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The Impact of Bio-Ethanol Conversion and Global Climate Change on Corn Economic Performanve of Indonesia

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Abstract

Many studies conclude that the rise in global food prices due to higher demand from the development of bio-fuels, climate anomalies, and increased of oil prices. Not only the food commodity index rose more than 60 percent, non-food commodity price index also rose over 60 percent and crude oil price index has increased even further above 60 percent. The purpose of this study is to analyze the impact of bio-ethanol conversion and global climate change on corn economic performance of Indonesia. The results showed that the food crisis caused by climate anomalies lead the world corn prices rose 50 percent, impact on Indonesia corn imports fell by 11.86 percent. And the other hand, the energy crisis that caused the corn used as feedstock for ethanol that caused U.S. corn exports only 20 percent of their products have an impact on Indonesia on maize imports fell 32.4 percent.

Keywords:
The energy crisis, Climate change, Corn

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INTRODUCTION

Corn is the third largest crop after wheat and rice, most of the corn products are used and traded as feed material in addition to a staple food. In addition to food and feed, corn has a wide range of industrial applications such as materials for the manufacture of ethanol.

Over the last decade of global corn production has shown increasing growth, the global corn market generally divided into two issues, first, the conversion of the global corn used as bio-ethanol industry, second, the share of globally traded corn are relatively constant.

The main cereal market - corn, wheat and rice - has shown some major adjustments in recent years. Since 2008 the global food crisis resulted in a large spike in corn prices. On the demand side of high oil prices encourage the development of bio-fuel which resulted in increased demand in addition to dietary changes and income and population growth. High oil prices also put pressure upward on the cost of crop production (e.g. fertilizer, tillage). On the supply side with low cereal stocks, exacerbated by a policy of trade restrictions on cereal and speculation in commodity markets. (Flammini, 2008).

The food crisis followed by the global financial crisis in the second half of 2008, high oil prices which led to concerns about the security of national oil and concerns about the environmental impact of fossil fuel use resulting in searching alternative energy sources, one of the interesting issues is the development of bio-fuels that affect the global corn market.

In the United States, the enhanced production of bio-ethanol because corn prices are relatively low, In the year 2007-2008, as many as 82 million tones of corn used for ethanol, which represents a quarter of U.S. corn production and 12% of global production (DEFRA, 2008). Besides the development of bio-ethanol, one of the factors that cause serious problems for the production of corn from time to time is the occurrence of El Niño weather phenomenon associated with an abnormal warming of sea surface temperatures in the Pacific Ocean. Corn plants are most affected by El Niño (mostly in the form of prolonged dry conditions) are concentrated in the southern hemisphere, particularly in southern Africa. During El Niño events of the 1980s and the 1990s, for example, corn production in the Republic of South Africa fell by 40 to 60 percent. Also in Brazil, corn producers suffered from floods and droughts driven by El Niño situation in the past. adverse weather conditions caused by the events of the last major El Niño of 1997/98 are located mostly in East Asia and led to a sharp decline in production in countries such as Thailand and Indonesia.

In Indonesia, corn has a very strategic role, especially for the farm development and other industries. In past, corn mainly used as staple. However, currently, corn mainly used as an industrial material. In line with the rapid growth of livestock industry, it is estimated more than 55% of domestic corn needs is used for feed, while for food consumption is only about 30%, and the remainder for other industrial needs and seeds (Indonesia Department of Agriculture, 2010).

Currently, the development of corn production can not meet high demand. Therefore, the governments meet the shortage of these needs through imports. For 2010 forecast figures, with area of 3 million ha of crops, it is estimated to produce 12.1 million tons.. Meanwhile, maize demand in the country reached 13.8 million tons, resulting in a shortage about 1 million ton to be imported (Ferrianta, 2012). If the import increment increase was not controlled, it will cause a reduction in foreign exchange, and can lower the domestic maize price, where the price was relatively low. Based on these facts, the government is trying to meet the domestic maize need through maize self-sufficiency program.

Maize self-sufficiency effort must be directed to external factors, not only change in domestic policy but also external shock e.g bio-ethanol development and global climate change. In line with the development of world economy, maize commodity will face a different environment. External and internal shock will affect corn economic performance of Indonesia.

Based on these facts, it is deemed necessary to conduct research on the impact of bio-ethanol development and global climate change on the economic performance of corn in Indonesia.

MATERIALS AND METHODS

Indonesia maize economic model is a simultaneous equations consisting of three sub-models: sub production, sub domestic market and sub world markets. The data collected is secondary time series data.

Model estimation is done using re-specification model. The goal is to obtain good models based on economic and econometrics criteria. In the estimation of these models studied the problem of identification, aggregation and the degree of correlation between explanatory variables.

Evaluation conducted to know the impact of instrument change simulation variable on the future endogenous variable. The evaluation model is based on economic theory and information related to the research phenomenon. A model is good if it meets the following criteria:

1. Economics, in association with signs and estimation parameters,
2. Statistics, relating to statistical tests, and
3. Econometrics, related to the model assumptions (Baltagi, 2008)

For unbiased and consistent estimations, simultaneous systems require a more complex procedure for estimation than single equation models, which can generally be estimated by regression with ordinary least squares (OLS). The most frequently used method of estimating simultaneous systems is the two-stage least squares (2SLS) method (Studenmund, 1997; Greene, 1993).

Furthermore, because the model contains a simultaneous equations and lagged endogenous variables, serial correlation test is performed using statistical dw (Durbin-Waston Statistics) in each equation. (Gujarati, 2004)

Model validation performed to analyze how constructed model could to represent the real world. In this study, statistical validation criteria for value estimate econometric model is Root Means Squares Error (RMSE), Root Means Squares Percent Error (RMSPE) and Theil's Inequality Coefficient.

Econometric modeling and estimation can be useful in providing a retrospective look at the economic effects of a policy change or external shock (MCDaniel, 2006). To simulation the impact of external shock to the import corn Indonesia, this study was used ex-post econometrics analysis to see changes in the value of endogenous variable due to changes in exogenous variables. (T. B. Palaskas 1988 ; Baumann, 2011).

Dynamic simultaneous equations system used to develop econometric model. Models specification used are described as follows:

1.$QJ = AJ * PRJ$

2. $AJ = {}_{a1} PJ + {}_{a2}Pkdl_{t-1} + {}_{a3}AJ_{t-1} + U_1$

3. $PRJ = {}_{b1} Pp + {}_{b2}\, i + {}_{b3}AJ + {}_{b4}W + {}_{b5}PRJ_{t-1} + {}_{b6}CH + U_2$

4. $DIT = DIP + DIL + DK$

5. $DIP = {}_{c1}Ppk + {}_{c2}Pj + {}_{c3}Pkdl + {}_{c4}DIP_{t-1} + U_3$

6. $DIM = d_0 + {}_{d1}Pop + {}_{d2}PJ + {}_{d3}Pni + U_4$

7. $DK = e_0 + e_1PJ + e_2Y + e_3DK_{t-1} + U_5$

8. $MIT = MIAS + MICH + MITH + MIO$

9. $MIAS = f_1(PIAS - PIAS_{t-1}) + f_2QJ + f_3DIT + f_4ERI + f_5(RISTI - RISTI_{t-1}) + U_6$

10. $MICH = g_1PICH + g_2QJ + g_3DIT + g_4RISTI + U_7$

11. $MITH = h_1PITH + h_2QJ + h_3DIT + h_4RISTI + U_8$

12. $MIO = MIT - (MIAS + MICH + MITH)$

13. $RISTI = (PJ - PWJ)/ PWJ$

14. $PIAS = PWJ + RISTAS$

15. $PICH = PWJ + RISTCH$

16. $PITH = PWJ + RISTTH$

17. $PJ = i_1MIT + i_2DIT + U_9$

18. $XAS = j_0 + j_1QAS + j_2DAS + j_3XTH + j_4XCH + j_5MJJ + j_6MJK + j_7PETH + U_{10}$

19. $XCH = k_1QCH + k_2DCH + j_3XAS + j_4XTH + j_5MJJ + j_6MJK + U_{11}$

20. $XTH = l_0 + 1l_PWJ + l_2QTH + l_3DTH + U_{12}$

21. $MJJ = m_0 + m_1PWJ + m_2NPRJj + m_3ERj + U_{13}$

22. $MJK = n_0 + n_1PWJ + n_2DJk + n_3MJK_{t-1} + U_{14}$

23. $XW = XAS + XTH + XCH + XRO$

24. $MW = MJJ + MJK + MRO$

25. $PW = o_1XW + o_2MW + U_{15}$

Note:

- AJ = acreage of corn harvested (ha)
- PRJ = productivity corn of Indonesia (tones / ha)
- QJ = corn production of Indonesia (tones)
- PJ = corn prices of Indonesia(US $ / tone)
- i = Indonesia interest rate (%)
- W = Indonesia wage labor (US $ / day)
- Pp = the price of fertilizer (US $/ tone)
- CH = climate change (oceanic nino index)

- DIT = total corn demand of Indonesia (tones)
- DIP = Indonesia corn demand for feed industry (tones)
- DIM = Indonesia corn demand for food industry (tones)
- DK = Indonesia corn demand for direct consumption (tones)
- KDP = feed prices of Indonesia (US $ / tone)
- Pkdl = soybean price of Indonesia (US $ / tone)
- Pop = population of Indonesia (people)
- MIT = Total Imports corn of Indonesia (tones)
- MIAS = Indonesia corn imports from US. (tones)
- MICH = Indonesia corn Import from China (tones)
- MITH = Indonesia corn imports from Thailand (tones)
- MIO = Indonesia corn imports from other countries (the rest)
- PIAS = the price of corn imports from US (US $ / ton)
- PITCH = the price of corn imports from China (US $ / ton)
- PITH = the price of corn imports from Thailand, (US $ / ton)
- RISTI = corn trade restrictions of Indonesia
- ERI = exchange rate of Indonesia (rupiah / US $)
- XAS = US corn exports (thousand tones)
- XTH= Thailand corn exports (thousand tones)
- XCH= Chinese corn exports (thousand tones)
- QAS = U.S. corn production (thousand tones)
- QTH = Thailand corn production (thousand tones)
- QCH= Chinese corn production (thousand tones)
- MJJ = Japan corn imports (thousand tones)
- PET = ethanol price (US$/bushel)
- MJK = Korea corn imports (thousand tones)
- DJ = corn demand of Korea (thousand tones)
- NPRJ= corn trade restrictions of Japanese (thousand tones)
- ER = exchange rate of Japan (Yuan / US $)
- XW = world exports (thousand tones)
- XRO = corn exports of other country (thousand tones)
- MJW = world corn imports (thousand tones)
- MRO =corn exports of other country (thousand tones)

This study used *time series data's*, starting in 1983 until 2010. The data is obtained from Indonesia Department of Agriculture, Bureau of Indonesia Statistics, Indonesia Ministry of Agriculture, Directorate General of Food Crops and Horticulture, Food and Agriculture Organization, United States Department of Agriculture, United Nations Commodity Trade Statistics Database, and International Monetary Fund.

RESULTS

International corn economy has undergone major changes over the past two decades in terms of production, utilization, trade and marketing structure. This change was driven by a number of factors ranging from rapid advances in seed technology and production, changes in national policy and international trade, expansion almost without interruption from the use of feed throughout the world and recently huge demand for ethanol.

Production

Over the past two decades, global corn production has increased nearly 50 percent, or 1.8 percent growth rate per year. Most of the increase in world corn production over the past decade can be attributed to rapid expansion in Asia.

Asian corn production grew nearly 35 percent over the past decade, nearly 30 percent of the global increase. The increasing expansion of acreage and yield contributed to high growth rates, like China that makes the most significant progress with contributions as much as 60 percent of total corn production of Asia over the past decade.

Although progress is associated with varieties that have high productivity, it is likely to increase corn production in many countries remains large along with the good level of production efficiency, especially in developing countries are still under

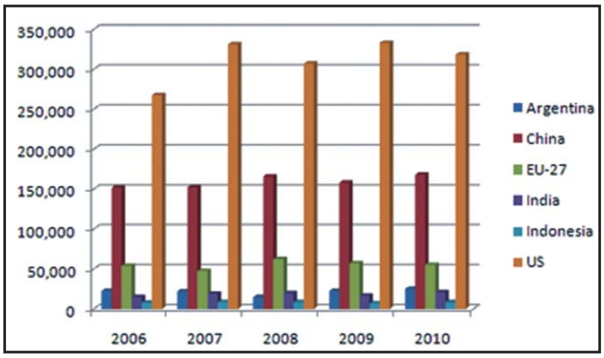

Figure 1: World Corn Production (Sources: USDA, 2010)

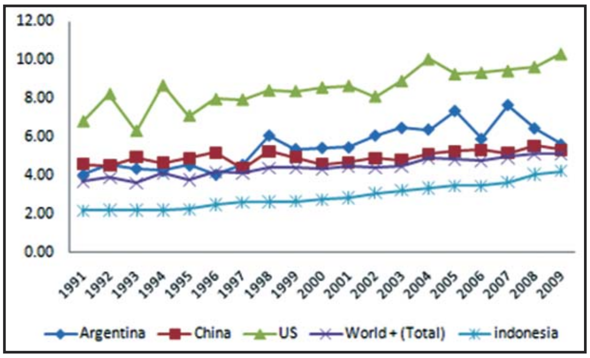

Figure 2: Corn Productivity in Some Countries
(Sources: FAOSTAT, 2010)

major manufacturers. Average corn yields among developing countries about a third of the countries major corn producer. Among some of the countries largest producer of corn (Figure 2), Argentina approximately 5.6 tones / ha, China about 5 tones / ha, while Indonesia about 3 tones / ha. This is much compared to the United States about 10 tones / ha.

Corn as Biofuels Material

Bio-diesel is an alternative diesel fuel energy sources are derived from vegetable oil (vegetable oil) and animal fats (animal fat) where corn is one potential source of bio-diesel product. World price of bio-diesel (FOB Central Europe) increased to $ 4.14 per gallon by 2010, driven by high oil prices and prices of edible oils. Increased crude oil prices and the existence of tariff barriers in Argentina, Brazil, European Union, as well as the U.S. led to an increase in world prices.

With the huge consumption demand for local industrial production of bio-diesel will increase production by 5% in 2010 and estimated production continues to increase and reached 3.5 billion gallons by 2019, on the other hand the consumption continues to grow to 4.0 billion gallons by 2019 so that the net import grow during the outlook period and reached 559 million gallons by 2019.

General Estimation of Econometrics Model

The empirical result of prediction models in the study is good. All exogenous variables included in the structural model has a parameter that the sign suitable with the theory and logical. Statistical criteria used in evaluating the prediction is quite good. Coefficient of determination (R^2) value in each behavioral equations ranged from 0,38 to 0.99. From 15 behavioral equations, there is only one behavioral equation with R^2 values of 31 percent and 14 other equation is above 64 percent. This shows that, in general, the exogenous variables included in the structural equation model can explain variance rightly for each endogenous variable.

The value of statistic F test generally high. There are 12 of 15 equation had value greater than 11.22. Meanwhile, only two equations have F-value 8,50 and a 1,38. That is, simultaneously, explanatory variable variance in each equation behavior are able to explain the variance of endogenous variable, at α= 0.0001; α = 0.0003 and α=0.2744. Detailed econometric model estimation for maize are presented in Table 1.

Simulation of External Shocks on the Economic Performance of Indonesia corn Performance

The world has been experiencing a global crisis caused by global warming, energy crises, and monetary crisis. Global warming has caused climate anomaly, resulting in a sharp decline in world agricultural production resulting food crises, including maize.

Global food price index increase has reached 120 percent, where about 60 percent in just the past two years, while the World Bank stated that the price index of food crops increased 86 percent between 2006 to 2008. Agricultural commodity prices rose in 2006 and 2007 and continued to increase even more sharply in 2008. Meanwhile, according to the World Bank, global wheat prices increased by 81 percent (World Bank, 2008), and 83 percent increase in overall global food prices.

The energy crisis has led to the development of corn as a bio-fuel feedstock, resulting in a decrease in world corn exports, especially in the US. The figure below shows the extent of the use of corn for the bio-fuels industry the United States, 1984-2009 a huge surge in the use of corn as an ethanol feedstock domestic product, this indication will be a large drop in exports US, in addition to other major exporting

Table 1: Econometrics Model Estimation

Model	Variable	coefficient	t-statistic	statistic
AJ	PJ	5.3656	0.41	0.6882
	PKDLL	-0.37924	-0.75	0.4618
	AJL	0.962391	7.61	<.0001
	F-test= 1016.30	R^2= 0.99284	DW = 1.73635	
PRJ	PUPUK	-5.87E-10	-2.57	0.0186
	I	-0.04547	-3.01	0.0072
	AJ	5.259E-08	0.31	0.7584
	W	-0.00018	-0.41	0.6869
	PRJL	1.246336	14.97	<.0001
	CH	-0.02339	-1.21	0.2416
	F-test = 2640.65	R^2= 0.9988	DW = 1.286932	
DIP	PPK	41.06936	2.19	0.0397
	PJ	-34.4608	-1.15	0.2642
	DIPL	0.881228	4.48	0.0002
	PKDL	-0.33793	-0.17	0.8647
	F-test= 92.47	R^2= 0.94628	DW = 1.241174	
DIM	Intercept	-15280000	-3.86	0.0009
	PJ	-128.926	-1.13	0.2709
	PNI	56.18753	5.59	<.0001
	POP	0.023537	3.18	0.0045
	F-test=12.62	R^2= 0.64325	DW = 0.880593	
DK	Intercept	769281.5	1.18	0.2496
	PJ	-22.447	-0.94	0.3578
	Y	-62.2421	-0.45	0.654
	DKL	0.652367	7.14	<.0001
	F-test= 58.46	R^2= 0.89306	DW = 0.985704	
DIT	DIT = DIP + DIM + DK			
MIAS	PIASH	-50301.5	-0.32	0.7514
	QJ	-0.39767	-5.13	<.0001
	DIT	0.403125	5.33	<.0001
	ERI	-16.0265	-0.84	0.4118
	RISTIH	-75.6419	-0.21	0.8352
	F-test= 13.82	R^2= 0.77557	DW = 2.307239	
MICH	PICH	-540.767	-0.35	0.728
	QJ	-0.15933	-1.27	0.2183
	DIT	0.195036	1.9	0.0716
	RISTI	-624179	-1.83	0.0815
	F-test= 8.28	R^2= 0.61206	DW = 1.874842	
MITH	PITH	-819.626	-1.62	0.1206
	QJ	-0.02801	-0.73	0.4737
	DIT	0.046871	1.41	0.1737
	RISTI	-45811	-0.37	0.7169
	F-test= 8.76	R^2= 0.62518	DW = 1.429704	
MIT	MIAS + MICH+ MITH+MIO			
PJ	MIT	-0.00093	-0.3	0.7638
	DIT	0.001993	6.89	<.0001
	F-test= 86.26	R^2= 0.88237	DW = 0.136375	
XAS	Intercept	9262248	0.11	0.9148
	QAS	0.061165	0.53	0.5999
	DAS	-0.02246	-0.14	0.8919
	XTH	-0.03033	-0.01	0.991
	XCH	-0.53669	-1.57	0.1352
	MJJ	3.226394	0.61	0.5487
	MJK	0.971053	0.91	0.3738
	PETH	-23310000	-1.38	0.1848
	F-test= 1.52	R^2= 0.38465	DW = 1.937323	
XCH	QCH	0.174571	1.2	0.2436
	DCH	-0.23146	-1.26	0.2232
	XAS	-0.23542	-1.76	0.0948
	XTH	-0.74319	-0.66	0.517
	MJJ	1.194996	2.27	0.0348
	MJK	0.638035	1.02	0.3217
	F-test=11.23	R^2=0.78010	DW = 2.12621	
XTH	Intercept	-427222	-1.98	0.0614
	PWJ	2148.176	2.73	0.0124
	QTH	1.011109	20.58	<.0001
	DTH	-0.93046	-40.62	<.0001
	F-test= 612.58	R^2= 0.98870	DW = 2.079181	
XW	XAS +XTH +XCH + XO			
MJJ	Intercept	21603517	10.37	<.0001
	PWJ	-8992.84	-1.44	0.165
	NPRJ	-148722	-1.49	0.1504
	ERJ	-24401.7	-4.73	0.0001
	F-test=14.61	R^2=0.67603	DW = 2.337765	
MJK	Intercept	-122641	-7.82	<.0001
	PWJ	-234.022	-1.85	0.0789
	DJK	1.005725	536.15	<.0001
	MJKL	0.003463	2.03	0.0549
	F-test= 130684	R^2= 0.99995	DW = 1.885428	
MW	MJK + MJJ + MIT +MJO			
PW	XW	-1.41E-07	-0.18	0.8566
	MW	1.72E-06	2.2	0.0382
	F-test= 227.42	R^2= 0.95187	DW =1.126065	

Source: Research findings.

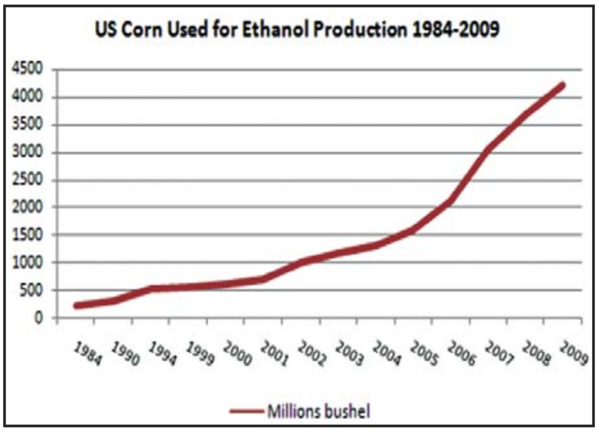

Figure 3: US Corn used for Ethanol Production 1984-2009 (Sources: USDA, 2010)

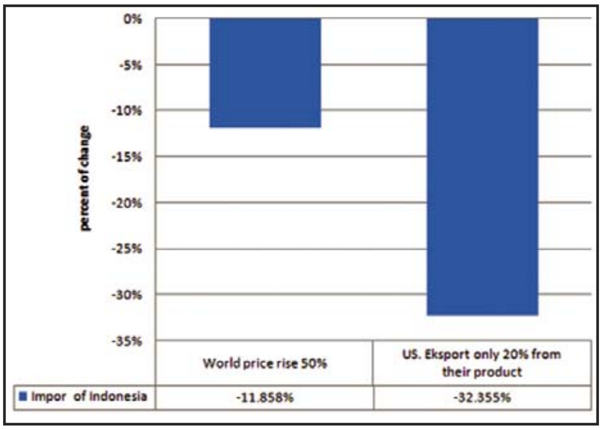

Figure 4: Estimated of Indonesia Corn Import at The Event of External Shock (Simulation analysis)

countries, especially in the European Union and Latin America jointly develop bio-ethanol industry. (Figure 3).

Simulation aims to analyze the impact of various changes in the exogenous variables. However, before doing the simulation, model validation must be done to look at the suitability of the predicted value in accordance with the actual value of each endogenous variable (Pindyck and Rubinfield, 1991).

Table 2 presents the results of the validation of the economic corn model. Based on Table 2 can be found, only three equations in the model has a RMSPE value of more than 50 percent, only one equation is greater than 100 percent and the rest have RMSPE value of less than 50 percent. U-Theil criteria there are 13 equations have a U value of less than 0.20, and 5 the equation has a value of U between 0.24 to 0.50. The highest value of the Theil-U in the equation is 0.5, and RMPSE value greater than 100 percent, is owned by the Indonesian corn price equation but there is no systematic bias, because the value of Um more than 0.20. Overall, this model is suitable for use as predictive models, so the structural model has been formulated which can be used for various simulations.

Simulation is used with the assumptions: (1) climate anomalies lead the world corn prices rose 50 and the energy crisis that caused the corn used as feedstock for ethanol, as a result the world corn prices rose 2.9 percent. Ex ante analysis for simulation model presented in table 3. Based

Table 2: Result of Validation Dynamic Econometric Models

No.	Variable	RMSPE	Reg (UR)	Var (US)	Covar (UC)	Coef U
1	AJ	0.5904	0.02	0.04	0.76	0.0028
2	PRJ	11.6864	0.02	0.02	0.00	0.0558
3	DIP	1.8582	0.01	0.00	0.37	0.0089
4	DIL	22.8999	0.00	0.00	0.00	0.1293
5	DK	38.9767	0.05	0.06	0.00	0.2509
6	MIAS	52.9878	0.99	0.62	0.37	0.2636
7	MICH	65.7784	0.25	0.11	0.14	0.4613
8	MITH	24.6001	0.14	0.00	0.14	0.1445
9	PJ	262.4	0.07	0.00	0.07	0.5018
10	PWJ	37.3681	0.08	0.08	0.00	0.2411
11	XAS	7.4399	0.22	0.22	0.00	0.0399
12	XTH	30.5445	0.10	0.10	0.00	0.1909
13	XCH	21.8008	0.00	0.00	0.00	0.1226
14	MJJ	3.0589	0.07	0.01	0.06	0.0150
15	MJK	0.3193	0.08	0.08	0.00	0.0016
16	DIT	16.9178	0.01	0.01	0.00	0.0926
17	QJ	12.0027	0.03	0.03	0.01	0.0574
18	MIT	30.1795	0.59	0.18	0.41	0.1761

Source: Research findings.

Table 3: The Ex-Post Analysis for Simultaneous Simulation

Variable	Base	World price rise 50%	US. Export only 20% from their product
AJ	2156142	2156584	2157446
PRJ	5.4348	5.4348	5.4348
DIP	5338632	5335799	5330258
DIL	6838667	6828066	6807336
DK	842862	841017	837408
MIAS	345879	338761	0
MICH	150932	103884	141042
MITH	119420	52425.8	117113
PJ	24919.9	25002.2	25162.9
PWJ	160.9	240	165.6
XAS	52286034	50281511	9242391
XTH	534673	704465	544645
XCH	6605682	6090199	16681027
MJJ	17055710	16344914	17013965
MJK	9501793	9483296	9500706
DIT	13020161	13004881	12975002
QJ	11747862	11750272	11754655
MIT	1106718	985558	748642

Source: Research findings.

on analysis can be show that the food crisis due to climate anomalies lead the world corn prices rose 50 percent impact on Indonesia corn imports fell by 11.86 percent. While the energy crisis that caused the corn used as feedstock for ethanol, causes U.S. limit maize exports only 20 percent of their products have an impact on corn imports Indonesia fell 32.4 percent. (Figure 4)

Ex-post simulation analysis results indicate that both the external shock of climate change and bio-ethanol conversion have an impact the decline in the amount of corn traded in world markets, and this has also impacted on the decline in imports of corn Indonesia. Based on the decrease in the value from the two simulations shows that the U.S. has a significant role in Indonesian corn economy, where if the U.S. lowered its export causes a considerable impact for more decline in Indonesia imports. This indicates Indonesia has a large dependence on the U.S for maize domestic supply, therefore the need for policy in terms of increased productivity and the expansion of planting area by utilizing the technology package and the existing land use to reduce dependence on other countries.

CONCLUSION AND RECOMMENDATIONS

The main objective of this study was to knows the impact of bio-ethanol development and global climate change on the economic performance of corn in Indonesia. This study used the annual time series data (1983-2010) and use a dynamic simultaneous equations system.

Ex- post simulation analysis results show that climate change, bio-ethanol conversion as a major determinant of import corn Indonesia. The results of simulation analysis of global climate change and the conversion of corn for bio-ethanol have an impact on the fall to import corn in Indonesia. This situation is expected to increase competitive advantage and comparative of Indonesian corn farming. Nevertheless there are still many problems faced by Indonesia such as corn farm land issues, technology, human resources, capital, fertilizer; rural infrastructure; and distortion distribution.

Some policies that are needed include (1) the expansion of planting area by increasing cropping index (IP) and extensification by making use of idle land, (2) suppress the difference in results between regions and agro-ecosystems through the use of new high yielding varieties and hybrid composites as well as site-specific application of the PTT model, (3) suppress the loss of the harvest and post harvest, and (4) increase the stability of the results between seasons and regions through the implementation of integrated pest management wisely. (5) human resource development of farmers through Farmer Field Schools (human capital) and also involve farmers in innovation (joint innovation), (6) institutional development (social capital) farmers as Farmer Field School activities continued; (7) irrigation infrastructure investment and drainage are more flexible (physical capital), and (8) investment in infrastructure and rural economy.

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