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Sustaining Malaysia's Rice Economy: The Role of Economic Drivers in Food Security

(*Kemampanan Ekonomi Padi Malaysia: Peranan Faktor Ekonomi dalam Keterjaminan Makanan*)

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ABSTRACT

Food security has consistently been a strategic goal for Malaysia, specifically given its dependence on imported food, diminishing agricultural land, and evolving agricultural policies. This study examines the impact of Malaysia's National Agricultural Policies, food export, food import, and agricultural land on food security. The study employs time-series data from 1964 to 2021. Using the autoregressive distributed lag-error correction model, the findings reveal that food import, agricultural land, 1st-3rd Malaysia Plan, and 3rd National Agricultural Policies exhibit long-run relationships with food security, while food export and food import adjust to equilibrium more rapidly than agricultural land. This study also investigates the interaction effects of National Agricultural Policies, and indicate that 3rd and 4th National Agricultural Policies strengthen the influence of food export and food import on food security, whereas 1st-3rd Malaysia Plan, and 3rd National Agricultural Policies moderate the relationship between agricultural land and food security. This research contributes to the literature by linking modernisation theory to policy outcomes and employing the autoregressive distributed lag-error correction model, which remains underutilized in food security studies. The policy implications of this study suggest that policymakers should consider formulating a new National Agricultural Policy by incorporating effective strategies from the 1st-3rd Malaysia Plans, as well as the 3rd National Agricultural Policy. Priority should be given to modernising the agro-food industry to enhance food production, while also addressing the dynamics of food exports and imports to strengthen Malaysia's overall food security.

Keywords: Food export; food import; food security; National Agricultural Policy; agricultural land

ABSTRAK

Keterjaminan makanan merupakan salah satu matlamat strategik Malaysia, ini disebabkan oleh kebergantungan negara terhadap makanan import, pengurangan tanah pertanian, serta perubahan dasar pertanian. Kajian ini meneliti kesan Dasar Pertanian Negara Malaysia, eksport makanan, import makanan, dan tanah pertanian terhadap keterjaminan makanan. Data siri masa dari tahun 1964 hingga 2021 digunakan untuk tujuan analisis. Melalui penggunaan Model Autoregresif Teragih Lag-Koreksi Kesilapan, hasil kajian menunjukkan bahawa import makanan, tanah pertanian, Rancangan Malaysia Pertama - Ke-3 mempunyai hubungan jangka panjang yang signifikan dengan keterjaminan makanan. Sementara itu, dalam jangka pendek eksport makanan dan import makanan menunjukkan penyesuaian yang lebih cepat ke arah keseimbangan berbanding tanah pertanian. Kajian ini turut menilai kesan interaksi dasar pertanian negara dan menunjukkan bahawa Dasar Pertanian Negara Ke-3 dan Ke-4 mengukuhkan kesan eksport makanan dan import makanan terhadap keterjaminan makanan. Selain itu, Rancangan Malaysia Pertama - Ke-3 dan Dasar Pertanian Negara Ke-3 bertindak sebagai moderator dalam hubungan antara tanah pertanian dan keterjaminan makanan. Penyelidikan ini memberi sumbangan kepada literatur sedia ada dengan mengaitkan teori pemodenan kepada keberkesanan dasar serta menggunakan pendekatan Model Autoregresif Teragih Lag-Koreksi Kesilapan, yang masih kurang digunakan dalam kajian keterjaminan makanan. Implikasi dasar daripada kajian ini mencadangkan agar penggubal dasar mempertimbangkan untuk merangka Dasar Pertanian Negara yang baharu dengan menggabungkan strategi berkesan daripada Rancangan Malaysia Pertama hingga Ke-3, serta Dasar Pertanian Negara Ke-3. Keutamaan harus diberikan kepada pemodenan industri agro-makanan bagi meningkatkan pengeluaran makanan, di samping meneliti dinamik eksport dan import makanan untuk mengukuhkan keterjaminan makanan negara secara keseluruhan.

Kata kunci: Eksport makanan; import makanan; keterjaminan makanan; Dasar Pertanian Negara; tanah pertanian

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INTRODUCTION

The global food crisis has persisted since the 1970s. The COVID-19 pandemic, which began in the early 2020s, triggered a dual health and economic crisis by halting global activities and disrupting supply chains. This disruption has resulted in a sharp rise in food prices (Ben Hassen & Bilali 2022). The Russian-Ukrainian war further exacerbated the crisis, through distorting global food production, and inflating food prices. The war pushed fertiliser and natural gas prices to all-time highs, leading to skyrocketing food production costs and reducing food supplies. According to the World Bank (2024), over half of all countries experienced food price inflation exceeding 5%, although the real figures may be higher. With domestic food production running low, rising prices have made food increasingly unaffordable, triggering food crisis from 2020 onwards. Many net food-importing countries accordingly restricted exports to prioritise domestic needs.

Malaysia was once an agriculture-driven economy, producing a wide range of food products such as rice, palm oil, and cocoa. In the 1960s, agriculture, forestry, and fishing contributed 43.7% to Malaysia's GDP. However, by 2022 this figure had declined to 8.9%. Modernisation has widened the gap between industrial and agricultural sectors. According to the Department of Statistics Malaysia (DOSM), the value-added gap between industrial and food crops was only 13.9% in the 1980s but surged to 30.3% in 2022 (World Bank 2022). Moreover, the agricultural growth rate has lagged behind population growth rate (Said et al. 2006), signalling insufficient domestic food production to meet demand. Despite this lack of self-sufficiency, especially in rice, Malaysia continues to export rice globally. Consequently, the country has increased its food imports (FI) to offset domestic shortages. This growing dependence on external sources has exposed Malaysia to price shocks, particularly during crises such as the Russian–Ukraine war. In this context, it is critical to re-examine the determinants of food security through the Food Production Index (FPI) in food-importing countries like Malaysia.

The Food and Agriculture Organisation (FAO, 2018) posits that sustainable agricultural development requires FS across economic, social, and environmental dimensions. Numerous studies have examined factors influencing FS or the FPI, including macroeconomic (Amegnaglo 2018; Hanif et al. 2019; Duasa et al. 2023), microeconomic (Panukhnyk et al. 2019), environmental (Bilan 2018; Duasa et al. 2023), and social (Alarcão et al. 2020) aspects. In the macroeconomic context, capital investment (Amegnaglo 2018), agricultural land area (Azizan & Hussin 2015), and population growth (Devesh et al. 2020; Kabir et al. 2023) are positively associated with food production. However, GDP has minimal short-run effects (Hanif et al. 2019). Duasa et al. (2023) found that GDP per capita, fixed capital formation, and CPI significantly improve food production in South ASEAN. Trade is another key determinant: FI enhances FS, but FE shows no similar benefit in Africa (Enilolobo et al. 2023). Despite Malaysia's low FPI in ASEAN (World Bank 2020), its FE value continues to rise annually. This raises critical questions about whether rising imports and exports can effectively address food insecurity. Thus, our baseline model incorporates agricultural land alongside trade indicators as vital determinants of Malaysia's FPI.

In addition to macroeconomic variables, microeconomic factors influence consumer food provision. Panukhnyk et al. (2019) found household cash and food expenditures positively impact food provision in Ukraine. Bilan (2018) observed that sustainable agro-management enhances food security, whereas high electricity consumption undermines it. Duasa et al. (2023) showed CO_2 emissions negatively mediate the effect of fixed capital on food production. Social factors - including demographic, socioeconomic, and health factors – also contribute to food insecurity, with disparities observed between immigrants and native populations (Alarcão et al. 2020). This study examines Malaysia's food security dynamics, with particular emphasis on the role of government policy in driving food production, using the FPI as an indicator.

Previous studies have assessed the effectiveness of various policies such as trade measures, market price support, consumer subsidies, public procurement, national stockpiling, and input subsidies on food security, though the results remain inconclusive. For instance, while input subsidies have reportedly suppressed productivity in Malaysia (Said et al. 2006), they proved beneficial in China (Yu et al. 2015). Domestic market price support policies appear more consistently effective, whereas trade policy impacts are mixed (Yu et al. 2015). Bala et al. (2014) stressed the importance of targeted domestic policies to enhance productivity, especially during price shocks. This study contributes to the discourse by analysing Malaysia's agricultural policy trajectory, from the 1st Malaysia Plan (1966–1970) to the National Agro-Food Policy (2011–2021), and its implications for national food security.

The study provides three (3) notable contributions to agricultural economics literature; firstly, it is among the pioneers in exploring the impact of national agricultural policies on food production in Malaysia. For the analysis, we comprehensively examine five (5) national policies including the 1st-5th Malaysia Plans (1966-1990) and the National Agricultural Plans, NAP1 – NAP4 (1991-2021). Using the ARDL-ECM models, we test the effectiveness of these agriculture-related policies on Malaysia's FS. Secondly, the study addresses the concerning imbalance in Malaysia's food trade. Malaysia's FI transactions have increased to meet the shortfall in domestic food demand due to the slow growth in domestic food production, while food exports have also risen. DOSM reported that Malaysian agricultural exports stood at MYR 7.42 million and imports at MYR 12.43 million in 2006 (Said et al. 2006). By 2021, exports had surged to MYR 154,479 million and imports to MYR 120,470 million. The disparity in trade balance warrants deeper investigation into how food export and import influence domestic food production.

Third, based on findings of Hansen et al. (2011), who observed that input subsidies and export restrictions improved China's grain output, this study further sheds light on how FE, FI and agricultural land (AGR_Land) affect food production in Malaysia. We control food demand (FD), GDP per capita (GDPPC) and Gross National Expenditure (GNP) using data from 1964 to 2021 sourced from the World Bank and Malaysia's Ministry of Economy. By interacting these variables with agricultural policies, the study identifies combinations that could enhance the FPI. These findings offer valuable insights for policymakers to address Malaysia's persistent food production challenges effectively.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature and theories and outlines the hypotheses tested for the study. Section 3 details the data and estimation model used for the analysis. Section 4 presents the preliminary and estimated model results. Section 5 concludes with a discussion on practical policy implications for regulators.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

FOOD POLICY AND FOOD SECURITY

Food policy functions as a comprehensive framework linking agriculture, commodities, trade, and food security (Qian et al. 2020). According to Brahnu et al. (2023), it enables stakeholders and practitioners to anticipate food security outcomes by identifying its key determinants. Several countries, including China (Huang & Yang 2017; Liu & Zhou 2021) and Nigeria (Shuaibu 2021), have successfully implemented food policies to address food security challenges. Modernisation theory provides an insightful lens to explore this relationship, identifying domestic expenditure and literacy as drivers of industrialization and cultural advancement, both of which foster economic growth and support the development of effective food policies. According to Scanlan (2001), important policy determinants such as increasing public spending on agricultural land development, investment in education and agricultural research, and technological assistance for food distribution are all consistent with modernisation theory. However, other studies challenge its universal applicability.

As mentioned by Byekwaso (2016), in certain contexts, modernisation - through emphasising urban-centric industrial development - could weaken local food production capacity and worsen food insecurity. These diverse findings highlight the need of addressing context-specific implications when applying modernisation concepts to food policy development. Empirical research indicate diverse links between food policy and food security. In China, subsidies, procurement pricing, and farmland initiatives have positively impacted food security (Huang & Yang 2017; Liu & Zhou 2021). In Nigeria, trade liberalisation significantly improved food access (Shuaibu 2021). However, the outcomes vary according to the context. India's Public Distribution System has faced criticism for poor targeting and data issues (Yu et al. 2015), while policies in Bangladesh have failed to eliminate hunger (Sultana & Sabau 2023). These findings underline the need to design, align and implement food policies according to local socioeconomic conditions.

Malaysia, a significant rice and palm oil exporter, has enacted 12 National Plans and four National Agricultural Policies (NAPs) aimed at enhancing food security. This paper reviews the First to Fifth Malaysia Plans and all four NAPs, which have consistently emphasised the agricultural sector's role in food security and economic development. The first Malaysia Plan (1966–1970) prioritised education and research in paddy and rubber, while the Second Plan (1971–1991) focused on irrigation and chemical inputs to increase production. As food issues increased, NAP2 shifted to prioritising food supply and accessibility. However, from the 1960s to1990s investment trends shifted towards industrial crops, which increased from 3.0% to 37.4% of total agricultural investment, while food crops declined from 31.5% to 17.9%. This confirms Byekwaso's (2016) assertion that modernisation may undermine food security by diminishing domestic food production. In response to the 2008 food crisis, NAP3 (1998–2010) focused on domestic food needs, innovation, and financing, while NAP4 (2011–2020) promoted sustainable production and food safety. Despite these policies, agrifood land decreased from 869,000 hectares in 2010 to 825,200 hectares in 2020, with paddy land shrinking by 2.4% annually

(Food and Fertilizer Technology Centre 2020), demonstrating a gap between policy and practice that jeopardises Malaysia's food security targets.

Consistent with previous studies highlighting the potential of food policy to mitigate food insecurity in many countries, this study investigates Malaysia's food-related policies in relation to food security. Notably, limited research has investigated the direct impact of food policy on Malaysia's food security, and none have employed the Modernisation theory as a primary analytical framework. Existing studies have mostly focused the determinants of food security in the country (Firdaus et al. 2020; Said et al. 2006; Tey & Radam 2011) without specifically addressing the role of food policy. To close this gap, this study evaluates the impact of food policy - using the dummy variables for Malaysia Plan and NAP implementation years - on food security, as measured through the Food Production Index. The following hypothesis is posited:

H_1 Food policy significantly increases the FPI.

AGRICULTURAL LAND AND FOOD SECURITY

Agricultural economic studies emphasise three critical factors as fundamental determinants in assessing food security – namely, labour, land, and capital. In this study, we include agricultural land (AGR_Land) as another important variable. Azizan and Hussin (2015) define agricultural land as the percentage of land classified as arable, including land used for permanent crops and pastures. AGR_Land is critical to a country's domestic food production, since economic theory emphasises its role in enhancing local production while optimising labour and capital inputs (Mahmood et al. 2016). The significance of AGR_Land in ensuring food security has been examined in previous studies (Azizan & Hussin 2015; Hossain et al. 2020; Mulusew & Mingyong 2023; Zhuang et al. 2022). Azizan and Hussin (2015) highlighted that due to the massive land conversion in Malaysia during the 1980s, domestic food production has decreased, exacerbating FS issues. This is consistent with Mulusew and Mingyong (2023), who discovered that the rising density of both urban and rural populations in Africa has reduced the accessibility of land for agriculture since the 1980s, triggering a state of food deficit.

Hossain et al. (2020) who examined the impact of AGR_Land degradation on soil fertility and its implications for food security, discovered that 40% of global soil degradation is caused by poor land management. This issue is explicitly acute in developing countries where regulatory measures to conserve soil fertility and reduce land degradation are inadequate. In consequence, these countries face diminishing agricultural output and deteriorating food security. Zhuang et al. (2022) discovered an inverse relationship between AGR_Land area and food supply in Egypt, Morocco, Tunisia, and Lebanon, highlighting the conversion of fertile land into non-productive areas. This trend reduces the land's capability to support food production. Additionally, rapid urbanization and population growth have accelerated the conversion of fertile AGR_Land into non-agricultural uses, further exacerbating the difficulty of maintaining national food supply levels.

In Malaysia, the importance of AGR_Land for food security is evident in patterns identified across various Malaysia Plans. For example, the 2nd Malaysia Plan highlighted declines in agricultural area owing to industrialisation and urbanisation, resulting in decreased self-sufficiency levels (SSL) for major crops such as rubber and rice. A notable example is the reduction in paddy acreage from 700,000 hectares in 2019 to 650,000 hectares in 2021, which coincided with a decrease in paddy production from 1,825,000 tonnes to 1,677,000 tonnes. Although Malaysia's AGR_Land expanded to 85,710 square kilometres in 2022, with an annual growth rate of 1.54% (World Bank Report 2021) this increase did not result in improved food security. The Global Food Security Index (GFSI) ranked Malaysia seven places lower in 2022 compared to the previous year. This corresponds with the findings of Omar et al. (2019), who reported Malaysia's continued status as a net rice importer, with SSL varying between 60% and 70%. Given rice's position as a staple food, these trends raise questions over long-term national food security. In view of the critical role of AGR_Land in enhancing FS, we propose the following hypothesis:

H_2 Agricultural land significantly increases the FPI.

In the context of AGR_Land and its implications for food security, a number of empirical studies have found that food policies play a crucial role in enhancing the positive impact of AGR_Land utilisation on food security (Bashir et al. 2013; Hossain et al. 2020; Petrikova 2013). Petrikova (2013) examined the impact of two agricultural policies, land concentration and trade openness, on improving food security in 58 developing countries. While a negative direct relationship between food production and FS was observed the study discovered that food policies enhance food production and, in turn, improve FS. It was suggested that enacting a land concentration policy, which evenly distributes land holdings among small-, medium-, and large-scale farmers, could strengthen the positive impact of food production on FS.

Similarly, Hossain et al. (2020) and Bashir et al. (2013) have also emphasised the significance of establishing food policies aimed at preserving soil fertility, preventing anthropogenic land degradation, and targeting specific farming groups. Consequently, such policies reinforce the strategic management of AGR_Land to address FS concerns effectively. Given the limited evidence on how emerging agriculture policy nexuses maximise the impact of AGR_Land on FS, particularly in Malaysia, we propose the following hypothesis:

H_{2a} Food policy moderates the relationship between agricultural land and FPI.

FOOD IMPORT, FOOD EXPORT AND FOOD SECURITY

Few empirical research have applied Heckscher-Ohlin (H-O) theory to investigate the dynamics of food or agricultural imports and exports mechanisms in relation to FS (Devesh et al. 2023; Enilolobo et al. 2022; Shang et al. 2024). According to the H-O theory, countries can be classed as capital- or labour-intensive producers. A country that produces capital-intensive goods is expected to export to labour-intensive countries, and vice versa. As such, nations should capitalise on their comparative advantage, whether in capital or labour intensity, to produce goods more efficiently, increase exports, and reduce reliance on imports. Enilolobo et al. (2022) examined the impact of agricultural imports and exports on FS in ten African countries. They demonstrated that both variables positively influence FS. This is also consistent with the majority of past empirical research, suggesting that agricultural trade contributes to improved FS in countries such as India and Bangladesh (Dorosh 2001), Nepal (Pyakuryal 2010), Oman (Devesh et al. 2020) and a cross-country study involving 151 nations (Dithmer & Abdulai 2017).

A number of researchers dispute the H-O theory. For example, Abbade and Dewes (2014) discovered that food imports are significantly related to food security only in countries that import high volumes of critically scarce food products. Specifically, they discovered that the import of Brazilian dry beans positively influence food security only in India and Angola, both being major importers experiencing acute food security issues. In contrast, no significant effects were observed in the other 26 countries that also import the same products. Given these mixed findings on the relationship between food trade on food security, the preceding literature analysis provides a strong rationale for investigating the effects of food exports and imports on Malaysia's food security.

In Malaysia, rice is the staple food. Since the Asian Financial Crisis in 1997-1998, the country's rice self-sufficiency level (SSL) has fallen from 85% to between 60%-70%. Despite efforts to import rice from India, Pakistan, and Vietnam since the Third Malaysia Plan (1976–1980), Malaysia's rice SSL has remained stagnant. According to the H-O theory, labour-intensive countries should prioritise the production of labour-intensive goods (such as agricultural products) while importing capital-intensive goods. Despite being a labour-intensive country, Malaysia exports and imports labour-intensive products (such as rice) to fulfil the demands of its growing population. To assess the role of food trade in addressing food insecurity, we propose the following hypotheses:

H_3 Food import significantly increases the FPI.
H_4 Food export significantly decreases the FPI.

Shang et al. (2024) adopted the H-O theory to examine the relationship between trade policies with agricultural exports in 38 Sub-Saharan countries from 2001 to 2021, aiming to address food security issues. During the 2007 – 2008 food crisis, several countries implemented food policies to stabilise and preserve domestic production. Most notably, export restriction policies were widely adopted (Giordani et al. 2016; Sun & Reed 2018). According to Sun and Reed (2018), China's food trade policies impose export restrictions, such as eliminating export tax rebates on raw grains and flour, and implementing temporary export tariffs on soybeans in 2007, which resulted in domestic food price instability and worsened food security conditions. Similarly, Giordani et al. (2016) investigated grain export restriction policies as a means of stabilising grain production, but concluded that such policies amplified grain price volatility, reduced grain yields, and ultimately harmed food security. While prior studies have primarily focused on food policies to stabilise food prices and enhance food security, none has investigated the role of food policies in enhancing food security through their influence on food trade. To address this research gap, we propose the following hypotheses:

H_{3a} Food policy moderates the relationship between food import and FPI.
H_{4a} Food policy moderates the relationship between food export and FPI.

DATA AND METHODOLOGY

In this section, we present the empirical model and econometric methodology that will be used to investigate the relationship between food policy, agricultural land, food import and export, and Malaysian food security. Furthermore, we provide thorough variable definitions, measurement methodology, and preliminary analyses for the variables used in the study.

DATA DESCRIPTION

To investigate the relationship between food policy, agricultural land (AGR_Land), food export (FE), food import (FI), and Malaysian food security. Following Soumbara and El Ghini (2023), we use the food production index (FPI) as a proxy to assess food security. The FPI is a reliable metric for measuring food availability over time and it is widely recognised as a key indicator that many countries use to compare food. Table 1 shows the details of the variable description used in this study.

TABLE 1. Variables measurement and source

Variables	Indicator/measurement	Data source
Dependent variable		
FPI	Food Production Index (FPI)	World Bank (2023)
Independent variables		
NAP_0	Dummy year, "1" the year that the country implements 1st – 3rd Malaysia Plan (1964 – 1983), and "0" otherwise	Ministry of International Trade and Industry of Malaysia (MITI) (2023)
NAP_1	Dummy year, "1" the year that the country implements 1st National Agricultural Food Policy (1984-1991), and "0" otherwise.	Ministry of International Trade and Industry of Malaysia (MITI) (2023)
NAP_2	Dummy year, "1" the year that the country implements 2nd National Agricultural Food Policy (1992-1997), and "0" otherwise.	Ministry of International Trade and Industry of Malaysia (MITI) (2023)
NAP_3	Dummy year, "1" the year that the country implements 3rd National Agricultural Food Policy (1998-2010), and "0" otherwise.	Ministry of International Trade and Industry of Malaysia (MITI) (2023)
NAP_4	Dummy year, "1" the year that the country implements 4th National Agricultural Food Policy (2011-2021), and "0" otherwise.	Ministry of International Trade and Industry of Malaysia (MITI) (2023)
AGR_Land	Agricultural land (sq/km)	World Bank (2023)
FE	Food export (% of merchandise imports)	World Bank (2023)
FI	Food import (% of merchandise imports)	World Bank (2023)
Control variables		
GDP	Natural logarithm of Gross domestic product per capita (GDP) (current US$)	World Bank (2023)
GNE	Natural logarithm of Gross national expenditure per capita (current US$)	World Bank (2023)

Source: https://data.worldbank.org/country/malaysia; Ministry of Investment, Trade and Industry (miti.gov.my)

Table 2 presents a summary of descriptive statistics and correlation coefficient analysis. According to modernisation theory, there is a positive correlation between food policy and FPI. Additionally, an increase in AGR_Land is projected to correlate positively with FPI due to increased production of commodities, vegetables, and fruits. In terms of food trade variables, Malaysia, a labor-intensive country, demonstrates a negative relationship between FE and the FPI. Similarly, FI has a negative correlation with the FPI. This finding contradicts the Heckscher-Ohlin (H-O) theory, which predicts a positive relationship between the two variables. One explanation for this inconsistency is that Malaysia imports a large proportion of products with high labor intensity. Moreover, active exportation of food products, particularly those with declining Self-Sufficiency Level (SSL) and those that are heavily consumed domestically (e.g., rice), exacerbates the FPI. Furthermore, at the 1% significance level, FD, GDP and GNE show a positive relationship with the FPI. In the following section, we present the econometric model for analysing the impact of food policy, AGR_Land, FE, and FI on the FPI.

TABLE 2. Descriptive statistics and correlation matrix

	LnFPI	LnFAP	LnAgriLand	LnFE	LnFI	LnFD	LnGDP	LnGNE
Mean	3.953	2.965	2.899	2.451	2.291	16.722	7.864	24.501
Median	4.108	2.970	3.037	2.399	2.172	16.750	8.087	24.772
Maximum	4.653	5.000	3.261	3.145	3.399	17.342	9.318	26.571
Minimum	3.006	0.000	2.318	1.712	1.467	15.994	5.713	21.690
Std. Dev.	0.471	1.426	0.286	0.313	0.545	0.421	1.136	1.512
Skewness	-0.275	-0.012	-0.553	-0.026	0.457	-0.141	-0.496	-0.398
Kurtosis	1.960	1.946	2.000	2.518	2.035	1.672	2.154	2.065
Jarque-Bera	3.345	1.592	5.366	0.567	4.275	4.451	4.112	3.649
Probability	0.188	0.314	0.068	0.753	0.118	0.108	0.128	0.161
Observation	58	58	58	58	58	58	58	58
Correlation matrix								
LnFPI	1		-	-	-		-	-
LnFAP	0.945***	1		-			-	
LnAgriLand	0.986***	0.993***	1	-	-		-	-
LnFE	-0.423***	-0.484***	-0.451***	1	-		-	-
LnFI	-0.821***	-0.859***	-0.908***	0.387***	1		-	-
LnFD	0.986***	0.959***	0.970***	-0.481***	-0.812***	1		
LnGDP	0.983***	0.974***	0.977***	-0.412***	-0.873***	0.987***	1	-
LnGNE	0.983***	0.975***	0.977***	-0.395***	-0.871***	0.981***	0.998***	1

Note(s): ** and *** indicate significance level at 5% and 1% respectively.
Source: Authors' computation

METHODOLOGY

UNIT ROOT TEST

For a time series analysis, checking the existence of unit root issues among tested variables is essential. We conducted the unit root tests via Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) tests to ensure our baseline models do not suffer any spurious estimation. Table 3 summarises the ADF and PP unit root test results. Based on Table 3, we found that without the trend, Food Import (FI) tends to be stationary at level I(0), while the FPI, FE, AGR_Land, GDPPC, FD and GNE were at their first difference I(1). We further conducted the ADF and PP tests using trend, and the results showed that FP was stationary at level I(0). The remaining variables were stationary at their first difference (I(1). Our unit root test results exhibit the existence of a mixture of I(0) as I(1) in our SEVEN (7) tested variables.

TABLE 3. ADF and PP unit root tests

Variables		ADF		PP	
		Level	1st Difference	Level	1st Difference
Food Production (FPI)	Without Trend	0.121	-6.012***	-0.025	-6.089***
	With Trend	-4.426***		0.475	-6.058***
Food Export (FE)	Without Trend	-1.993	-7.042***	-1.822	-8.471***
	With Trend	-2.573	-7.030***	-2.432	-8.434***
Food Import (FI)	Without Trend	-4.248***		-4.502***	
	With Trend	-1.592	-7.707***	-1.631	-8.239***
Agricultural Land (AGR_Land)	Without Trend	-0.945	-2.968***	-1.031	-4.908***
	With Trend	-2.338**		-1.683	-4.913***
GDPPer Capita (GDPPC)	Without Trend	-1.895	-5.895***	-1.895	-5.922***
	With Trend	-1.102	-6.104***	-1.283	-6.023***
Food Demand (FD)	Without Trend	-2.466	-1.729	-2.188	-10.864***
	With Trend	3.251	-0.364	1.098	-12.177***
Gross National Expenditure (GNE)	Without Trend	-1.588	-5.441***	-1.487	-5.366***
	With Trend	-2.166	-5.535***	-1.447	-5.404***

Note: *** and ** denote statistical significance at 1% and 5% levels respectively. The GDP, Population and Government Expenditure variables have been transformed into natural logarithms.

BOUNDS TESTING FOR COINTEGRATION

Given the mixed stationarity of variables at I(0) and I(1), we employed the ARDL bounds test (Pesaran et al. 2001) to examine potential cointegration. As the initial step in the ARDL-ECM estimation, this test assesses whether a long-run equilibrium relationship exists. It relies on a joint F-statistic with a non-standard asymptotic distribution under the null hypothesis of no cointegration. The F-statistics show at least one cointegration relationship in tested variables, therefore, we can estimate the log-level ARDL error correction model for the cointegration relationship with long-run and short-run association. The study aims to test how agricultural-related policy increases the FP in Malaysia. We grouped FIVE (5) ARDL estimation models to cater to FIVE (5) different NAP policies implemented by the Malaysian government between 1964 and 2021. We further interact the policies with our FE, FI, and AGR_Land and the bound test results are presented in Table 4. Based on our results in Table 4, the F-statistics for our multiple baseline estimation models (FPI, FE, FI, AGR_Land, GDPPC, GNE, FD, NAP; k=7, n=58) and interaction estimation models (k=8, n= 58) are more than the high bounds critical value or lower than the lower bounds critical values, thus at least one cointegration relationship can be established in our estimation models. To estimate the ARDL-ECM, we further manually determine the lag length for each of our models, and the appropriate n, p, q, r, s, t and u can be found in Table 4.

TABLE 4. Bounds test results

Model	F-statistic	Significant level	I (0)	I(1)
Baseline				
FPI|FE,FI,AGR_Land,FD,GDPPC,GNE,NAP				
Baseline ARDL(1, 0, 1, 1, 0, 4, 0)	4.077471	1%	2.88	3.99
NAP ARDL(1, 0, 1, 1, 0, 4, 1, 0)	3.936162	1%	2.73	3.90
NAP0 ARDL(1, 4, 0, 1, 4, 4, 1, 1)	4.991154	1%	2.73	3.90
NAP1 ARDL(1, 4, 0, 0, 1, 4, 1, 0)	12.98969	1%	2.73	3.90
NAP2 ARDL(2, 4, 1, 0, 1, 0, 0, 3)	10.13225	1%	2.73	3.90
NAP3 ARDL(4, 3, 2, 1, 4, 0, 4, 4)	4.224035	1%	2.73	3.90
NAP4 ARDL(1, 0, 1, 1, 0, 4, 1, 0)	3.704520	2.5%	2.43	3.51
FPI|FE,FI,AGR_Land,FD,GDPPC,GNE,NAP, FE*NAP				
NAP0 ARDL(1, 3, 1, 1, 0, 4, 0, 1)	4.048285	1%	2.73	3.9
NAP1 ARDL(1, 4, 0, 0, 1, 4, 0, 3, 3)	13.10318	1%	2.62	3.77
NAP2 ARDL(2, 2, 1, 0, 1, 0, 3, 0, 0)	7.736942	1%	2.62	3.77
NAP3 ARDL(1, 3, 1, 2, 1, 1, 3, 3, 2)	4.056194	1%	2.62	3.77
NAP4 ARDL(4, 3, 4, 4, 3, 4, 3, 3, 1)	17.74365	2.5%	2.43	3.51
FPI|FE,FI,AGR_Land,FD,GDPPC,GNE,NAP, FI*NAP				
NAP0 ARDL(1, 3, 1, 0, 3, 4, 0, 1, 1)	5.458313	1%	2.62	3.77
NAP1 ARDL(1, 4, 0, 0, 3, 4, 1, 1, 0)	9.843723	1%	2.62	3.77
NAP2 ARDL(1, 0, 2, 1, 1, 0, 3, 0, 0)	4.029164	1%	2.62	3.77
NAP3 ARDL(2, 4, 4, 4, 2, 4, 4, 2, 2)	5.614495	1%	2.62	3.77

NAP4 ARDL(4, 4, 4, 4, 4, 4, 4, 4, 4)	7.803613	2.5%	2.62	3.77
FPI|FE,FI,AGR_Land,FD,GDPPC,GNE,NAP, AGR_Land*NAP				
NAP0 ARDL(1, 3, 0, 4, 3, 0, 1, 0, 1)	5.411159	1%	2.62	3.77
NAP1 ARDL(2, 2, 1, 0, 1, 3, 0, 0, 0)	7.364446	1%	2.62	3.77
NAP2 ARDL(1, 0, 2, 0, 1, 3, 1, 0, 0)	4.040828	1%	2.62	3.77
NAP3 ARDL(1, 4, 0, 4, 1, 2, 4, 4, 4)	5.480628	1%	2.62	3.77
NAP4 ARDL(1, 0, 1, 1, 0, 2, 0, 1, 1)	5.081936	1%	2.62	3.77

Note: *** and ** denote statistical significance at 1% and 5% levels respectively.

MODEL SPECIFICATION : ARDL-ECM MODEL

We applied the ARDL approach advocated by Pesaran et al. (1996) which is compatible with the mixed order of integration at level and first difference identified in the earlier unit root test results in Table 3. In addition, the effect of each factor is not within a year, it could be more than that, due to lag effect which captured by lag distribution in ARDL approach. Next, to establish the long-run and short run association via ARDL-ECM, we estimate the long-run coefficients using the following ARDL (n, p, q, r, s, t, u) specification as follows:

$$\Delta lnFPI_t = \beta_0 + \sum_{i=1}^{n}\emptyset_{1i}\Delta lnFPI_{t-i} + \sum_{i=1}^{p}\emptyset_{2i}\Delta lnFE_{t-i} + \sum_{i=1}^{q}\emptyset_{3i}\Delta lnFI_{t-i} + \sum_{i=1}^{r}\emptyset_{4i}\Delta lnAGR_{Land_{t-i}} + \sum_{i=1}^{s}\emptyset_{5i}\Delta lnFD_{t-i} + \sum_{i=1}^{t}\emptyset_{6i}\Delta lnGDPPC_{t-i} + \sum_{i=1}^{u}\emptyset_{7i}\Delta lnGNE_{t-i} + \mu_{2t} \quad (1)$$

Where $\emptyset_{1i}$ to $\emptyset_{7i}$ are long-run multipliers. The Schwarz Information Criterion (SIC) is used to determine the optimal lag length criteria since this study's annual data is low-frequency, as Koehler & Murphree (1988) highlighted.

In food production practice, it is generally recognized that production does not immediately adjust to its long-run equilibrium level following a change in its determinants, such as food export, food import, and agricultural land. This may be due to cost adjustment and lags in perceiving changes. The error correction model is estimated to capture the short-run association and the speed of adjustment, and the model is based on the following:

$$\Delta lnFPI_t = \lambda_0 + \sum_{i=1}^{n}\lambda_{1i}\Delta lnFPI_{t-i} + \sum_{i=0}^{p}\lambda_{2i}\Delta lnFE_{t-i} + \sum_{i=0}^{q}\lambda_{3i}\Delta lnFI_{t-i} + \sum_{i=0}^{r}\lambda_{4i}\Delta lnAGR_{Land_{t-i}} + \sum_{i=0}^{s}\lambda_{5i}\Delta lnFD_{t-i} + \sum_{i=0}^{t}\lambda_{6i}\Delta lnGDPPC_{t-i} + \sum_{i=0}^{u}\lambda_{7i}\Delta lnGNE_{t-i} + \lambda_8 CointEq_{t-1} + \mu_{3t} \quad (2)$$

where the difference operator Δ represents the change of the short-run dynamics. While $CointEq_{t-1}$ is lagged one period of error correction term represents the speed of adjustment in the event of shock to the system in the long run equilibrium. Next, we repeat to estimate Equations (1) and (2) by testing the effect of national agricultural policy toward overcoming the food security issue. To achieve this objective, we then include National policy (NP) and FIVE (5) respective national policy dummies in both equations. Finally, we incorporate the interaction of these FIVE (5) NAPs with FE, FI and Agr_Land to detect which NAPs effectively work best to improve Malaysian FPI.

RESULT AND DISCUSSION

ARDL-ECM RESULTS

In Table 4, we detected cointegration within our estimation model, we next investigate the long-run and short-run dynamic association between FP and FE, FI, AGR_Land, GDPPC, FD, GNE and NAP via ARDL-ECM model and the long-run estimation results for our baseline models are presented in Table 5 (Panel a). We estimated SEVEN (7) ARDL-ECM models, where Model (1.1) is for FP against FE, FI, AGR_Land, FD, GDPPC and GNE. In Model 1.2, we added the dummy for the National Agriculture Policy (NAP), and Model 1.3-1.7 are for FIVE (5) different NAP (NAP_0 -NAP_4), respectively. The long-run findings in Table 5 (Panel a) showed that food import significantly increased food production (Model 1.1- β=0.166, ρ=0.05; Model 1.2- β=0.179, ρ=0.05) and insignificant results for the remaining five models. Surprisingly, food export positively correlates with FPI for Model 1.4, and most of the other SIX models unanimously showed insignificant results. Therefore, the FE does not impact the Malaysian FPI. Consistent with the present literature (Azizan & Hussin 2015; Hossain et al. 2020; Mahmood et al. 2016; Mulusew & Mingyong 2023), larger AGR_Land leads to higher food production. For our agricultural-related policy, generally, the policy (NAP) does not affect the FPI in Malaysia (Model 1.2), but when we tested each of FIVE (5) different NAPs (NAP_0 – NAP_4), only NAP_0 β=0.120, ρ=0.01and NAP_2 β=0.067, ρ=0.01enhance the FPI in Malaysia but not the other NAPs. NAP represents the 1st to 5th Malaysian Plan 1 (1966-1990) to introduce the agricultural regulatory framework, research and development (R&D), and promote skilled farmers. While NAP_2 (1992-1997) focused on increased agricultural productivity, higher food export, and strengthened agricultural-related R&D. To raise productivity and efficiency, the policy promoted privatisation for agriculture-related companies. For control variables, population which is used to measure food demand (FD), shows a positive long-run relationship with food production (FP), indicating that higher populations drive increased food demand and FP. This consistency with the results shows population growth to be a key determinant of essential good demand, such as water demand (Anang et al. 2019) and food security in Nigeria (Kabir et al. 2023). In contrast, GDP per capita and gross national expenditure (GNE) are insignificant. Thus, H_2 is fully supported in the long run, while H_1 and H_3 are only partially supported, and H_4 is not supported, reflecting mixed outcomes among the control variables.

Table 5 (Panel b) depicts the ECM model results, and the findings suggest that FE (lagged 1& 3) reduced food production. However, in the short term, FI and AGR_Land are not relevant factors driving the FP. As for the NAPs, NAP_1 (negatively related for lagged 2) and NAP_3 [negatively related for (0) and positively related for (lagged 1-3)] are significant toward FPI. Such results support the idea that NAP_3 introduced food security, bolstered food production, and promoted sustainable food production and an agroforestry approach in 1998-2010 to enhance food production. The significant results prove that NAP_3 translates into higher FPI in the short run (lagged 1-3). In the short run, GDP per capita (GDPPC) positively influences the FPI at lags 1–3, suggesting that rising income levels temporarily enhance food production. Food dependency (FD), however, only significantly impacts FPI at lag 1. This supports Applanaidu and Baharudin (2014), who found GDPPC to be a stronger determinant of FPI than FD due to its effect on household expenditure in Malaysia. They noted that GDPPC shocks have more enduring effects on FPI than FD shocks. Similarly, Mathur (2011) observed that in countries with high Human Development Index (HDI) values, such as Malaysia (HDI: 0.829), FD has a limited effect on FPI. Conversely, in lower-HDI countries like Timor-Leste (HDI: 0.489), FD strongly affects FPI. This is consistent with Asumadu-Sarkodie and Owusu (2016), who linked FPI to demographic factors in less developed economies. The ECM coefficients are highly significant, ranging from -0.413 to -0.688 at 1% confidence interval for all SEVEN (7) models. These significantly higher negative coefficients imply that 41.3% to 68.8% disequilibrium from the current year's shock can be adjusted to its equilibrium in the next 2 to 3 years. We further run the stability tests to ensure the reliability of our estimation models and avoid misspecification in our time series data. For breviary, the stability results are available upon request. Our stability tests conclude that our estimations are reliable.

TABLE 5 (Panel a). Estimated long run coefficients using the ARDL-ECM Approach

	BASELINE (1.1)	NAP (1.2)	NAP0 (1.3)	NAP1 (1.4)	NAP2 (1.5)	NAP3 (1.6)	NAP4 (1.7)
LNFE	-0.099772	-0.127178	0.22889	0.30205***	0.176012*	-0.321756	-0.124728
LNFI	0.165819**	0.179425**	-0.05034	-0.005616	0.073909	0.266673	0.208917
LNAGR_Land	1.322199***	0.525903***	0.458934**	0.473717***	0.252958**	0.469776	0.595778***
LNFD	0.645958***	0.306314**	0.446602**	0.371518***	0.617903***	0.433871	0.266941***
LNGDPPC	-0.287036	-0.290462	-0.487759	-0.390198***	-0.064713	0.633681*	-0.315156
LNGNE	0.139517	0.072236	0.103821	0.068034*	-0.052229	-0.238132**	0.075729
NATIONAL_POLICY (NP)		-0.008752					
NAP0			0.120471***				
NAP1				-0.066546***			
NAP2					0.067596***		
NAP3						-0.071259	
NAP4							-0.015829
C	-12.01664***	-5.745465***	-8.199807**	-6.499876***	-8.10536***	-3.224097	-5.340954***

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively.

TABLE 5 (Panel b). Estimated short run and ECM coefficients using the ARDL-ECM Approach (Continued)

	BASELINE (1.1)	NAP (1.2)	NAP0 (1.3)	NAP1 (1.4)	NAP2 (1.5)	NAP3 (1.6)	NAP4 (1.7)
D(LNFI)	0.007613	-0.006445			-0.085676**	-0.077869*	-0.001606
D(LNFI(-1))						-0.079796	
D(LNAGR_Land)	1.16156***	0.525972***	0.482738***			0.586913***	0.485957***
D(LNGDPPC)	-0.087304**	-0.079902**	0.058127	-0.136118***			-0.105657***
D(LNGDPPC(-1))	0.123782***	0.114253***	0.164579***	0.141975***			0.107842***
D(LNGDPPC(-2))	0.104296***	0.116439***	0.122085***	0.141294***			0.123401***
D(LNGDPPC(-3))	0.125415***	0.114256***	0.086667**	0.101566***			0.108227***
D(LNFE)			0.023824	0.057779***	0.025281	-0.002928	
D(LNFE(-1))			-0.056785**	-0.127092***	-0.104277***	0.060996**	
D(LNFE(-2))			0.037266	-0.013798	-0.011453	0.115538***	
D(LNFE(-3))			-0.060503**	-0.062821***	-0.061601***		
D(LNFD)			0.288777	0.03492	-0.04841	0.437877**	
D(LNPFD(-1))			0.482835***			0.75776***	
D(LNFD(-2))			-0.03893			0.218244	
D(LNFD(-3))			-0.352343*			-0.306077	
D(LNFP(-1))					0.15322*	0.018827	
D(LNFP(-2))						0.15432	
D(LNFP(-3))						0.33169***	
D(LNGNE)			-0.018619		-0.028379**	-0.140575***	
D(LNGNE(-1))					0.032435***	0.040728**	
D(LNGNE(-2))					0.04142***	0.090482***	
D(LNGNE(-3))						0.036368*	
D(NAP0)			0.016325				
D(NAP1)				-0.023622***			
D(NAP3)						-0.03502***	
D(NAP3(-1))						0.029306**	
D(NAP3(-2))						0.045965***	
D(NAP3(-3))						0.022016**	
D(NAP4)							0.013398
D(NATIONAL_POLICY_NP)		0.008756					

CointEq(-1)*	-0.427464***	-0.421822***	-0.41364***	-0.688245***	-0.595559***	-0.454454***	-0.413349***
R-squared	0.616533	0.643184	0.762292	0.770372	0.748193	0.802942	0.631595
Durbin-Watson stat	1.985723	2.127321	1.789175	1.809965	2.059779	2.097476	2.14236
Serial correlation LM test (p-value)	0.9548	0.3997	0.482	0.2524	0.5107	0.557	0.7218
Heteroscedasticity test (p-value)	0.7462	0.7479	0.7428	0.9192	0.9394	0.904	0.7833
Ramsey RESET test (p-value)	0.2185	0.1730	0.6969	0.8248	0.4259	0.7805	0.0779
CUSUM	yes	yes	yes	Yes	yes	yes	yes
CUSUM square	yes	yes		Yes		yes	yes

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively.

FURTHER ANALYSIS

In the next stage, we re-estimate ARDL-ECM with the interaction between NAPs and FE, FI and AGR_Land. The interactions will provide a better understanding of which NAPs with FE, FI and AGR_Land will induce Malaysian FPI, and the results can be found in Table 6 (Panel a, b and c).

TABLE 6 (Panel a). Estimated long-run coefficients using the ARDL Approach: Food Export x NAPs

	NAP0	NAP1	NAP2	NAP3	NAP4
LNFE	-0.25865*	0.337139***	0.136202*	-0.13212	-0.341728***
LNFI	0.246418**	0.003241	0.089508	-0.054911	1.25795***
LNAGR_Land	1.557251***	1.035936***	0.77523***	0.611152	1.097906***
LNFD	0.183093	0.885209***	1.265041***	1.207168*	1.53468***
LNGDPPC	-0.102057	-0.194385	-0.018125	0.073952	-2.08186***
LNGNE	0.088858	0.013824	-0.140661	-0.1902	1.842114***
LNFExNAP0	0.004237				
LNFExNAP1		-0.269152**			
LNFExNAP2			0.076245		
LNFExNAP3				0.296583**	
LNFExNAP4					4.119795***
NAP1		0.578227*			
NAP2			-0.024296		
NAP3				-0.801621**	
NAP4					-10.95029***
C	-4.992536	-13.44198***	-16.38912***	-13.46043*	-55.21607***

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively.

TABLE 6 (Panel b). Estimated long-run coefficients using the ARDL Approach: Food Import x NAPs (Continued)

	NAP0 (1.1)	NAP1 (1.2)	NAP2 (1.3)	NAP3 (1.4)	NAP4 (1.5)
LNFE	-0.061147	0.363938***	0.050903	0.010919	-0.245665*
LNFI	0.725929**	-0.001324	0.136605**	-0.173611	0.736012*
LNAGR_Land	1.992963***	0.933107***	0.806732***	-0.578547	1.57609*
LNFD	0.043964	1.03079***	1.213579***	0.178782	0.452932
LNGDPPC	-0.23974	-0.528173***	0.098399	-2.316156***	-1.240185
LNGNE	0.224976	0.250715**	-0.206872	2.051781***	1.134336
LNFIxNAP0	-0.155498				
LNFIxNAP1		-0.039696			
LNFIxNAP2			0.186944		
LNFIxNAP3				0.910384***	
LNFIxNAP4					26.27207**
NAP0	0.359591*				
NAP1		-0.067159			
NAP2			-0.165076		
NAP3				-1.326752***	
NAP4					-55.93852**
C	-8.044456	-18.90239***	-14.82523***	-29.10576***	-26.82273

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively.

TABLE 6 (Panel c). Estimated long-run coefficients using the ARDL Approach: Agricultural Land x NAPs (Continued)

	NAP0 (1.1)	NAP1 (1.2)	NAP2 (1.3)	NAP3 (1.4)	NAP4 (1.5)
LNFE	0.079195**	0.19369**	0.048222	0.037189	-0.014106
LNFI	-0.040917	0.030443	0.137435**	-0.203099*	0.429733
LNGDPPC	-0.241276	-0.132957	0.100177	-1.013088*	-0.738021*
LNFD	0.287837**	0.282567***	0.526753***	0.574781***	0.290803**
LNGNE	0.042525	0.000819	-0.090431	0.30393	0.241954
LNAGR_Land	0.199722	0.55337***	0.350926***	-0.090666	0.681895**
LNAGR_LandxNAP0	0.136481***				
LNAGR_LandxNAP1		-0.089328**			
LNAGR_LandxNAP2			-0.955877		
LNAGR_LandxNAP3				4.072003***	
LNAGR_LandxNAP4					-0.165355
NAP0	-0.411292***				
NAP1		0.197024			
NAP2			2.980921		
NAP3				-12.53019***	
NAP4					0.363584
C	-4.038815*	-4.396261***	-6.424934***	-11.48149***	-8.894738***

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively.

Focusing on the interactions results in Table 6 (Panel a and b), Food export and Food Import with the assistance of NAP_3 (FExNAP_3 – β=0.297, ρ=0.05; FIx NAP_3 – β=0.919, ρ=0.01) and NAP_4 (FExNAP_4 – β=4.120, ρ=0.01; FIxNAP_4 – β=26.272, ρ=0.01) are likely to be effective in raising the food production in Malaysia. As for Agriculture Land in Panel c, the 1^{st} – to 4^{th} Malaysian Plans in NAP_0 and NAP_3 positively affected the Malaysian FP (AGR_Land xNAP_0– β=0.136, ρ=0.01; AGR_LandxNAP_3– β=4.072, ρ=0.01). NAP_0 within the 5 Malaysian Plans is expected to work better for Agricultural Land since the Malaysian plans (1966-1990) actively explored the new land development and replanting for crops undertaken by FLDA, FELCRA and SEDC agencies to enhance the crop productivity in Malaysia. Comparative analysis of interaction coefficients reveals that NAP3, designed to strengthen food security, shows a stronger association with the FPI, while FE and FI alone exert limited influence on FPI (see Table 6, panels a and b). However, when integrated with NAP3 and NAP4, these trade variables become more impactful. Notably, NAP4 interactions outperform NAP3 in enhancing the effect of FE and FI, with the NAP4–FI interaction showing a significant effect (β=26.272, ρ=0.01). As an extension of NAP3, NAP4 emphasises agricultural modernisation to improve food security. This focus is timely, given Malaysia's underutilization of its agricultural land and resources. Technological advancement under NAP4 offers potential to boost food productivity, reducing overreliance on food imports that fail to address food insecurity in the short or long term. Additionally, significant interactions are observed between NAP0 and agricultural land (AGRI_Land), and between NAP3 and NAP4 with FE and FI, respectively. These results provide empirical support for hypotheses H_{2a}, H_{3a}, and H_{4a}, highlighting the importance of aligning food trade with appropriate policy frameworks.

Table 7 panels a, b, c presents the ECM estimation results for all the short-run interactions. Similar NAP_3 and NAP_4 work best only for FE at their current lagged (0) (β=0.137, ρ=0.01; β=.693, ρ=0.01), FI (β=0.312, ρ=0.01; β=3.903, ρ=0.01) and AGR_Land (β=0.643, ρ=0.01; β=0.672, ρ=0.01). However, inverse significant short-term relationships were found for FE, FI and AGR_Land (at Lagged 1-3). The findings in Table 7 support the FE, FI and AGR_Land with the NAP_3 and NAP_4 implementation, which did not significantly increase the FPI in lagged 1-3. Similar to our baseline ARDL-ECM models the ECM coefficients range from -0.427 to -0.691 at 1% confidence interval for all TEN (10) models for FExNAPs and FIxNAPs. And the ECM coefficients were within -0.262 to -0.624. The error terms signify that 42.7% to 69.1% disequilibrium from the present year's shock can converge to equilibrium for both FE and FI in the next 1 to 3 years. But AGR_LandxNAPs took longer to converge within 1 to 4 years (26.2% to 62.4%).

TABLE 7 (Panel a). Estimated short run and ECM using the ARDL-ECM Approach: Food Export x NAPs

	Food Export				
	NAP0 (1.1)	NAP1 (1.2)	NAP2 (1.3)	NAP3 (1.4)	NAP4 (1.5)
D(LNFE)	-0.072547**	0.056003**	0.034058	0.030159	-0.00829
D(LNFE(-1))	0.022231	-0.15912***	-0.058941**	0.015153	0.044994***
D(LNFE(-2))	0.074651***	-0.057113*		0.067858***	0.047618***
D(LNFE(-3))		-0.06379***			
D(LNFI)	0.004531		-0.105944***	-0.172238***	-0.235567***
D(LNFI(-1))					-0.941443***
D(LNFI(-2))					-0.706695***
D(LNFI(-3))					-0.377133***
D(LNFP(-1))			0.138039		-0.810286***
D(LNFP(-2))					-0.599589***
D(LNFP(-3))					-0.203338***
D(LNFD)		0.070579	-0.19543	-0.578929**	-1.576823***
D(LNFD(-1))					-2.136725***
D(LNFD(-2))					-0.777925***
D(LNAGR_Land_)	1.313371***			1.336756***	2.027362***
D(LNAGR_Land_(-1))				0.582981**	2.096567***
D(LNAGR_Land_(-2))					-0.626558***
D(LNAGR_Land_(-3))					-1.453195***
D(LNGDPPC)	-0.024311	-0.020958		0.182362**	-0.06104
D(LNGDPPC(-1))	0.092431**	0.133146***			0.885286***
D(LNGDPPC(-2))	0.129063***	0.135174***			0.483897***
D(LNGDPPC(-3))	0.081924**	0.101384***			0.076404***
D(LNGNE)			-0.08359***	-0.233858***	-0.031743
D(LNGNE(-1))			0.070429**	0.112379***	-0.812829***
D(LNGNE(-2))			0.100989***	0.190643***	-0.263065***
D(LNFExNAP0)	0.012992**				
D(LNFExNAP1)		-0.008831			
D(LNFExNAP1(-1))		0.151299***			
D(LNFExNAP1(-2))		0.116566***			
D(LNFExNAP3)				0.137473**	
D(LNFExNAP3(-1))				-0.189875***	
D(LNFExNAP3(-2))				0.035702***	
D(LNFExNAP4)					0.693254***
D(LNFExNAP4(-1))					-0.057194***
D(LNFExNAP4(-2))					-0.049162***
D(NAP1)		-0.010138			
D(NAP1(-1))		-0.377952***			
D(NAP1(-2))		-0.29473**			
D(NAP3)				-0.387047***	
D(NAP3(-1))				0.510206***	

D(NAP4)					-1.913277***
CointEq(-1)*	-0.436555***	-0.691131***	-0.568324***	-0.424242***	-0.434307***
R-squared	0.676091	0.821662	0.68921	0.758393	0.965275
Durbin-Watson stat	1.893077	1.892979	2.195202	2.038394	2.17172
Serial correlation LM test (p-value)	0.7598	0.3055	0.253	0.5605	0.1288
Heteroscedasticity test (p-value)	0.9757	0.6965	0.6572	0.8202	0.8762
Ramsey RESET test (p-value)	0.3291	0.7607	0.6870	0.7208	0.0879
CUSUM	yes	yes	yes	yes	yes
CUSUM square	yes	yes	yes	yes	

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively.

TABLE 7 (Panel b). Estimated short run and ECM using the ARDL-ECM Approach: Food Import x NAPs (Continued)

	Food Import				
	NAP0 (1.1)	NAP1 (1.2)	NAP2 (1.3)	NAP3 (1.4)	NAP4(1.5)
D(LNFE)	-0.006975			-0.049674*	0.013535
D(LNFE(-1))	0.019378			-0.160211***	0.039518*
D(LNFE(-2))	0.119216***			-0.099015***	0.032481*
D(LNFE(-3))				-0.153439***	-0.036433*
D(LNFP(-1))		0.160105*		0.330995***	-0.228816**
D(LNFP(-2))					-0.357916***
D(LNFP(-3))					-0.15288*
D(LNFI)	0.067984	-0.075765*	-0.125599***	-0.169023***	-0.087436**
D(LNFI(-1))			-0.072148*	-0.0345	-0.602714***
D(LNFI(-2))				-0.19219***	-0.424399***
D(LNFI(-3))				-0.234671***	-0.268843***
D(LNFD)	0.83502**	-0.321673	-0.077138	-1.991046***	-2.042522***
D(LNFD(-1))	2.142774***			-1.213618***	-3.115825***
D(LNFD(-2))	1.409543***				-2.689083***
D(LNFD(-3))					-1.004266**
D(LNGDPPC)	-0.074735**			0.041881	0.106171*
D(LNGDPPC(-1))	0.119988***			1.138324***	0.757747***
D(LNGDPPC(-2))	0.142814***			0.930898***	0.542186***
D(LNGDPPC(-3))	0.093671**			0.490674***	0.397652***
D(LNFINP)	-0.006331				
D(LNGNE)		-0.017965	-0.11001***	-0.018486	-0.071695
D(LNGNE(-1))		0.071456**	0.053001*	-0.916078***	-0.655354***
D(LNGNE(-2))		0.09723***	0.103359***	-0.743592***	-0.3903***
D(LNGNE(-3))				-0.336317***	-0.271993***
D(LNAGR_Land_)			0.870593***	1.173971***	1.648106***
D(LNAGR_Land_(-1))				1.654155***	0.466544*
D(LNAGR_Land_(-2))				1.931132***	-0.379547
D(LNAGR_Land_(-3))				0.721752***	-0.677876**
D(LNFIxNAP3)				0.311663***	
D(LNFIxNAP3(-1))				-0.428397***	
D(LNFIxNAP4)					3.903054***
D(LNFIxNAP4(-1))					-9.961008***
D(LNFIxNAP4(-2))					-5.2054***
D(LNFIxNAP4(-3))					-2.615983***
D(NAP3)				-0.509327***	
D(NAP3(-1))				0.722963***	
D(NAP4)					-8.590713***
D(NAP4(-1))					20.95586***
D(NAP4(-2))					10.95388***
D(NAP4(-3))					5.578014***
D(NAP0)	0.05733				
CointEq(-1)*	-0.446275***	-0.503533***	-0.482173***	-0.621481***	-0.608732***
R-squared	0.728685	0.637611	0.682162	0.896836	0.971364
Durbin-Watson stat	1.90003	2.205104	2.092698	1.672594	2.16676
Serial correlation LM test (p-value)	0.4696	0.21	0.2289	0.2967	0.1357
Heteroscedasticity test (p-value)	0.9441	0.5218	0.8394	0.9889	0.4179
Ramsey RESET test (p-value)	0.4926	0.3479	0.2656	0.1165	0.0825
CUSUM	yes	yes	yes	yes	
CUSUM square	yes	yes	yes		

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively.

TABLE 7 (Panel c). Estimated short run and ECM using the ARDL-ECM Approach: Agricultural Land x NAPs (Continued)

	AGR_Land				
	NAP0 (1.1)	NAP1 (1.2)	NAP2 (1.3)	NAP3 (1.4)	NAP4 (1.5)
D(LNFE)	0.020469	0.051646**		-0.030313	
D(LNFE(-1))	0.008732	-0.056684**		-0.096739***	
D(LNFE(-2))	0.093758***			-0.064208**	
D(LNFE(-3))				-0.116559***	
D(LNGDPPC)	-0.014934			0.040448	-0.05216
D(LNGDPPC(-1))	0.133068***			0.496034***	
D(LNGDPPC(-2))	0.1551***			0.233271***	
D(LNGDPPC(-3))	0.08406***			0.11571**	
D(LNFD)	0.455899***	-0.11065	-0.034499	-0.094726	
D(LNFD(-1))	0.88095***				
D(LNFD(-2))	0.535679***				
D(LNAGR_Land_)	0.337123***		0.384728***	0.441805***	
D(LNAGR_Land_(-1))				0.480563***	
D(LNAGR_Land_(-2))				0.324347**	

D(LNAGR_Land_(-3))				0.208104**	
D(LNFI)		-0.074526*	-0.126154***		-0.025385
D(LNFI(-1))			-0.068703*		
D(LNGNE)		0.014388	-0.048189***	-0.03557	0.005424
D(LNGNE(-1))		0.033695***	0.023558*	-0.169103***	0.032085**
D(LNGNE(-2))		0.045275***	0.044816***		
D(LNFP(-1))		0.208257**			
D(LNAGR_LandxNAP3)				0.642764**	
D(LNAGR_LandxNAP3(-1))				-0.791653**	
D(LNAGR_LandxNAP3(-2))				-0.94154***	
D(LNAGR_LandxNAP3(-3))				-0.731677***	
D(LNAGR_LandxNAP4)					0.672268***
D(NAP3)				-1.984791**	
D(NAP3(-1))				2.435399**	
D(NAP3(-2))				2.939196***	
D(NAP3(-3))				2.291532***	
D(NAP4)					-2.120669***
D(NAP0)	-0.186076***				
CointEq(-1)*	-0.49536***	-0.623529***	-0.476976***	-0.534352***	-0.262312***
R-squared	0.750514	0.678747	0.682635	0.855855	0.539244
Durbin-Watson stat	2.063574	2.192501	2.101625	2.062559	2.187335
Serial correlation LM test (p-value)	0.2665	0.3774	0.2109	0.7587	0.1722
Heteroscedasticity test (p-value)	0.7793	0.3492	0.8457	0.7393	0.1322
Ramsey RESET test (p-value)	0.9058	0.5899	0.2607	0.0703	0.7834
CUSUM	yes	yes	yes	yes	yes
CUSUM square	yes	yes	yes	yes	yes

Note: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively.

CONCLUSION AND DISCUSSION

This study examines the impact of NAPs on Malaysia's food security using the Food Production Index (FPI) and ARDL-ECM analysis. Results reveal a long-run relationship between FI, AGR_Land, NAP0, NAP3, and FPI. FI significantly enhances FPI, addressing rising food demand from population growth. Strengthening FI by reducing the import taxes and incentives to exporters can help meet this demand. Consistent with economic theory, AGR_Land also positively affects FPI, highlighting the importance of land availability and use in sustaining Malaysia's agricultural productivity and food security.

An important finding from the long-run relationship analysis is that NAP_0 and NAP_3 significantly impact the FPI in Malaysia. Therefore, it is recommended to urgently focus on the strategies outlined in these plans. For instance, NAP_0 emphasises increasing farmers' education, skills, and research to boost agricultural productivity and develop agricultural land through government agencies such as FLDA, FELCRA, and SEDC, while NAP_3 focuses on enhancing food security and agro-forestry approach. Additionally, the findings regarding interaction variables for both long- and short-run relationships indicate that NAP_3 and NAP_4 act as moderators in the relationship between FE, FI, and FPI, whereas NAP_0 and NAP_3 for AGR_Land . This research bridges the gap between Modernisation Theory and practice by verifying the positive moderating role of NAPs, specifically NAP_0, NAP_3 and NAP_4, in strengthening the relationship between FE, FI, AGR_Land, and FPI.

In light of the research results, to improve food security in Malaysia, policymakers should develop a new NAP by integrating effective strategies from NAP0, NAP3, and NAP4. Emphasis should be placed on modernising the agro-food industry to increase the FPI. This includes upgrading agricultural research centers with advanced technology to enhance farmers' R&D, education, and innovation. Government subsidies for technological adoption can further increase productivity. Additionally, encouraging private sector participation is vital for raising awareness and fostering collaboration with public agencies to advance agro-food modernisation and strengthen national food security.

Referring to the short-run interaction analysis results, FE and FI revert to equilibrium in a shorter time frame (i.e., 1-3 years) compared to AGR_Land, which takes a longer period (i.e., 1-4 years). This emphasises the importance of NAPs in influencing FE and FI. To shorten the response period of AGR_Land on FPI, the Malaysian government, in collaboration with the Ministry of Agriculture and Food Security, could expedite their response by considering other contributing factors. For example, climate change and sustainability variables have consistently been shown to be related to AGR_Land and FPI (Ani et al. 2021; Zaw & Charoenratana 2023).

Despite offering new insights, this study has limitations. First, food security is measured solely by the FPI due to limited data availability, as Malaysia lacks other consistent food security indicators dating back to 1964. Future research should explore alternative databases with longer coverage. Second, while the study assesses the effects of different NAPs on FPI, it uses general food security determinants (FI, FE, AGR_Land), which may not reflect the specific impact of each NAP. Data limitations, particularly for NAP1 and NAP2, constrain analysis. Future studies should seek more detailed, policy-specific food security data.

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