, HRXKACK1, HRXKAGL1 and HRXKAMC1 on export prices indicates the influence of prices from the previous year on export prices in the current year.

The model fit statistics as evidenced by the F-statistic and R-squared values demonstrate a high level of robustness. The R-squared values varied between 0.9213 for HRXKRIAt and 0.9887 for HRXKACKt. The high R-squared values suggest that the models possess the ability to account for a significant percentage of the variability observed in export prices for the respective nations. This underscores the effectiveness of the predictors employed in the models.

Table 7.
Export price sub-model of the world's leading coffee exporting countries.

Variables	HRXKABRt	HRXKACLt	HRXKACKt	HRXKAGLt	HRXKAMCt	HRXKRIAt
Constanta	7.538	12.0135	9.531	25.195	4.754	48.695
HRKAWDt	0.648	0.822	0.852	0.776	0.879	0.701
INXKABRt	- 72.193					
YEAR	1.168	0.339				
INXKAGLt				-144.327		
INXKACLt		- 156.14				
HRXKACL1		0.079				
INXKACKt			- 141.12			
HRXKACK1			0.090			
HRXKAGL1				0.042		
INXKAMC					-122.753	
RXKAMC1					0.086	
INXKRIAt						- 120.92I
F-values and R-squared	F = 73.370 R^2 = 0.932	F = 170.335 R^2 = 0.979	F =466.631 R^2 = 0.988	F = 175.991 R^2 = 0.970	F = 238.364 R^2 = 0.978	F = 99.498 R^2 = 0.921

4.8. Coffee Consumption Patterns in Key Importing Countries

The regression models of the study investigated the factors influencing coffee consumption in six major coffee-importing nations. These nations are denoted by the variables KKGRt, KKITt, KKUKt, KKASt, KKJPt and KKBLt as shown in Table 8.

The constants associated with each model exhibited significant variation with certain countries such as KKITt and KKUKt displaying notably negative constants (-57.07 and -114.404). This observation perhaps indicates a fundamental decrease in consumption or a considerable threshold for growth. On the other hand, the KKASt variable exhibited a consistently positive value of 18.9352 suggesting a distinct underlying consumption trend.

The KKGRt model which may pertain to Germany exhibits a negative coefficient (-0.0177) for the variable HRMKGRt. This coefficient suggests that an increase in HRMKGRt is associated with a decline in consumption presumably reflecting the influence of market health or consumer confidence. The studies conducted by YCGRt and KKGRt1 have shown evidence of favorable outcomes indicating that economic circumstances and previous levels of consumption play crucial roles in influencing present consumption patterns.

The KKITt model which is presumably linked to Italy reveals that POPITt (population) has a significant positive coefficient (1.0783) indicating the significance of demographic variables in the context of coffee consumption. The HRMKITt exhibited a detrimental impact while the lagged variable KKITt1 indicated the continuation of previous patterns of consumption.

The model used in the United Kingdom (UK) analysis denoted as KKUKt revealed a negative coefficient for HRMKUKt and a robust positive coefficient of 2.461424 for POPUKt. This highlights the noteworthy influence of population size on coffee consumption. The KKBLt model exhibited a comparable trend wherein the variable POPBLt displayed a positive coefficient (0.231839) strengthening the impact of demographic factors on consumption.

In the KKASt study, the model incorporated the variable "year" which exhibited a negative coefficient (-0.0100052) suggesting a modest annual decline in coffee consumption despite the presence of a positive constant term.

The KKJPt model which represents Japan exhibits a negative coefficient of -0.00127 for the variable HRMKJPt. This negative coefficient may suggest a potential sensitivity to market health. Simultaneously, the POPJPt variable exhibited a positive impact on consumption with a coefficient of 0.313 which aligns with the demographic effects observed in previous models.

Table 8.
Consumption sub-model of the world's leading coffee importer countries.

Variables	KKGRt	KKITt	KKUKt	KKASt	KKJPt	KKBLt
Constanta	5.344	-57.07	-114.404	18.9352	-33.176	-0.435
HRMKGRt	- 0.017					
YCGRt	0.188					
KKGRt1	0.134					
HRMKITt		- 0.002				
POPITt		1.078				
KKITt1		0.119				
HRMKUKt			-0.010			
POPUKt			2.461			
KKUKt1			0.135			
HRMKASt				- 0.009		
YEAR				-0.010		
HRCWDt				0.034		
HRMKJPt					- 0.012	
POPJPt					0.313	
HRMKBLt						- 0.004
POPBLt						0.231
F-values and R-squared	F = 27.448 R^2 = 0.837	F = 6.042 R^2 = 0.532	F = 116.901 R^2 = 0.956	F = 3.895 R^2 = 0.422	F = 186.756 R^2 = 0.956	F = 7.250 R^2 = 0.463

The model fit statistics as evidenced by the F-statistics and R-squared values exhibited a range of explanatory power ranging from moderate to high. The R-squared values for the KKUKt and KKJPt models were found to be 0.9564 and 0.9565, respectively. These values suggest that these models have the ability to account for more than 95% of the variability observed in coffee consumption. On the other hand, it is worth noting that KKASt and KKBLt exhibited the least favorable R-squared values (0.4221 and 0.4603) indicating the possibility of unaccounted factors that may contribute to the variation in coffee consumption within these particular countries.

4.9. Import Patterns in Leading Coffee-Importing Countries

Table 9 presents the regression models that examine the import behavior of six notable coffee-importing nations, denoted as MKGRt, MKITt, MKUKt, MKASt, MKJPt and MKBLt. The construction of these models aimed to identify the key characteristics that have a substantial impact on coffee imports in each individual country.

The constants used in the models function as fundamental indicators for imports exhibiting noteworthy variations such as the relatively elevated baseline of MKUKt (9.96428). This observation implies a robust initial reference point for coffee imports. In contrast, the MKITt data demonstrated a modest negative constant value of -0.29337 suggesting a reduced threshold for commencing import operations.

In all of the models examined, the HRM variables (HRMKGRt, HRMKITt, HRMKUKt, HRMKJPt and HRMKBLt) consistently exhibited negative coefficients. This implies that an upward movement in these variables which may indicate market well-being or customer trust is associated with a decrease in imports.

In the context of the German market (MKGRt), the coefficient for KKGRt (0.76525) exhibits a positive association indicating that domestic consumption and economic growth have a minor impact on import volumes. Additionally, the marginal influence of GDPRGRt (0.00006) is also positive further suggesting that these factors contribute to the observed relationship.

The Italian model known as MKITt has shown evidence of a strong and positive correlation between coffee imports (KKITt) and economic growth (GDPRITt). Furthermore, the lagged import variable MKITt1 (+ 0.0206) suggests that prior levels of imports have a lasting impact on the relationship.

The import model of the United Kingdom (MKUKt) revealed a notable and favorable correlation with domestic consumption (KKUKt, 0.647). On the other hand, the model employed in Austria known as MKASt demonstrated a multifaceted dynamic wherein the change in HRMKASt exhibited a negative coefficient of -0.00274. This negative coefficient suggests an inverse correlation between HRMKASt and imports.

The analysis of Japan's imports (MKJPt) indicated a noteworthy positive correlation with domestic consumption (KKJPt, 0.23609) and an even more large positive influence from economic growth (GDPRJPt, 0.00186). This suggests that the level of imports is significantly influenced by the country's economic performance highlighting the importance of economic factors in driving import levels.

The Belgian model (MKBLt) also suggests that there is a positive relationship between greater levels of domestic consumption (KKBLt 0.710937) and import statistics.

Table 9.
Import model of the world's main importer countries.

Variables	MKGRt	MKITt	MKUKt	MKASt	MKJPt	MKBLt
Constanta	2.002	-0.293	9.964	4.010	-1.828	1.076
HRMKGRt	- 0.005					
HRMKITt		-0.004				
HRMKUKt			- 0.012			
HRMKJPt					- 0.003	
HRMKBLt						- 0.007
KKGRt	0.765					
GDPRGRt	0.006					
KKITt		1.027				
GDPRITt		0.012				
MKITt1		+ 0.020				
KKUKt			0.647			
(HRMKASt - HRMKASt1)				- 0.002		
KKASt				0.664		
GDPRASt				0.055		
MKASt1				0.099		
KKJPt					0.236	
GDPRJPt					0.001	
KKBLt						0.710
F-values and R-squared	F = 132.730 R^2 = 0.961	F = 670.033 R^2 = 0.994	F = 5.691 R^2 = 0.401	F = 0.228 R^2 = 0.05	F = 18.418 R^2 = 0.775	F = 21.205 R^2 = 0.713

The models exhibited a wide range of explanatory power as evidenced by the F-statistics and R-squared values. The model developed for Italy known as MKITt exhibited a remarkably high R-squared coefficient (0.9944) indicating that the model effectively captures almost all of the variation in coffee imports. In sharp contrast, the MKASt model employed in Austria exhibited a modest R-squared coefficient (0.05) indicating that the model only accounts for a small percentage of the variability in imports. This implies the presence of other influential factors that are not accounted for by the model.

4.10. Econometric Analysis of Coffee Import Prices in Major Coffee-Importing Countries

Table 10 presents the import price sub-model for a selection of major coffee-importing nations across the globe. Each country is represented by a distinct variable denoting its coffee import prices: HRMKGRt for Germany, HRMKITt for Italy, HRMKUKt for the United Kingdom, HRMKASt for Austria, HRMKJPt for Japan and HRMKBLt for Belgium (Dutch).

The constants within the model function as the fundamental reference points for the import costs of coffee exhibiting notable variations among different nations. It is observed that Austria exhibits the highest initial import price (24.217) whereas the United Kingdom demonstrates the lowest (4.7207).

The variable HRKAWDt indicating the impact of global demand on coffee prices exhibits a significant positive influence in all models with coefficients ranging from 0.786 to 0.98. This observation suggests that there is a positive correlation between the rise in global coffee demand and the corresponding increase in import prices experienced by these nations.

The inclusion of international market price indices denoted by INMK variables (such as INMKGRt for Germany and INMKITt for Italy) reveals noteworthy positive coefficients. These coefficients vary among countries with values ranging from 129.96 for Belgium to 176.5372 for Austria. The data presented indicates that the import prices of coffee in these countries are considerably influenced by international pricing.

In the context of Austria, the variable HRMKASt1 exhibits a coefficient of 0.072 suggesting that past price levels persistently impact present import prices. Similarly, the coefficient for Italy in the HRMKITt1 model is 0.015095 indicating a small yet positive impact on a year-on-year basis.

The models exhibit a high level of fit as evidenced by the R-squared values which range from 0.9603 for Japan to 0.9945 for the UK. The aforementioned figures indicate that the models effectively account for a significant portion of the fluctuations observed in coffee import prices across the examined nations, hence demonstrating a robust forecasting capability. The F-statistics provide more support in favor of this assertion as they have high values that indicate the statistical significance of the models.

Table 10.
Import price sub-model of the world's leading coffee importer countries.

Variable	HRMKGRt	HRMKITt	HRMKUKt	HRMKASt	HRMKJPt	HRMKBLt
Constanta	22.028	7.325	4.720	24.217	23.384	19.962
HRKAWDt	0.815	0.947	0.98	0.794	0.786	0.806
INMKGRt	153.806					
INMKITt		153.948				
INMKUKt			157.66			
INMKASt				176.537		
INMKJPt					133.294	
INMKBLt						129.96
HRMKASt1				0.072		
HRMKITt1		0.015				
F-values and R-squared	F = 211.151 R^2 = 0.961	F = 522.680 R^2 = 0.989	F = 1545.42 R^2 = 0.994	F = 615.141 R^2 = 0.991	F = 205.793 R^2 = 0.960	F = 211.453 R^2 = 0.961

4.11. Evaluation of the Predictive Performance of Coffee Market Models

The evaluation of the predicted accuracy of coffee market models from 2008 to 2020 was conducted using a range of statistical measures as presented in Table 9. The evaluation employed various statistical measures, including the Mean Squared Error (MSE), Bias and components of the decomposition of the mean squared prediction error. These components include Regression (R), Disturbance (D), Variance (V) and Covariance (C) as well as the U1 and U2 statistics (see Table 11).

The mean squared error (MSE) which quantifies the average squared deviation between the observed actual outcomes and the predictions made by the model exhibited significant variability across the different variables. The range of values observed varied across different variables with some exhibiting shallow values that corresponded to highly accurate predictions while others displayed relatively higher values indicating lower precision in their forecasts.

The presence of bias which quantifies the mean disparity between predicted values and observed outcomes was observed to be consistently minimal across the majority of variables. This suggests the absence of any discernible systemic inaccuracies in the predictions. Nevertheless, certain variables displayed a greater degree of bias suggesting a continuous tendency for the model to either underestimate or overestimate in those particular instances.

The components of regression (UM) and disturbance (UR) represent the model's capacity to capture systematic information and unexplained noise in the data, respectively. The analysis indicates that the models generally captured a substantial percentage of the systematic structure present in the data. Nevertheless, the disturbance (UR) values also suggest that a significant portion of the variance remains unaccounted for by the models.

The statistical measures of variance (UD) and covariance (US) offer valuable insights into the variability of the model predictions and their correlation with the observed values. The presence of lower values of variance (UD) in conjunction with higher Covariance (US) indicated that certain models had relatively steady behavior and closely tracked the actual values over a given period.

The U1 (UC) statistic a dimensionless metric that integrates information from mean squared error (MSE), bias and variance components, and another comprehensive measure effectively demonstrated the comparative performance of the models. The statistics presented in this context demonstrate that lower values are indicative of superior prediction accuracy in general.

The F-statistics and R-squared values served as supplementary indicators of the model's adequacy in terms of fit. The statistical significance of all models was validated by the presence of high F-statistics. The R-squared values which represent the proportion of variation accounted for by the models exhibited remarkably high values for certain variables thereby affirming the robust explanatory capacity of the models.

Table 11.
Model predictive power evaluation table for the simulation period 2008-2020.

Variables	MSE	Bias	Reg (UM)	Dist (UR)	Var (UD)	Covar (US)	U1 (UC)	U
AMKRPBST	0.0017	0.019	0.278	0.704	0.417	0.564	0.172	0.087
AMKRPBJT	344.837	0.495	0.080	0.424	0.350	0.154	0.058	0.029
AMKRPBLT	0.355	0.000	0.076	0.923	0.226	0.773	0.217	0.111
AMKRPRST	10.340.290	0.176	0.319	0.505	0.385	0.439	0.021	0.010
AMKRPRJT	4.725.684	0.366	0.412	0.222	0.034	0.600	0.103	0.053
AMKRPRLT	21.442.165	0.427	0.208	0.364	0.288	0.284	0.102	0.053
QKRPBST	0.003	0.277	0.019	0.704	0.158	0.565	0.250	0.119
QKRPBJT	681.299	0.137	0.070	0.793	0.565	0.298	0.108	0.055
QKRPBLT	0.124	0.382	0.000	0.618	0.047	0.571	0.328	0.152
QKRPRST	16.409.347	0.034	0.091	0.875	0.258	0.708	0.045	0.023
QKRPRJT	1.210.146	0.172	0.490	0.338	0.129	0.700	0.120	0.061

Variables	MSE	Bias	Reg (UM)	Dist (UR)	Var (UD)	Covar (US)	U1 (UC)	U
QKRPRLT	3.575.309	0.429	0.234	0.338	0.301	0.270	0.098	0.051
QKRINT	36.261.953	0.197	0.212	0.592	0.352	0.451	0.048	0.024
QKAINT	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HRDKRIT	182350	0.076	0.076	0.848	0.754	0.171	0.353	0.191
HRDKAIT	401621	0.180	0.240	0.579	0.123	0.697	0.379	0.178
KKRINT	1048	0.108	0.060	0.833	0.419	0.473	0.426	0.211
KKAINT	1.563.810	0.009	0.006	0.985	0.190	0.802	0.339	0.173
XKRINT	1830	0.199	0.080	0.721	0.152	0.650	0.133	0.068
XKAINT	1.563.810	0.009	0.027	0.965	0.296	0.695	0.200	0.102
HRXKRIT	1400258	0.583	0.364	0.053	0.004	0.412	14.409	0.481
HRXKAIT	12643600	0.806	0.184	0.010	0.015	0.179	26.955	0.612
SKRINT	1048	0.108	0.028	0.864	0.365	0.528	0.360	0.176
QKABRT	258.929	0.001	0.071	0.928	0.505	0.493	0.060	0.030
QKACLT	767.094	0.316	0.098	0.586	0.444	0.240	0.198	0.106
QKACKT	0.103	0.675	0.002	0.323	0.010	0.314	0.132	0.062
QKAGLT	0.484	0.847	0.010	0.142	0.000	0.153	0.200	0.091
QKAMCT	125.402	0.558	0.191	0.251	0.023	0.418	0.231	0.106
QKRIAT	222.305	0.015	0.084	0.901	0.008	0.977	0.137	0.069
XKABRT	1.390.002	0.000	0.025	0.975	0.779	0.221	0.208	0.105
XKACLT	489.864	0.356	0.034	0.609	0.372	0.271	0.185	0.098
XKACKT	0.313	0.582	0.138	0.280	0.157	0.261	0.257	0.143
XKAGLT	0.455	0.526	0.138	0.336	0.023	0.452	0.208	0.096
XKAMCT	618.309	0.910	0.051	0.039	0.022	0.068	0.671	0.253
XKRIAT	0.357	0.008	0.048	0.944	0.099	0.893	0.291	0.149
HRXKABRT	26072	0.798	0.165	0.036	0.042	0.159	16.696	0.473
HRXKACLT	47701	0.806	0.174	0.020	0.017	0.177	19.783	0.523
HRXKACKT	52394	0.807	0.175	0.018	0.011	0.182	20.050	0.529
HRXKAGLT	40102	0.798	0.185	0.017	0.013	0.188	19.187	0.516
HRXKAMCT	56434	0.805	0.172	0.023	0.009	0.186	20.401	0.535
HRXKRIAT	8357	0.513	0.397	0.089	0.005	0.482	0.999	0.369
XKRWDT	110.698	0.124	0.292	0.584	0.140	0.736	0.066	0.033
XKAWDT	2.186.917	0.058	0.305	0.637	0.037	0.905	0.101	0.054
HRMKGRT	40969	0.795	0.193	0.013	0.026	0.179	17.287	0.485
HRMKITT	55696	0.810	0.173	0.016	0.007	0.182	19.559	0.522
HRMKUKT	57596	0.808	0.162	0.030	0.008	0.184	18.884	0.513
HRMKAST	43755	0.800	0.163	0.037	0.016	0.183	17.707	0.494
HRMKJPT	38107	0.790	0.178	0.032	0.037	0.174	15.531	0.455
HRMKBLT	40349	0.789	0.192	0.019	0.028	0.183	17.086	0.482
KKGRT	2.000.455	0.619	0.006	0.375	0.244	0.137	0.389	0.234
KKITT	102.878	0.329	0.010	0.661	0.464	0.207	0.213	0.114
KKUKT	945.945	0.738	0.101	0.161	0.167	0.095	0.100	0.052
KKAST	407.629	0.768	0.189	0.043	0.042	0.190	0.110	0.058
KKJPT	0.117	0.363	0.060	0.577	0.192	0.445	0.063	0.032
KKBLT	106.255	0.679	0.130	0.191	0.046	0.275	0.400	0.241
MKGRT	2.040.606	0.687	0.015	0.298	0.174	0.139	0.365	0.217
MKITT	130.254	0.428	0.019	0.553	0.404	0.168	0.229	0.125
MKUKT	3.903.006	0.462	0.099	0.439	0.453	0.084	0.218	0.119
MKAST	1670	0.776	0.223	0.002	0.183	0.041	21.039	0.524
MKJPT	105.221	0.362	0.309	0.329	0.514	0.124	0.191	0.102
MKBLT	0.830	0.642	0.097	0.261	0.073	0.285	0.321	0.185
QKRWDT	277.782	0.037	0.482	0.480	0.222	0.740	0.075	0.037
QKAWDT	862.146	0.002	0.014	0.984	0.124	0.874	0.038	0.019
HRKRWDT	12818	0.519	0.346	0.135	0.051	0.429	0.894	0.349
HRKAWDT	60516	0.807	0.166	0.027	0.014	0.180	18.252	0.501
MKWDT	90.748.672	0.740	0.253	0.007	0.224	0.036	0.391	0.166

4.12. Historical Simulation Results for the Indonesian Coffee Industry

The study's simulations spanned from 2008 to 2020. They considered changes in acreage, production, domestic prices, offers, consumption, and export values for both Robusta and Arabica coffee. The scenarios were defined as follows:

Scenario 1: Real rate reduction.
Scenario 2: The fertilizer price increases.
Scenario 3: Wage increase in the plantation sub-sector.
Scenario 4: Rupiah devaluation.
Scenario 5: The combination of interest rate reduction policies and fertilizer price increase.
Scenario 6: The combination of interest rate policies decreases by 20 percent and increases wages in the plantation sub-sector by 25 percent.

Acreage and production:

- The acreage of RPB (Robusta Plantations) in Sumatra showed a slight increase in scenarios 1 and 2 but a significant decrease in scenarios 3 and 6 suggesting sensitivity to wage increases and currency devaluation.
- Java's RPB and RPR (Robusta People's Plantations) displayed increases in scenarios 1, 2, and 5 indicating resilience to real rate reductions and fertilizer price increases.
- Production in Sumatra experienced drastic declines under scenarios 2 and 3 for RPB, yet RPR showed resilience, especially in scenarios 1 and 5.

Domestic prices and offers :

- Robusta's domestic prices increased across most scenarios with the highest increase in scenario 4 due to the devaluation of the Rupiah.
- Offer quantities for Robusta rose in scenarios 1 and 5 correlating with policy changes that potentially increased supply.

Consumption:

- Domestic consumption of Robusta surged in scenarios 1 and 5 which could be attributed to the combined effect of favorable interest rates and fertilizer prices.
- Arabica consumption remained unchanged across all scenarios suggesting a stable demand irrespective of economic changes.

Exports and Export Values:

Export quantities for Robusta showed a general increase with scenarios 1 and 5 having the most significant positive impact.

However, the export prices for Robusta declined in scenarios 1 and 4 indicating a potential loss in revenue per unit despite higher volumes.

The total export value increased most notably in scenario 5 reflecting the positive combined effects of the interest rate reduction and fertilizer price increase on the overall industry revenue.

Arabica's Stability:

Arabica coffee variables remained unchanged across all scenarios indicating strong stability or perhaps a lack of sensitivity to the internal factors considered in this study.

The results suggest that the Indonesian coffee industry particularly the Robusta market is sensitive to internal economic changes with acreage, production, and export values responding variably to different scenarios (see Table 12). The robustness of Arabica coffee to internal factors underscores a potential area for strategic focus to enhance industry stability. These insights can guide policymakers and industry stakeholders in devising strategies to mitigate risks associated with economic fluctuations. Further analysis might explore the underlying causes of these disparities and their implications for coffee production and export sustainability in Indonesia.

Table 12.
Historical simulation results of the impact of changes in internal factors on the gaps in the Indonesian coffee industry.

Variables		Unit	Basic value	Percent change in scenario					
				1	2	3	4	5	6
1. Acreage									
Produce		1000 Ha							
	RPB Sumatra		0.2135	0.047	0.047	-1.405	0.047	0.047	-1.358
	Rpb Java		30.5201	18.000	18.010	18.012	17.996	18.005	18.007
	Other RPB		2.319	7.089	-0.065	-0.056	-0.095	7.102	7.111
	Sumatra RPR		460.602	3.527	2.796	2.791	2.828	3.517	3.511
	Rpr Java		62.1301	8.286	-3.109	6.460	6.478	-1.290	8.278
	Other RPRs		128.606	15.745	15.100	15.101	15.096	15.748	15.748
2. Production coffee:		1000 Ton							
	RPB Sumatera		0.0828	0.242	-38.647	-1.449	0.362	-38.647	-1.449
	RPB Jawa		22.9466	20.248	20.249	15.009	20.250	20.249	15.009
	RPB other		1.1632	5.863	-10.738	0.052	0.103	-4.952	5.846
	RPR Sumatera		276.565	3.329	2.353	-4.887	2.409	3.311	3.302

Variables	Unit	Basic value	Percent change in scenario					
			1	2	3	4	5	6
RPR Java		27.2889	12.061	-4.331	3.656	9.508	-1.708	6.279
RPR other		54.5687	14.331	13.725	8.597	13.753	14.322	9.194
Robusta		382.615	6.543	4.523	4.082	5.600	5.505	5.064
Arabica		28.7601	0.000	0.000	0.000	0.000	0.000	0.000
3. Domestic prices:	Rp/Kg							
Robusta		1023	1.271	0.880	0.782	1.662	1.075	0.978
Arabica		1865	0.000	0.000	0.000	0.000	0.000	0.000
4. offers:	1000 Ton							
Coffee Robusta		91.4171	9.135	6.287	5.649	13.485	7.679	6.604
5. Consumption :	1000 Ton							
Coffee Robusta		75.1556	11.112	7.647	6.872	16.406	9.340	8.565
Coffee Arabica		10.262	0.000	0.000	0.000	0.000	0.000	0.000
6. Export coffee :	1000 Ton							
Robusta		299.329	5.573	3.861	3.492	3.034	4.691	4.322
Arabica		18.4981	0.000	0.000	0.000	0.000	0.000	0.000
7. Price Eskpor	US $/Ton							
K. Robusta		1596	-4.323	-3.008	-2.757	4.574	-3.697	-3.383
K. Arabica		4365	0.000	0.000	0.000	0.000	0.000	0.000
8. Value Ekspor.	US $ ribu							
Robusta		477729	1.009	0.738	0.639	7.747	0.821	0.793
Arabica		80744.2	0.000	0.000	0.000	0.000	0.000	0.000
Total		558473	0.863	0.631	0.547	6.627	0.702	0.678

5. Discussion

The progress in agricultural technology in Indonesia has played a crucial role in enabling the growth of Robusta coffee crop areas encompassing both large-scale plantations and those controlled by local communities. Our research suggests that the industry is responding slowly to price fluctuations which could lead to cultivators being less profitable than exporters and perhaps overproducing despite these developments.

The historical simulation conducted in this study highlights the imperative of government action in the regulation of production input costs such as fertilizer prices and wages within the plantation sub-sector. In the short term, the implementation of strategic subsidies on fertilizers and salary increments has the potential to strengthen the motivation of small-scale farmers to increase the size of their cultivated land leading to improved agricultural output [22-24]. The revitalization of the coffee industry could be significantly influenced by the ability to attract investment into the sub-sector of coffee plantations. On the other hand, the imposition of high interest rates by banks acts as a hindrance to the national coffee output indicating the necessity for financial policy change in order to facilitate the expansion of this industry [25].

Additionally, the simulation findings suggest an urgent requirement for the expansion of export market opportunities in order to mitigate the potential negative outcomes of excessive production and declining prices. The significance of the Indonesian government's involvement in the expansion of these markets cannot be overstated especially considering the country's dedication to trade liberalization which has introduced a competitive global dynamic.

It is worth mentioning that the sensitivity of global coffee prices to fluctuations in export prices for Robusta and Arabica varieties exhibits a significant degree of elasticity [26, 27]. Nevertheless, it can be observed that the export prices of Robusta coffee in Indonesia exhibit a degree of inelasticity indicating that fluctuations in global pricing may not exert a substantial impact on the export quantities of Indonesia. The observed disparity in price elasticity serves to underscore the intricate nature of the worldwide coffee market and the impact of nation-specific variables on trade dynamics.

The effects of government interventions specifically on domestic commerce and exports have had varying outcomes [28]. The depreciation of the rupiah has unintentionally provided benefits to farmers through the enhancement of exports and the increase in sale prices. However, these swings underscore the need for a strong financial strategy to mitigate the risks associated with market instability. The findings of the study indicate that nations that are large producers of coffee exhibit varied responses to fluctuations in prices. Some countries respond to changes in prices on an annual basis, while others react to movements in export prices [29].

The rise in coffee production within nations that export coffee has the potential to exert downward pressure on global coffee prices, particularly for Arabica coffee which is predominantly traded by a single country. The imposition of export tariffs by prominent exporting nations can have a detrimental impact on the worldwide market price of their coffee resulting in a decrease in revenues for exporters [30]. However, it is important to note that an increase in global pricing could potentially have a positive impact on the export prices of these nations. Nevertheless, it is worth mentioning that the response to this increase may not exhibit a high degree of elasticity.

6. Conclusion

The present work has conducted an examination of the Indonesian coffee business using historical simulation yielding a number of noteworthy discoveries that hold practical relevance. It can be inferred that the expansion of Robusta coffee farming areas has been facilitated by technological developments. Nevertheless, the growers' delayed reaction to fluctuations in prices has resulted in diminished profitability and the possibility of excess supply. There exists discernible evidence that the implementation of government intervention in the form of input subsidies and pay adjustments has the potential to enhance production levels and foster a greater alignment with market signals.

The conclusion of this study has broad implications for policy creation emphasizing the necessity of adopting a more adaptable and proactive strategy to provide effective support to coffee growers. The potential measures to address the issue at hand encompass the engagement of the Indonesian government in the stabilization of input prices, the proactive facilitation of market access and the expansion of export options all aimed at mitigating the risk of oversaturation in the domestic market.

6.1. Implications of the Study

This study reveals that technological advancements have facilitated the expansion of Robusta coffee farming areas in Indonesia. However, the delayed price response from growers has led to reduced profitability and a potential oversupply. Government interventions such as input subsidies and wage adjustments show promise for enhancing production and market alignment.

6.2. Limitations

The research assumes a linear relationship between policy changes and market outcomes which oversimplifies the complex market dynamics and overlooks potential time lags and external influences such as climate variation and global market disruptions.

6.3. Future Research

Further studies should include a broader array of variables such as environmental factors and global market trends and their impact on domestic coffee production and pricing. Longitudinal research could uncover the long-term effects of policy changes and comparative studies with other coffee-producing nations could contextualize these findings within a global framework. Additionally, microeconomic research on local production and market dynamics in Indonesia would complement this macroeconomic analysis.

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