AN ECONOMIC ANALYSIS OF ANTHROPOGENIC CLIMATE CHANGE ON LOCAL RICE OUTPUT IN MALAYSIA

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ABSTRACT

Rice is an important staple food in Malaysia and represents a substantial household expenditure. Although the average rice consumption in Malaysian households has dropped due to preference change, total demand has increased. This can be attributed to the high population growth. Malaysian rice farmers have not been able to meet the country's demand. Hence, Malaysia imports large quantities of rice from neighbouring countries to supplement its rice stockpile. Malaysia, which imports about 40 percent of its rice, is the 10th largest importer of rice in the world. This makes Malaysia susceptible to global rice crisis, similar to the one in 2008. To solve this problem, the government implemented policies to safeguard the country's food security and self-sufficiency levels. These efforts may be difficult in the future, as climate projections have shown that climate change will affect countries in the tropics most negatively with increased temperature and flooding due to anthropogenic carbon dioxide emissions. This study analysed the effect of anthropogenic carbon dioxide emissions on rice production in Malaysia during the period 1970-2013. The analysis incorporated the following variables: total local rice production, carbon dioxide emissions, precipitation, land used for paddy farming, total rice imports, and global average crude oil prices. The assessment of the impact of these determinants on rice production was achieved using the Vector Error Correction Model (VECM). The results indicated that in the long-run, climate changes will affect rice cultivation in the country, with carbon dioxide negatively affecting output, and increased rainfall positively affecting output. In the short-run, only precipitation and land showed effects on rice production. The significance of the error correction term also inferred that a long-run relationship exists. This study showed that climate variations in the future should be taken into consideration when formulating policies to ensure Malaysia's rice stockpile.

Keywords: rice production, climate change, temperature rise, precipitation, carbon dioxide emission.

ABSTRAK

Nasi adalah makanan ruji di Malaysia dan ia mewakili perbelanjaan isi rumah yang besar. Walaupun purata penggunaan beras isi rumah di Malaysia telah menurun disebabkan oleh perubahan keutamaan, namun begitu jumlah permintaan terhadap beras masih lagi meningkat. Hal ini boleh dikaitkan dengan kadar pertumbuhan penduduk yang tinggi. Justeru, para petani padi di Malaysia tidak dapat memenuhi permintaan negara yang semakin meningkat. Oleh itu, Malaysia mengimport beras dari negara jiran dengan kadar yang besar bagi tujuan untuk menambah stok beras di Malaysia . Malaysia mengimport kira-kira 40 peratus beras dari negara tersebut, dan ia adalah pengimport beras terbesar yang ke-10 di dunia. Hal seperti ini menjadikan Malaysia mudah terdedah kepada krisis beras global, seperti yang telah berlaku pada tahun 2008. Bagi menyelesaikan masalah ini, kerajaan melaksanakan dasar-dasar untuk menjaga tahap keselamatan makanan dan tahap pencapaian negara. Usaha ini mungkin sukar pada masa hadapan kerana unjuran iklim telah menunjukkan bahawa perubahan iklim akan mempengaruhi negara-negara di kawasan tropika. Apa yang paling negatif adalah dengan peningkatan suhu dan banjir akibat daripada pelepasan karbon dioksida antropogenik. Kajian ini akan menganalisis kesan pengeluaran karbon dioksida antropogenik terhadap pengeluaran beras di Malaysia dalam tempoh 1970-2013. Analisis ini akan menggabungkan beberapa pemboleh ubah, iaitu jumlah pengeluaran beras tempatan, pelepasan karbon dioksida, hujan, tanah yang digunakan untuk pertanian padi, jumlah import beras, dan purata harga minyak mentah global. Penilaian terhadap kesan penentu ini terhadap pengeluaran beras dicapai dengan menggunakan Model Pembetulan Kesalahan Vektor (VECM). Hasilkajian menunjukkan bahawa dalam jangka masa panjang, perubahan iklim akan memberi kesan terhadap penanaman padi di negara ini, manakala karbon dioksida memberi kesan negatif terhadap output, dan peningkatan hujan secara positif pula mempengaruhi output. Dalam jangka masa pendek, hanya hujan dan tanah sahaja yang menunjukkan kesan terhadap pengeluaran beras. Kepentingan istilah pembetulan ralat juga menyimpulkan bahawa hubungan jangka panjang adalah wujud. Kajian ini memperlihatkan bahawa variasi iklim pada masa hadapan harus diambil kira apabila merumuskan dasar-dasar untuk memastikan stok simpanan beras di Malaysia adalah mencukupi.

Kata Kunci: pengeluaran beras, perubahan iklim, kenaikan suhu, hujan, pelepasan karbon dioksida

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List of Abbreviations and Acronyms

AEZ	Agro-Ecological Zones
API	Application Program Interface
BLS	Basic Link System Model
CO2	Carbon dioxide
CRUTEMP	Climate Research Unit, Temperature
DOSM	Deparment of Statistics Malaysia
ESRL NOAA	Earth System Research Laboratory, National Oceanic and Atmospheric Organization
FELDA	Federal Land Development Authority
GCM	General Circulation Model
GISS	Goddard Institute of Space Studies
GTOP30	Global 30 Arc-second Elevation
IPCC	Intergovernmental Panel on Climate Change
MARA	Majlis Amanah Rakyat
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Organization
PPM	Parts per Million
USDA ERS	United States Department of Agriculture Economic Research Service
VECM	Vector Error Correction Model
WMO	World Meteorological Organization

CHAPTER ONE

INTRODUCTION

The agriculture sector is an important component in any country as it provides food and economic opportunities for the people. Due to its importance, various polices and budget allocation have been implemented to ensure it safekeeping. Although this has been the case, it has been projected that in the coming two decades, developing countries would be affected by crop production problems following changes in global temperatures and weather (Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W. P., & Naylor, R. L. 2008). These climate changes stemming from anthropogenic activities such as mass deforestation, urbanization and vehicular pollution would cause adaption issues leading to food and economic problems in the country. Anthropogenic climate change in definition is "... a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." (The United Nations Framework Convention on Climate Change, 21 March 1994). In the future, countries may experience food supply shortages, which in turn may cause price hikes.

Food security has recently been heavily debated and discussed among different parties and institutions around the world, as food and food prices is an important component in one's daily life. Various researches have shown that there has been a sharp increase in food and calorie demand comparatively to previous decades among the world's countries (Tscharntke, Clough, Wanger, Jackson, Motzke, Perfecto & Whitbread, 2012). Besides

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APPENDIX

Table A.1: Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: LRICE LCO2 LRAIN LAGRILAND LIMPORTS LOILAVG
Exogenous variables: C
Date: 05/10/17 Time: 21:52
Sample: 1970 2016
Included observations: 42

Lag	LogL	LR	FPE	AIC	SC	HQ
0	53.69273	NA	4.16e-09	-2.271083	-2.022844	-2.180093
1	278.1891	374.1606	5.36e-13	-11.24710	-9.509431*	-10.61018
2	329.3100	70.59548*	2.90e-13*	-11.96714*	-8.740041	-10.78428*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table A.2: Johansen Co-integration test

Sample (adjusted): 1973 2013
Included observations: 41 after adjustments
Trend assumption: Linear deterministic trend
Series: LRICE LCO2 LRAIN LAGRILAND LIMPORTS LOILAVG
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.812448	165.0787	95.75366	0.0000
At most 1 *	0.583602	96.45693	69.81889	0.0001
At most 2 *	0.551244	60.53624	47.85613	0.0021
At most 3	0.311838	27.68397	29.79707	0.0860
At most 4	0.257517	12.36102	15.49471	0.1404
At most 5	0.003726	0.153060	3.841466	0.6956

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**

None *	0.812448	68.62177	40.07757	0.0000
At most 1 *	0.583602	35.92069	33.87687	0.0281
At most 2 *	0.551244	32.85228	27.58434	0.0096
At most 3	0.311838	15.32295	21.13162	0.2669
At most 4	0.257517	12.20796	14.26460	0.1031
At most 5	0.003726	0.153060	3.841466	0.6956

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table A.3: Vector Error Correction Model Output

Estimation Proc:
================================
EC(C,1) 1 2 LRICE LCO2 LRAIN LAGRILAND LIMPORTS LOILAVG

VAR Model:
================================
D(LRICE) = A(1,1)*(B(1,1)*LRICE(-1) + B(1,2)*LCO2(-1) + B(1,3)*LRAIN(-1) + B(1,4)*LAGRILAND(-1) + B(1,5)*LIMPORTS(-1) + B(1,6)*LOILAVG(-1) + B(1,7)) + C(1,1)*D(LRICE(-1)) + C(1,2)*D(LRICE(-2)) + C(1,3)*D(LCO2(-1)) + C(1,4)*D(LCO2(-2)) + C(1,5)*D(LRAIN(-1)) + C(1,6)*D(LRAIN(-2)) + C(1,7)*D(LAGRILAND(-1)) + C(1,8)*D(LAGRILAND(-2)) + C(1,9)*D(LIMPORTS(-1)) + C(1,10)*D(LIMPORTS(-2)) + C(1,11)*D(LOILAVG(-1)) + C(1,12)*D(LOILAVG(-2)) + C(1,13)

Error Correction:	D(LRICE)	D(LCO2)	D(LRAIN)	D(LAGRILAND)	D(LIMPORTS)
CointEq1	-0.105599	0.055759	-0.155721	0.001713	0.144424
	(0.03822)	(0.04305)	(0.04372)	(0.00665)	(0.11231)
	[-2.76282]	[1.29521]	[-3.56150]	[0.25761]	[1.28597]
D(LRICE(-1))	-0.508713	-0.110874	0.055533	0.022328	-0.106229
	(0.19202)	(0.21628)	(0.21966)	(0.03341)	(0.56421)
	[-2.64932]	[-0.51265]	[0.25282]	[0.66835]	[-0.18828]
D(LRICE(-2))	-0.317084	-0.256466	-0.304378	-0.009894	-0.295044
	(0.17841)	(0.20095)	(0.20409)	(0.03104)	(0.52423)
	[-1.77727]	[-1.27626]	[-1.49136]	[-0.31873]	[-0.56281]
D(LCO2(-1))	0.044594	-0.198587	0.069700	-0.061541	-0.189533
	(0.16195)	(0.18241)	(0.18526)	(0.02818)	(0.47586)
	[0.27536]	[-1.08869]	[0.37623]	[-2.18410]	[-0.39830]
D(LCO2(-2))	-0.035050	0.023791	-0.108959	0.014494	0.657892
	(0.17464)	(0.19670)	(0.19978)	(0.03038)	(0.51314)
	[-0.20070]	[0.12095]	[-0.54541]	[0.47702]	[1.28209]
D(LRAIN(-1))	0.545400	-0.058003	0.112037	0.000196	-0.299075
	(0.17796)	(0.20044)	(0.20357)	(0.03096)	(0.52290)
	[3.06481]	[-0.28938]	[0.55035]	[0.00632]	[-0.57196]
D(LRAIN(-2))	0.548090	0.159527	0.100847	0.007300	-0.845418
	(0.14737)	(0.16599)	(0.16859)	(0.02564)	(0.43303)
	[3.71906]	[0.96105]	[0.59819]	[0.28471]	[-1.95232]

D(LAGRILAND(-1))	-0.645479	-1.167825	-0.469826	0.631082	-4.767322
	(1.19349)	(1.34428)	(1.36531)	(0.20765)	(3.50690)
	[-0.54083]	[-0.86873]	[-0.34412]	[3.03915]	[-1.35941]
D(LAGRILAND(-2))	3.004961	0.719280	2.839825	0.053784	0.272815
	(1.33637)	(1.50521)	(1.52875)	(0.23251)	(3.92672)
	[2.24860]	[0.47786]	[1.85761]	[0.23132]	[0.06948]
D(LIMPORTS(-1))	-0.136589	-0.042075	-0.235352	-1.83E-05	0.124297
	(0.05973)	(0.06728)	(0.06833)	(0.01039)	(0.17551)
	[-2.28669]	[-0.62539]	[-3.44431]	[-0.00176]	[0.70819]
D(LIMPORTS(-2))	0.011033	0.057871	-0.096528	-0.009099	-0.525489
	(0.04777)	(0.05380)	(0.05464)	(0.00831)	(0.14036)
	[0.23097]	[1.07561]	[-1.76648]	[-1.09485]	[-3.74392]
D(LOILAVG(-1))	-0.049704	-0.037377	0.016136	-0.002904	-0.138114
	(0.04967)	(0.05594)	(0.05682)	(0.00864)	(0.14594)
	[-1.00078]	[-0.66816]	[0.28401]	[-0.33611]	[-0.94641]
D(LOILAVG(-2))	-0.024072	0.009497	-0.071239	0.000833	0.134614
	(0.04579)	(0.05158)	(0.05238)	(0.00797)	(0.13455)
	[-0.52568]	[0.18413]	[-1.35992]	[0.10459]	[1.00045]
C	-0.010579	0.086976	-0.009742	0.007964	0.091669
	(0.03347)	(0.03770)	(0.03828)	(0.00582)	(0.09834)
	[-0.31609]	[2.30736]	[-0.25447]	[1.36769]	[0.93219]

Table A.4: Residual Correlation Matrix

	LRICE	LCO2	LRAIN	LAGRILAND	LIMPORTS	LOILAVG
LRICE	1.000000	0.300962	-0.466243	-0.007066	-0.394314	0.354236
LCO2	0.300962	1.000000	0.186438	-0.135177	0.083116	0.432481
LRAIN	-0.466243	0.186438	1.000000	-0.015061	0.267401	-0.374696
LAGRILAND	-0.007066	-0.135177	-0.015061	1.000000	-0.528235	-0.400549
LIMPORTS	-0.394314	0.083116	0.267401	-0.528235	1.000000	0.205853
LOILAVG	0.354236	0.432481	-0.374696	-0.400549	0.205853	1.000000