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The Role of Agricultural Technology in Improving Productivity Maize: A Case from Indonesia

Yudi Ferrianta*, Rifiana
Department of Agribusiness, University of Lambung Mangkurat, Banjarbaru 70714, Indonesia
*E-mail fo the corresponding author: ferrianta@gmail.com

Abstract
The role of the data is really important in estimating the state of the economy, the accuracy of capital is needed to perform the projection so that the resulting value has a small bias and can be used as the basis for a policy to deal with future problems. This paper attempts to estimate the economic behavior of maize Indonesia by building economic models simultaneously and compare the estimation results with the estimated made by the government. Based on the estimation of the model constructed shows that there are similarities with the estimates of the value of government, however, based on the result of estimation indicate that the value is more detailed than the estimation made by the government. This suggests that the accuracy in the preparation of the model produces best value in the analysis.

Introduction

Corn is the third largest crop after wheat and rice, most of the products are used and traded maize 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. During the last decade of global corn production has shown increasing growth , the global corn market is generally divided into two issues , first , about two - thirds of the global corn is used as feed for the last 40 years. second, the share of globally traded corn is relatively constant. It is estimated by 2050, demand for maize in developing countries will increase, and in 2025 corn crop will be the largest production in the world and in developing countries. However, in the current low productivity growth to meet increasing demand

This paper attempts to estimate the economic behavior of maize Indonesia by building economic models simultaneously and compare the results of these estimates with the estimated by the government.

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 MSE Decomposition Proportions - Var (US) 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 economic corn Indonesia, this study was used ex-post econometrics analysis to estimate changes in the value of endogenous variable. (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. $AJ = a_1 PJ + a_2 Pkdl_{t-1} + a_3 AJ_{t-1} + U_1$
3. $PRJ = b_1 Ppk + b_2 S + b_3 AJ + b_4 W + b_5 PRJ_{t-1} + b_6 CH + b_7 I + U_2$
4. $DIT = DIP + DIL + DK$
5. $DIP = c_1 Ppk + c_2 Pj + c_3 Pkdl + c_4 DIP_{t-1} + U_3$
6. $DIM = d_0 + d_1 Pop + d_2 PJ + d_3 Pni + U_4$
7. $DK = e_0 + e_1 PJ + e_2 Y + e_3 DK_{t-1} + U_5$
8. $PJ = f_1 MIT + f_2 DIT + U_6$

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)
- Pni = price of corn product (%)
- S = seed (tones)
- W = wage labor (US$/day)
- Y = disposable income (US $ /years)
- I = water allocation irrigation for corn farming (db)
- Ppk = fertilizer (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)
- Pkdl = soybean price of Indonesia (US $ / tone)
- MIT = Total Imports corn of Indonesia (tones)

This study used *time series data's,* starting in 1983 until 2011. 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.

International trade

International maize economy has undergone major changes over the last two decades in terms of production , utilization , trade and marketing structure . This change was driven by a number of factors ranging from the rapid advances in seed technology and production, changes in national policies and international trade .

In the last decade . world corn production rate reaches 3:59 percent per year . World corn production in 2006-2007 recorded 713 451 million tonnes and increased to 818 524 million tonnes in 2010/11 . Meanwhile , the volume of maize traded in the international market in 2006-2007 was 91 474 million tonnes and 93 150 million tonnes in 2010/11 or an average of about 11.7 percent of world corn production .

Map of major corn producing countries in the world the same period was relatively constant , which until the year 2010/11 the United States (U.S.) is the largest position with a share of about 39.51 percent of world corn production . The next rank is China (20.2%) , European Union (7.1%) , Brazil (6.8%) , Mexico (2.9 %) and Argentina (2.7%) , while Indonesia ranks 12 with number of production by 1.02 % percent of the world's corn production .

Table 1. Production, Export and Import of Corn World, (thousand tons)

Years	Productivity (tones/ha)	production (million tons)	world trade (million tons)	Percentage (%)
2006/07	4.8	713,451	91,474	12.82
2007/08	4.8	793,615	98,265	12.38
2008/09	5	797,769	83,953	10.52
2009/10	5	812,403	92,697	11.41
2010/11	5.1	818,524	93,150	11.38

Source : USDA, 2011

China's contribution to world maize production appears consistent over that period, which is more than 20 percent , while production of Argentina and Brazil reached 8.8 percent in the same time. Corn production in China showed a considerable rise fantastic with 3.5 percent per year rate . This production level has increased

the share of China in world corn production , from 17 percent in 1993 to 22.5 percent in 2010/2011 .
Corn traded on the world market is relatively constant , or about 11.7 percent of world corn production . Of corn products traded on world markets mostly from the United States , followed by China , the EU , Brazil , Mexico and Argentina . But not all corn producing countries exporting country . As an illustration , Brazil is one of the world's corn producers , but it is not a corn exporting countries . This is due to high domestic demand for corn , so that almost all of the production allocated to fulfill domestic . Something similar happened in the European Union , where corn production is almost destined for its member countries .
Table 2. Major producer Corn of the World, 2006/2010 (milion tons)

Country	2006/07	2007/08	2008/09	2009/2010	2010/11	Average
China	151,600	152,300	165,900	158,000	168,000	159,160
Brazil	51,000	58,600	51,000	56,100	51,000	53,540
Mexico	22,350	23,600	24,226	20,374	24,500	23,010
Argentina	22,500	22,017	15,000	22,500	25,000	21,403
India	15,100	18,960	19,730	16,680	21,000	18,294
South Africa	7,300	13,164	12,567	13,420	12,500	11,790
Canada	8,990	11,649	10,592	9,561	11,714	10,501
Ukraine	6,400	7,400	11,400	10,500	12,000	9,540
Indonesia	7,850	8,500	8,700	7,000	8,400	8,090
Nigeria	7,800	6,500	7,970	8,759	8,700	7,946
Philippines	6,231	7,277	6,853	6,231	6,800	6,678
United States	267,503	331,177	307,142	333,011	318,522	311,471
World Total	713,451	793,615	797,769	812,403	820,713	787,590

Source : USDA, 2011
Major exporting countries of the world corn relative shift. For the 1993 main maize exporting countries , the United States , Argentina , Hungary , the EU , and Thailand , then turned into , the United States , China , Uni Eropa , and Brazil until 2010 .

Economic Behavior of Maize in Indonesia
With the rapid growth of the livestock industry , estimated at more than 55 % of the domestic corn used for feed , while food consumption is only about 30 % , and the remainder to the needs of other industries and seeds . Overall, by 2009 the average Indonesian corn needs to reach 13,665,312 tons per year , with growth of 6:38 per cent / year . Meanwhile, to meet the needs of the domestic corn Indonesia still has to import maize to meet the supply shortfall . In 2008 imports of maize Indonesia reached 1.842 million tons , although in 2009 fell to 421 231 tones.
In terms of production , the development of maize production during the period (1993-2010) the national maize production increased by 6.66 percent / year , production of low performance is due to the low increase in yield per hectare (4:06 percent / year) . While the crop area is relatively fixed, because every year only increased by 2:47 percent . Average productivity in 2009 reached 3:08 tons / ha . When compared with other corn producers , corn farming in Indonesia is still behind . Compared to the main maize producing countries (United States , Argentina and China) , even compared to U.S. corn farming productivity Indonesia reached half . During the period 1991-2009 the average productivity of U.S. corn farming , Argentina and China respectively reached 10.4 tons/ha , 5.61 tons/ha and 5,35 tons/ha . The average productivity of maize world reaches 5,12 tons / ha.

Table 3. Maize Productivity in Some Countries, Y.ear 1991-2009

Years	Argentina	China	United States of America	World + (Total)	Indonesia
1991	4.04	4.58	6.82	3.69	2.19
1992	4.52	4.53	8.25	3.89	2.20
1993	4.36	4.96	6.32	3.62	2.20
1994	4.24	4.70	8.70	4.12	2.21
1995	4.52	4.92	7.12	3.80	2.26
1996	4.04	5.20	7.98	4.21	2.49
1997	4.56	4.39	7.95	4.15	2.61
1998	6.08	5.27	8.44	4.44	2.64
1999	5.37	4.95	8.40	4.42	2.66
2000	5.43	4.60	8.59	4.32	2.77
2001	5.46	4.70	8.67	4.48	2.84
2002	6.08	4.93	8.12	4.41	3.09
2003	6.48	4.81	8.92	4.46	3.24
2004	6.39	5.12	10.06	4.94	3.34
2005	7.36	5.29	9.29	4.84	3.48
2006	5.90	5.33	9.36	4.75	3.47
2007	7.67	5.17	9.46	4.96	3.66
2008	6.45	5.56	9.66	5.13	4.08
2009	5.61	5.35	10.34	5.12	4.23

Source : FAO. Production Yearbook

The rapid development of the poultry business in Indonesia is the main factor driving the rapid growth of domestic demand for corn , so that Indonesia is now a net importer of corn in a large enough volume . Relatively high import dependence and slowing the rate of increase in productivity suggests that there is a problem how to improve the capacity of national food production in a sustainable manner . To improve the national food production capacity, we still have the potential for expansion of farming land . Of the land area suitable for agriculture amounted to 100.8 million hectares , 68.8 million hectares have been utilized , so the land has not been used about 32 million hectares . In addition , there is the potential of land for agriculture in the form of 11.5 million hectares of abandoned land and 5.4 million acres of grounds , and does not include peatlands and lowland that potential is quite large .

Table 4. Indonesian Corn Imports (year 1996- 2009)

years	Impor (1000 mt)	Nilai impor (million US$)
1996	616.989	132.971
1997	1,098.62	171.826
1998	313.694	47.965
1999	86.449	80.489
2000	1,265.14	158.448
2001	1,031.83	121.99
2002	1,149.84	132.56
2003	1,345.44	168.66
2004	1,008.93	177.67
2005	234.6	45.5
2006	1,842.90	299.1
2007	771.7	174.6
2008	393.304	135.859
2009	421.231	107.379

Source : USDA, 2011

Efforts Ministry of Agriculture

On the government side , there is a Research and Development Center Food Crops , Ministry of Agriculture whose job doing research and development to be able to produce a crop of technology innovations that can increase the production and productivity of food crops .

The technology can be in the form of :

1. Physical material (material) such as improved varieties, fertilizer (fertilizer formulation / bio-fertilizers) , and pesticides .
2. Recommendation technologies , such as fertilizing , pest control (pest) , and water use .
3. Technological processes , such as seed production , the production of bio-fertilizers and bio- pesticides production or vegetable .
4. Design / prototype equipment and agricultural machinery , such as pumping water , cropping tools , fertilizer applicators, Cultivators , sheller , and dryers .

During the period 2003 - 2009 , Seralia Maros Research Institute have found as many as six new varieties of corn seeds , namely : Bima 1 and Bima 6 . Bima 1-5 are propagated through cooperation with the private sector , and has been used by farmers . While Bima 6 will also be released to farmers in the near future.

In addition, Maros Cereals Research Institute has found new varieties of corn he was only 85 days , much shorter than the previous which reached 110 days . New seedlings have been piloted in 20 locations across Indonesia, and productivity between 12-14 tons per hectare . In comparison , only previous seed productivity from 7.0 to 11.7 tons per hectare. So that the work of these researchers can be applied by farmers, it is necessary to inform the public at large, and the farmers in particular . Socialization can be implemented Degree Appropriate Technology , School Jamboree Field Crop Integrated Resource Management Rice - Corn - Soybeans , Week National Cereal and others.

In order to maintain food self-sufficiency , particularly corn , relevant agencies have made projections of national maize production and consumption for the years 2010 to 2014 . Data based on increasing production and productivity of crops released by the Ministry of Agriculture stated that in the period 2005 - 2009, crop production generally experience a significant increase compared to the previous period. Rice production increased from 54.09 million tons in 2004 to 60.33 million tons in 2008 with an increase rate of 2.78% per year. Corn production has increased with the rate of 9.52% per year. Assuming the government's application of the technology to estimate the harvested area of maize production and productivity as presented in the following table 2.

Table 5. Indonesian Corn Production Estimate for 2010 to 2014

Years	Plantation area (hectare)	Harvest area (hectare)	Productivity (tones/hectare)	Production (tones)
2010	4.412.000	4.200.000	4,71	19.800.000
2011	4.632.000	4.400.000	5,00	22.000.000
2012	4.850.000	4.600.000	5,22	24.000.000
2013	5.000.000	4.800.000	5,42	26.000.000
2014	5.263.000	5.000.000	5,80	29.000.000

Source: Agriculture department of Indonesia

Yield or production will be able to be achieved when the harvest area also increased and productivity improved from year to year , as illustrated in Table 4 . The table also informs us that corn production is projected to increase an average of 10 % per year , harvested area is projected to increase an average of 4.07 % per year , and productivity of maize is projected to rise an average of 6.93% per year . In order to increase productivity is required implementation of cutting edge technology .

Result and Discussion

Model Validation

Validation of the model is used to determine whether the model can be used to perform simulations to generate policy alternatives , in other words, validation aims to analyze the extent to which the model can represent the real world . Validation criteria econometric model estimation using multiple indicators include (1) the proportion of variance (U.S.) , which indicates the ability of the model to replace the variation of the dependent variable , if the value is zero then the model indicates precisely replace variation of the dependent variable , and (2) Inequality Thiel coefficient (U) with the ideal number is close to zero because if the value of the model is said naively . Corn trade performance model validation performed by simulation basis for sample observation period 2010-2015 .

Results corn trade performance model validation is presented in Table 5. From 3 equations selected , based on the value of U Theil all equations have values close to zero so that it can be interpreted simulation models follow the actual data well . While it is based on a percentage value of the components of the value of U.S. statistics ,

the overall equation has a value of less than 0.04 . Based on all the above criteria, it can be concluded that the model is valid enough to do further predictions .

Table 6. Theil Forecast Error Statistics

Variable	MSE Decomposition Proportions - Var (US)	Inequality Coef - U
AJ	0	0.369
PRJ	0.02	0.0588
QJ	0.03	0.2427

Rise technology Simulation on Indonesia corn Performance

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 5 presents the results of the validation of the economic corn model. Based on Table 2 can be found, three equations in the model has a **MSE Decomposition Proportions - Var (US)** value of less than 0.03 percent,. U-Theil criteria have value of less than 0.3. 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: application of fertilizations, the use of quality seeds, irrigation water management and increase farmers' knowledge.

Ex ante analysis for simulation model presented in Table 6. Based on analysis can be show that harvest area, productivity and production of corn are rose. When compared with the projections made by the government so that the analysis showed that nearly the same value, however, the simulation results show the value of a more detailed in describing the increase in productivity due to technology implementation.

Table 7. Ex ante analysis for simulation harvest area, productivity and production of corn

Obs	YEARS	_TYPE_	_MODE_	_ERRORS_	AJ	PRJ	QJ
1	2010	PREDICT	SIMULATE	0	4509517.1	4.87442	21981264.64
2	2011	PREDICT	SIMULATE	0	4512808.75	5.03534	22723545.69
3	2012	PREDICT	SIMULATE	0	4597966.04	5.29939	24366432.14
4	2013	PREDICT	SIMULATE	0	4690193.36	5.57463	26146111.5
5	2014	PREDICT	SIMULATE	0	4789490.73	5.86107	28071518.01
6	2015	PREDICT	SIMULATE	0	4895858.13	6.15869	30152060.58

Conclusions

The main problem in corn farming is a high demand for corn products , so that domestic production should be increased . So far, the government is trying to increase production with various technology packages such as improved varieties, irrigation management and increase knowledge for farmers . based on these efforts , the Government recently released data projection Indonesian corn production and productivity .

Author trying to do analysis to test whether the data released by the government is a valid data that can be used as a basis for future policy making . Based on the results of prediction models built shows that there is a similarity value projections made by the government and carried out by the authors , however, based on the results of the analysis indicate that the value is more detailed than the projections made by the government . This suggests that the accuracy in the preparation of the model produces accuracy in the analysis .

References

1-Abdulai, A., (2000). Spatial Price Transmission and Asymmetry in The Ghanaian Maize Market. Journal of Development Economics 63, 327 – 349.

2-Anderson, T.W. and C. Hsiao (1981). “Formulation and Estimation of Dynamic Models Using Panel Data,” Journal of Econometrics, 18: 570-606.

3-Ashok Gulati and Jhon Dixon. (2008). Maize in Asia: Changing Markets and Incentives, CIMMYT and IFPRI. New Delhi.

4-Armstrong, J. Scott and Collopy, F. (1992). Error Measures For Generalizing About Forecasting Methods: Empirical Comparisons. International Journal of Forecasting, 8: 69-80.

5-Baltagi, Badi H.(2008). Econometrics. Springer Publishing, Germany.

6-Bernstein, H., (1996). The Political Economy of The Maize Fliere. Journal of Peasant Studies 23 (Issue 2 and 3, double issue), 120–145.

7-Blundell, R. and S. Bond (1998). Initial Conditions and Moment Restrictions in Dynamic Panel Data Models.

Journal of Econometrics, 87: 115-143.
8-ngle, R., Lilien, D., Robbins, R., (1987). Estimating Time Varying Risk Premia in The Term Structure: the ARCH-M model. Econometrica 55, 391–407.
9-Evans, A. 2008. *Rising Food Prices.* "*Beefing Paper".* Chatham House, London.
10- FAO. (2010). Food Outlook, 2009. FAO Publications, Rome.
11-Flammini, Alesandro. (2008) Biofuels and the Underlying Causes of High Food Prices. Rome, Global Bioenergy Partnership.
12-Greene, W. H., (1993) Econometric Analysis (2nd ed.), New York: Macmillan.
13-Giampiero M. Gallo and Marcellino M (1998). Ex post and Ex ante Analysis of Provisional Data. Institute for Economic Research (IGIER) working paper no 141.
14-Gujarati, Damodar N. (2004). Basic Econometrics, 4th ed. McGraw-Hill, New York.
15-Harris, R.I.D., (1995). Using Cointegration Analysis in Econometric Modelling. Prentice Hall, London.
16-Im, K.S., M. H. Pesaran and Y. Shin (2003). Testing for Unit Roots in Heterogeneous Panels, Journal of Econometrics, 115: 53-74.
17-Indonesia Department of Agriculture (2010). Prospects and Corn Development in Indonesia. Agency for Agricultural Research and Development, Ministry of Agriculture, Jakarta.
18-Johansen, S., 1988. Statistical Analysis of Cointegrating Vectors. Journal of Economic Dynamic and Control 12 2–3 , 231–254.
19-Levin, A., C.F. Lin and C.S.J. Chu (2002). Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties, Journal of Econometrics, 108: 1-24.
20-Lisazo, J.I., Westgate, M.E., Batchelor, W.D., Fonseca, A., (2003). Predicting potential kernel set in maize from simple flowering characteristics. Crop. Sci. 43, 892–903.
21-Neter, J., Kutner, M.H., Nachtsheim, C.J., Wasserman, W., (1996). Applied Linear Statistical Models, fourth ed. McGraw-Hill Professional Publishing, New York.
22-Robert Baumann and Victor A. Matheson (2011). Estimating Economic Impact using Ex post Econometric Analysis: Cautionary tales, College Of The Holy Cross, Department Of Economics Faculty Research Series, Paper No. 11-03.
22-Studenmund, A. H., (1997). Using Econometrics: A Practical Guide (3rd ed.), New York: Addison-Wesley.
23-Stevens, W.E., Berberich, S.A., Sheckell, P.A., Wiltse, C.C., Halsey, M.E., Horak, M.J., Dunn, D.J., (2004). Optimizing Pollen Confinement in Maize Grown for Regulated Products. Crop Sci. 44, 2146–2153.
24-Swastika, D.K.S. (2002). Corn Self Sufficiency in Indonesia: The Past 30 YEars and Future Prospect. Indonesia Agricultural Research and Development Journal. Vol. 21 No. 3. AARD. Jakarta
25-USDA. (2010). Grain: World Markets and Trade. Circular Series, FG 06-10, USA.
26-USDA-ERS.(2008). Cost of Production Estimates. Economic Research Service. USDA Publications. Washington, DC.
27-White, H. (1980). Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity.*Econometrica* 48:817-38.
28-Wooldridge, J., (2000). Introductory Econometrics: A Modern Approach. South-Western College Publishing, United States of America.
29-Von Braun J. (2007). The World Food Situation, Food Policy Report. IFPRI. Washington, D.C.
30-Yamamura, K.. (2004). Dispersal Distance of Corn Pollen Under Fluctuating Diffusion Coefficient. Popul. Ecol. 46, 87–101.