科技部補助專題研究計畫成果報告
期末報告

氣候變遷對亞洲開發中國家之經濟衝擊：可計算一般均衡模型之應用分析(第 2 年)

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計 畫 主 持 人 ：李慧琳

報 告 附 件 ：出席國際會議研究心得報告及發表論文

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中 華 民 國 103 年 03 月 31 日

中文摘要：氣候變遷對亞洲各開發中國家的影響至廣甚鉅，其中糧食安全更是備受關注。本研究應用一全球可計算一般均衡模型來模擬在氣候變遷使得中國糧食作物產出率(crop yield)下降的情境下中國若放寬其糧食自給率將可能對亞洲各開發中國家以及其糧食進出口國造成的影響。本研究結果發現，亞洲開發中國家中，印尼、馬來西亞、菲律賓、中東及北非之糧食安全將因中國增加糧食進口所致之國內及國際糧價上漲而受到負面影響。歐洲、北美洲、澳洲等小麥穀物主要出口國則因亞洲稻米缺口而受惠。因此，為使亟需糧食進口之亞洲開發中國家的糧食安全免受衝擊，作為糧食需求大國的中國應戮力提升其糧食作物產出率，以免在未來極可能發生的氣候變遷下在國際糧食市場造成開發中國家之外部性。

中文關鍵詞：糧食自給率、糧食安全、中國、可計算一般均衡模型、氣候變遷。

英文摘要：In this study we used a better and more realistic approach that recognizes agro-ecological dissimilarities in land characteristics for agricultural purposes in a multi-regional, multi-sectoral computable general equilibrium model and apply such model to investigate the possible consequences of China’s relaxation on its efforts in sustaining grain self-sufficiency and how this would imply for the world, particularly for countries that are competing food imports with China. Our results find that even for the least traded rice, China ‘s policy shift can have far reaching effect, passing through the spatial dimension with countries competing for same source of export supply, as well as the sectoral dimension with land-based sectors competing for land resource. If policy efforts cease to further advance crop yield for counteracting the climate impact, China ‘s demand increase for imported rice would end up aggravating food insecurity in Indonesia, Malaysia, The Philippines, Middle East, and North Africa by driving up both domestic and global prices of all the food staples: rice, wheat, and coarse grains. On the other hand, wheat-producing EU, North America, Australia, which are also exporting countries would gain, as wheat and coarse grains lose in the land competition in the affected

Asian rice-consuming and -importing countries. Based on our analysis, it is important for China to sustain policy efforts for advancement of crop yield, for the sake of global food security, especially in a highly probable scenario of climate change which the world is projected to incur.

英文關鍵詞： Food self-sufficiency, food security, China, Computable General Equilibrium Model, climate change.

行政院國家科學委員會補助專題研究計畫成果報告

（□期中進度報告/■期末報告）

氣候變遷對亞洲開發中國家之經濟衝擊：可計算一般均衡模型之應用分析

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計畫主持人：李慧琳

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中　華　民　國 103 年 3 月 20 日

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Abstract:

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Keywords: Food self-sufficiency, food security, China, Computable General Equilibrium Model, climate change.

摘要：

氣候變遷對亞洲各開發中國家的影響至廣甚鉅，其中糧食安全更是備受關注。本研究應用一全球可計算一般均衡模型來模擬在氣候變遷使得中國糧食作物產出率(crop yield)下降的情境下中國若放寬其糧食自給率將可能對亞洲各開發中國家以及其糧食進出口國造成的影響。本研究結果發現，亞洲開發中國家中，印尼、馬來西亞、菲律賓、中東及北非之糧食安全將因中國增加糧食進口所致之國內及國際糧價上漲而受到負面影響。歐洲、北美洲、澳洲等小麥穀物主要出口國則因亞洲稻米缺口而受惠。因此，為使亟需糧食進口之亞洲開發中國家的糧食安全免受衝擊，作為糧食需求大國的中國應戮力提升其糧食作物產出率，以免在未來極可能發生的氣候變遷下在國際糧食市場造成開發中國家之外部性。

關鍵字：糧食自給率、糧食安全、中國、可計算一般均衡模型、氣候變遷。

1. Introduction

Foreseeing the potential pressure on the world resources from development intensification of developing countries, Brown (1995) gave a wake-up call implied by the fast growing China: "To feed its 1.2 billion people, China may soon have to import so much grain that this action could trigger unprecedented rises in world food prices." This wake-up call had prompted the Chinese government to launch more policy efforts to sustain its granary self-sufficiency. The Chinese government quickly adopted several key production-boosting measures, including a 40% increase in the grain support price paid to farmers, an increase in agricultural credit, and heavy investment in developing higher-yielding strains of wheat, rice, and corn (Brown, 2011). These efforts turned out to be successful as China managed to attain a remarkable 95% of grain self-sufficiency rate over the past decade. This also appeared as a big blessing for global food security, particularly for Asian developing countries that depends on grain imports.

However, challenges still remain. With its rapid economic development, China has been seeing water shortage for agriculture and land lost to urbanization and industrialization. During the period of 1980 to 2003, China's grain area declined 7.65%—with rice and wheat areas dropping by 16.06% and 24.84% respectively, while corn area rising by 25.94% (see Table 1). Fast industrialization and increased urbanization were pronounced in the south and coastal provinces. Grasslands in the northwestern provinces were thus turned into crop growing so as to fill the production gap due to the cropland losses to urbanization. Key production area thus shifted towards north and northeast of China, growing at the rate of 2.56% and 21.49%, respectively (You et al., 2011). Unlike the traditionally granary provinces of the south—where weather and water availability are favorable for agriculture—north and northeast China rely very much on irrigation for crop production. In quite some areas, irrigation was made possible by over-pumping aquifers. Climate change induced water shortage could possibly hit these new granary regions and thus impede the food security of China.

As the super-sized population outgrows the currently self-sufficiency in food, coupled with the worsening environment for crop growing, China's food insecurity is likely to deepen. This may spread out of the Chinese borders as the modern Chinese economy is connected closely with the world. This paper uses a global multi-regional, multi-sectoral computable general equilibrium (CGE) model to investigate the possible consequences of China's relaxation on its policy efforts in sustaining grain self-sufficiency and how these imply for the world, particularly for countries that are competing food imports with China. We focus particularly on rice, the most importance of staple crop in China and the Asian developing countries that could possibly be affected by China's reduced self-sufficiency.

The CGE model we use for this study is modified, based on the Global Trade Analysis Project (hereafter, GTAP) model (Hertel, 1997), to incorporate the concept of Agro-Ecological Zoning (AEZ) as developed by FAO(2000) and Fischer et al. (2002) so that transition of land between uses is subject to crop suitability of land—which is implied by the terrestrial characteristics and the weather condition at the location of the land. Price-induced adjustments in food production would affect significantly the reallocation of agricultural land among uses. We believe this describes better and more realistically the adjustment in land use of the agricultural sector. Like conventional CGE models, the economic core of the GTAP model describes inter-sectoral linkage through input-output relations and inter-regional

linkage through bilateral trade. The model is calibrated to the GTAP Version 8 Data Base (Narayanan, Aguiar and McDougall, 2012) and the GTAP Land Use Data Base (Lee et al., 2009).

The paper is organized as follows: Section 2 introduces briefly the facts of world rice production and consumption; Section 3 provides a description of the global multi-regional, multi-sectoral CGE model and the data base for benchmarking the CGE model, particularly on the use of land that reflects heterogeneity in mapping out suitability for crop growing; Section 4 explains the scenarios assumed for the CGE simulation of various aspects that could hinder China's grain self-sufficiency; Section 5 discusses the results; Section 6 concludes the report.

2. World rice production, consumption, and trade

Rice is the major staple crop and the mainstay for most Asian economies. A majority of rice production locates in East Asia, Southeast Asia and South Asia (see Fig. 1). International Rice Commission. (2003) indicates that China, India, Indonesia, Bangladesh and Viet Nam are the major producers of rice, producing more than 70% of world volume. However, due to strong consumer preference towards rice varieties and qualities, world rice trade is thin in volume—accounting for as few as 5% of global output. Fig. 2 shows the utilization and domestic supply statistics of the rice-growing and -consuming countries. Most of the Asian countries are quite dependent on their domestic supply of rice.

Asian rice-producing countries tend to consume most of its own production. China and India are the two largest producers of rice in the world; however, both countries consume the majority of their own rice production, contributing little for trade. Only Thailand and Viet Nam are able to export rice (see Fig. 2, whose domestic utilization-supply position appear southeast off the diagonal), to, for example, neighboring Philippines, Bangladesh, Malaysia and Indonesia (see Fig. 2, northwest off the diagonal).

3. Model and Data

The GTAP Model and Land Use Change Modeling

We modify the multi-regional CGE model, GTAP (Hertel 1997), to go with the GTAP land use database (Lee et al., 2009) for the simulation of climate-change impact on global food supply, prices and land use. Such a model and database permits us to incorporate varying land features of agro-ecological zones, with which climatic conditions and terrain properties are considered. The standard GTAP model (Hertel 1997) allows all land-based sectors to compete for land according to relative land rents. However, it does not explicitly identify the suitability and viability of land for growing various crops -- model settings like this would produce misleading results concerning the substitutability of land use between the competing sectors. For a country with arable land located under diverse climate and terrain conditions, crop suitability of the land may diverge, and thus land use change between sectors as a whole may be subject to temperature, precipitation, and soil conditions of the location. The AEZ distinction is the key feature of our modeling effort and also contribution to the literature of integrated assessment on climate change impact.

Agro-Ecological Zoning

The GTAP land use database (Lee et al., 2009) is compiled following the agro-ecological zoning (AEZ) approach[1]—pioneering work of the Food and Agriculture Organization of the United Nations, (FAO) (FAO 2000) and Fischer et al. (2002)—which distinguishes land areas of a region/country by their agro-ecological features. Arable land is classified into agro-ecological zones according to temperature, precipitation, soil type, soil pH, topography, etc. of the location[2]. That is, land areas located in the same agro-ecological zone have similar physical environmental limitations and crop growing potential. The FAO/IIASA AEZ methodology has provided a standard framework for classifying land according to crop suitability (FAO and IIASA, 2000). Agro-ecological zoning of land is mainly based on the length of growing period (LGP), which refers to the length of period (or number of days) within a year that the temperature is above 5 degree Celsius and the soil moisture is sufficient for crop growth (FAO, 2000). The LGP also provides a rough measure for crop productivity of the AEZ.

The GTAP land use database

The GTAP land use database (Lee et al. 2009) includes data of land cover, harvested area of crops, area of timber plantation, and production of crops and timber, by 18 agro-ecological zones of all countries/regions in the world (Ramankutty et al. 2007; Sohngen and Tennity 2004). The 18 agro-ecological zones are classified by 6 categories of LGP in 3 climatic zones (boreal, temperate, and tropical). The 6 categories of LGP are identified according to the FAO/IIASA AEZ methodology. LGP of AEZ1 is below 60 days in a year; LGP of AEZ2 ranges between 61 to 120 days of a year; LGP of AEZ3 is between 121 to 180 days; LGP of AEZ4 is between 181 to 240 days; LGP of AEZ5 ranges between 241 to 300 days; and LGP of AEZ6 is above 300 days of a year. Fig. 3 shows global distribution of AEZs, at a 0.5 degree latitude by 0.5 degree longitude resolution. Fig. 4 shows the country-specific distribution of paddy rice production across AEZs.

The GTAP land use model

Fig. 5 shows the nesting structure for agricultural production in the GTAP land use model. The agricultural sectors include crops sectors (e.g., paddy rice, wheat, other cereal grains, vegetables and fruits, oil seeds, sugar cane and beets, and other crops), and livestock sectors (e.g., cattle, cows, goats, sheep, horses and other animal products). Under the weak separability assumption, we categorize the inputs to agricultural production as: (A) intermediate inputs, and (B) primary factors. We specify a Constant Elasticity of Substitution (CES) function to govern the substitution[3] between labor, land, capital and natural resources. As such, use ratios

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[1] The AEZ methodology is developed by the United Nations Food and Agriculture Organization (FAO) and the International Institute for Applied Systems Analysis (IIASA), for evaluating biophysical limitations and agro-ecological potentials of land in various regions, in particular, developing countries.

[2] Irrigation is not accounted for in the AEZ methodology, and thus our CGE model of land use considers only the rain-fed conditions of the agro-ecologically zoned land resources.

[3] The specified elasticities of substitution between primary factors vary across sectors. For agricultural and natural resource-based sectors, we specify values ranging from 0.2 to 0.62; and 1.3 for manufacturing and services sectors—which follows the

between primary factors vary to their relative prices. We assume that all intermediate inputs are used in proportion to output levels[4]—that is, relative prices of intermediate inputs do not affect their use ratios.

Fig. 6 shows the nesting structure of AEZ-specific land demand by the agricultural sectors. We specify a CES function with a large substitution elasticity (of 20) between AEZs, so that land rents of all AEZs, when responding to the exogenous shocks, would change in the same direction and of very similar magnitude. This helps save data and computation resource requirements in implementing the idea of Lee (2004), in which differentiated production technologies are to be identified for the same crop grown in different AEZs. Since there is not yet good data to support the implementation of the Lee (2004) idea, a large substitution elasticity CES function would perform similarly to the results of Lee (2004), where production technology of a sector is assumed the same across all AEZs—albeit with differentiated output levels.

Fig. 7 shows the three-tier nesting structure of AEZ-specific land supply under the weak separability assumption. For each tier of the nesting, we specify a Constant Elasticity of Transformation (CET) function to govern the optimal allocation of land according to relative land rents payable by the using sectors. The bottom most tier of the nesting structure shows the land in an AEZ is first allocated between agriculture and forestry, following the CET function. The middle tier shows the CET governed allocation of land between livestock husbandry and crop farming activities. The top tier shows the CET governed allocation of land among farming activities of various crops.

4. Simulation design

Using the above introduced model and the land use database of Lee et al. (2009), we simulate the impact on China and its peer countries in terms of global food supply and prices if China, for the next five-year period or so, ceases to further reinforce policy efforts in enhancing agricultural production against a backdrop of the assumed future development path that reflects growing population and intensified urbanization, coupled with declining crop yield due to climate change inflicted water constraints and temperature change.

An assumed development scenario of China

The scenario is numerically translated into shocks to the CGE model. The assumed short to medium term (5 years or so) development scenario for China is plotted as follows as an ensemble of various studies in the literature:

(a) population increases 5.64% for the period of 2009-2015 (Ye et al., 2013), which is based on the SRES A2 scenario;
(b) cropland loss to urbanization: -1.44% for the period of 2009-2015 (Ye et al., 2013), which is based on the SRES A2 scenario;
(c) Climate induced yield reduction not counteracted by agronomic advancement: paddy rice (-4.3%), wheat (-2.2%), Coarse grain (-0.4%), based on the modest impact as projected by Lin et al.(2005).

Our model is a comparative static model. We combined the land use data base of Lee et al. (2009) and the version 8 of the GTAP database (Narayanan, Aguiar and

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suggestion as in Dimaranan (2004).

[4] In this paper we use "production" and "output levels" interchangeably.

McDougall, 2012). The GTAP database is used as the benchmark equilibrium for global CGE simulations—which presents transactions of commodities and services between sectors within and across countries/regions.

Table 2 lists the 29 world regions/countries of this simulation. Table 3 shows the sector dimension of this simulation, which covers 17 producing activities of the whole economy. Key food crops like paddy rice, wheat, and other cereal grains as well as processed food sectors are kept unaggregated, while activities not directly linked with agricultural land are aggregated—e.g., energy, manufacturing and service sectors.

All endogenous variables in our model—including domestic demand, exports, prices, and output levels of crops and other commodities/services being produced in all the economies—will respond to such shocks and simultaneously reach a new equilibrium where demand equals supply for all commodities/services in all economies. We then calculate the percentage deviations of all economic variables (e.g., prices, supplies, and demands) in the new equilibrium from the old one. This percentage deviation of the variable measures the impact it receives due to the prospective change in the Chinese agricultural context.

5. Discussion of simulation results

We present the key results from the simulation, focusing on China and countries with which China trades rice. Table 4 shows Percentage change in domestic production and price in China and Thailand, which is a main provider of imported rice to China. Paddy rice production in China increases by 0.209% with the domestic market price rising by 11.689%. Rising price of paddy rice attracted in ag. land from other crop sectors to address demand pressure. Thus, market prices of other crops are thus driven up, although with a halved magnitude compared with paddy rice. This effect spread over to Thailand, a key source of China's imported rice. Domestic production of paddy rice in Thailand increased by 0.388%, with a 1.011% rise in price. Prices of other grain crops in Thailand rose due to reduced land availability—that is, competed away by paddy rice—and thus supply fell at the new equilibrium. As rice is traded in processed form, Thai processed rice increased due to export demand increase, while Chinese one decrease as less volume of paddy rice is available for export.

Table 5 shows percentage changes in the volume of China's grain imports, driven by the three exogenous shocks. All shocks considered, imports of both rice (processed) and wheat to China increase dramatically, by 17.86% and 23.70%. Wheat gave way in ag. land share to paddy rice due to strong demand pressure of rice, thus China needed to increase wheat imports. Among the three shocks, crop yield decline posed the greatest impact on China's grain imports. This suggests that China should manage to sustain continuous agronomic advancement so as to counteract potential climate infliction on yield loss.

Table 6 shows percentage changes in grain prices at the global market, driven by the three exogenous shocks to China. With all the three shocks considered, price of processed rice at the global market rose by a double magnitude compared with other grains. China's crop yield decline—with rice decreasing the most, by 4.3%, doubled of wheat, and tenfold of other coarse grains—contributed to half of the price upbeat.

Table 7 shows the impact on selected countries that are also dependent on Thai rice (processed) exports. China's increased import demand for Thai processed rice pushed up the price of Thai rice. First column of Table 7 indicates the processed rice import volume, assessed at the 2007 US dollar term, of the countries that are dependent on supply from Thailand. In the benchmark year of 2007, Thailand

exported nearly half (48.94%) of its processed rice, and the 6 regions listed in Table 7 took 66% of Thailand's processed rice exports. With China increasing rice imports from Thailand by 17.864%, the other 5 dependent regions would face a higher price of Thai rice—thus, import demand reduced. Differences in the magnitude of price rise among various regions reflect the discrepancies in the demand response (that is, the Armington elasticity) of the 5 regions to the impact as rippled from China through the channel of global trade.

The price rise of processed rice import from Thailand would then drive up domestic rice prices of these dependent countries, and triggered land competition between grain sectors with these regions. Land competition is also contributing to price upbeat of grains other than rice. This could aggravate food insecurity in these regions, particularly on the accessibility of food.

6. Concluding remarks

In this study we used a better and more realistic approach that recognizes agro-ecological dissimilarities in land characteristics for agricultural purposes in a multi-regional, multi-sectoral computable general equilibrium model and apply such model to investigate the possible consequences of China's relaxation on its efforts in sustaining grain self-sufficiency and how this would imply for the world, particularly for countries that are competing food imports with China. We focus particularly on rice, the most importance of staple crop in China and the Asian developing countries that could possibly be affected by China's reduced self-sufficiency.

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Figures

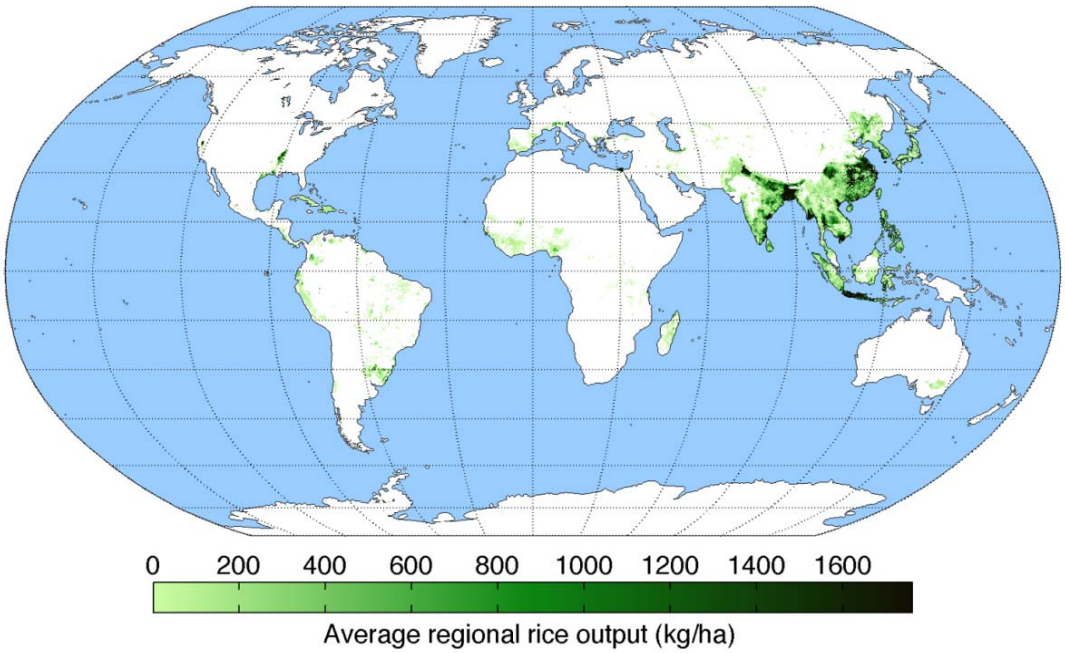

Fig. 1. Global distribution of paddy rice production

Source: Map compiled by the University of Minnesota Institute on the Environment with data from: Monfreda, Ramankutty, and Foley (2008).

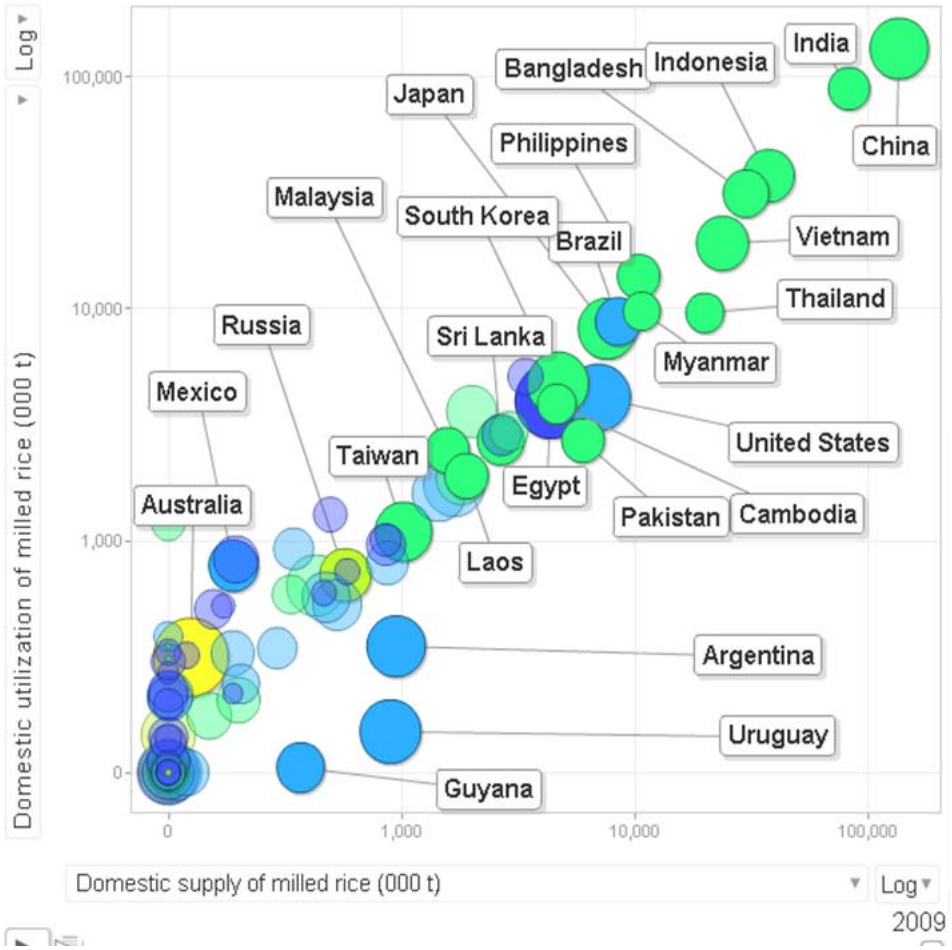

Fig. 2. Rice utilization and domestic supply of the world nations

Source of data: IRRI World Rice Statistics.

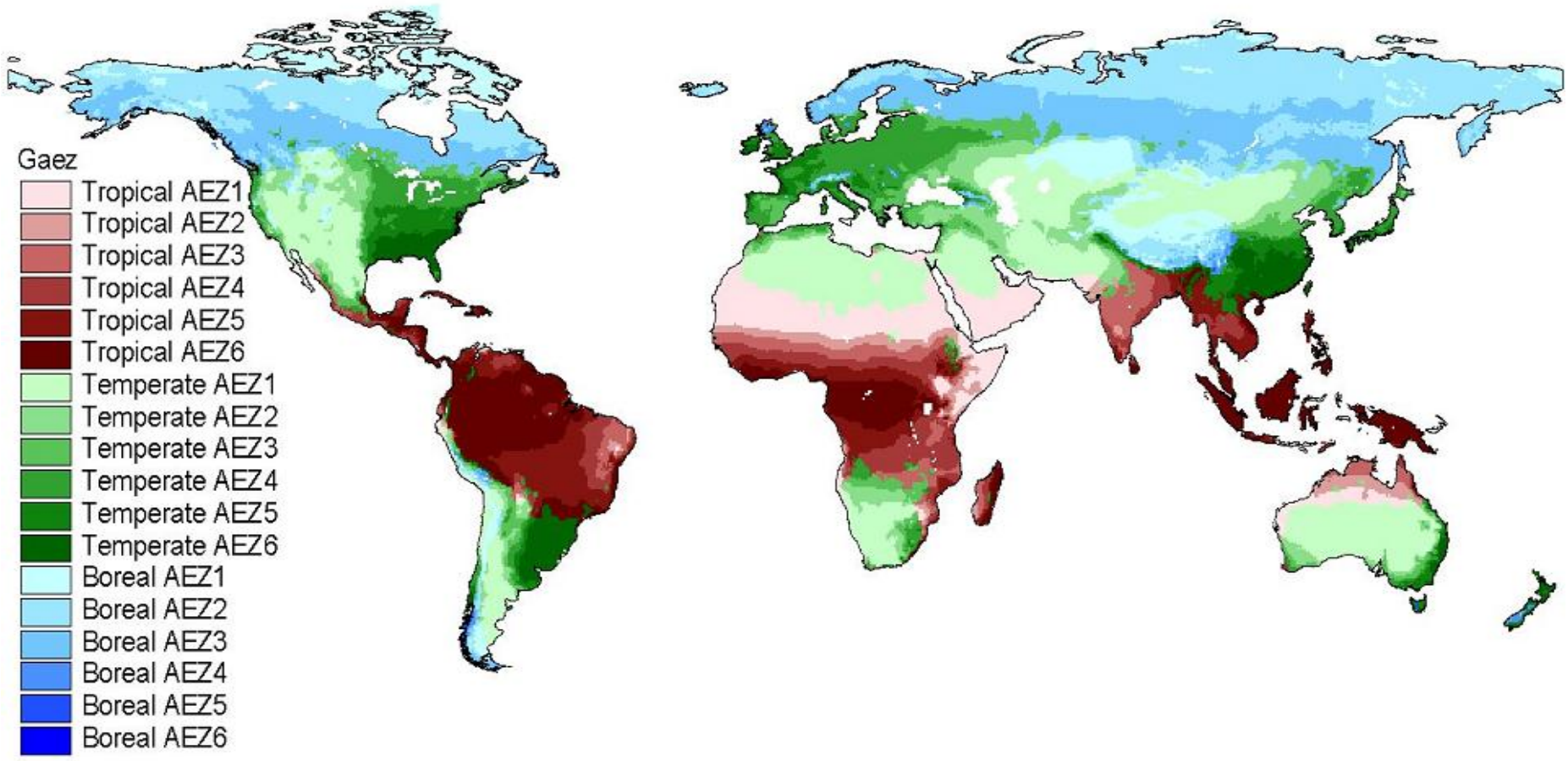

Fig. 3. Global distribution of AEZs

Source: Ramankutty et al. (2007)

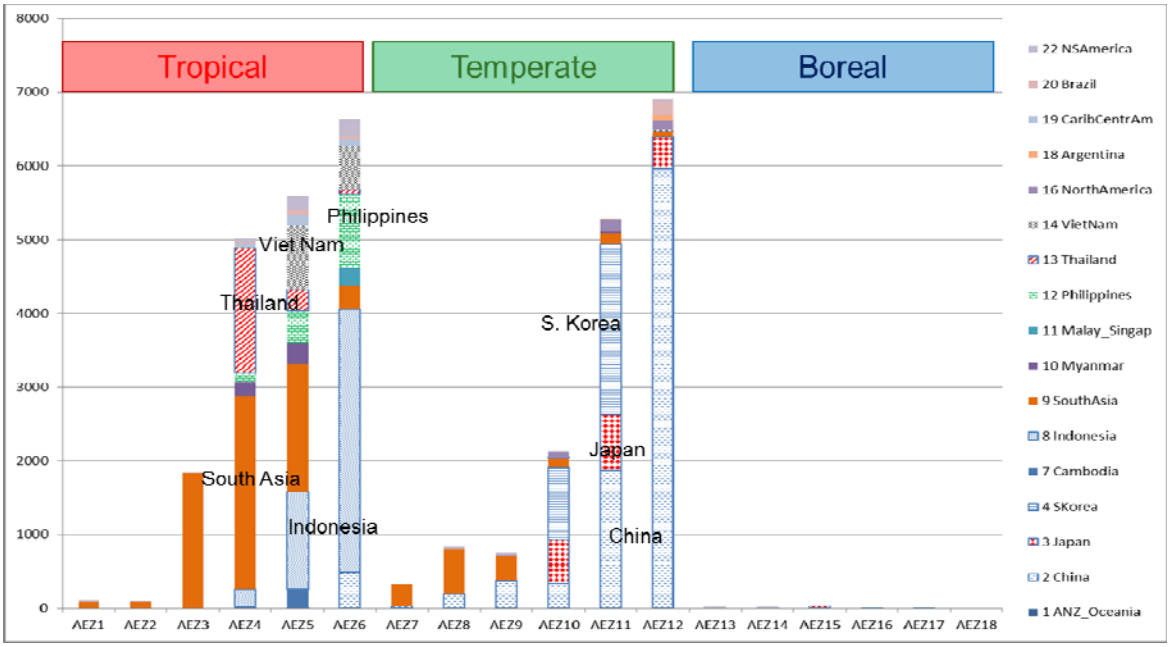

Fig. 4. AEZ distribution of paddy rice production

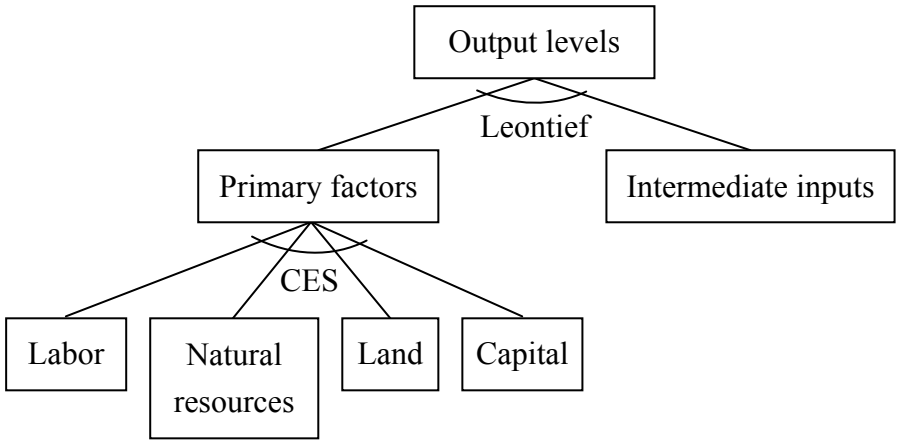

Fig. 5. Production structure of the agricultural sectors

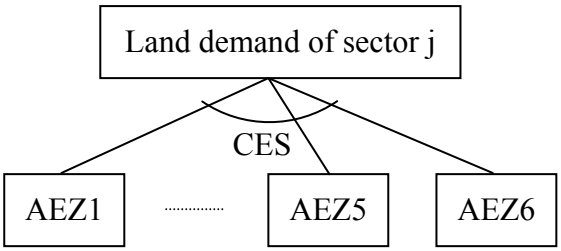

Fig. 6. Nesting structure of sector-specific land demand

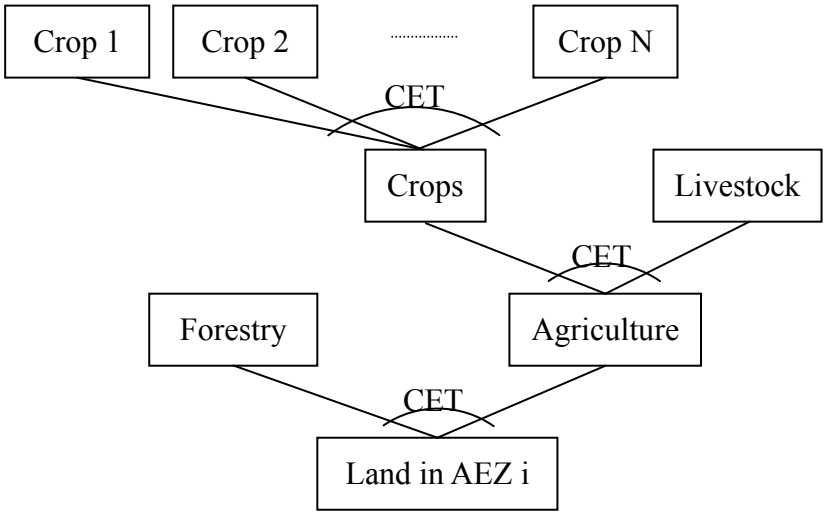

Fig. 7. Nesting structure for AEZ-specific land supply

Tables

Table 1. Changes (%) in crop area in China from 1980 to 2003

Region	**Rice**	**Wheat (%)**	**Corn**	**Grain**
Northeast	222.67	−86.13	35.86	21.49
North	−9.27	−5.90	17.48	2.56
Northwest	40.56	−37.59	83.73	−4.15
Central	−19.06	−53.32	17.55	−21.84
Southeast	−30.56	−1.07	68.25	−15.77
Southwest	−5.09	−14.37	0.64	−5.93
South	−31.29	−86.25	23.58	−30.45
China	−16.06	−24.84	25.94	−7.65

Source: You et al. (2011, Table 1).

Table 2. Table 2 Regions in the model

No.	Code	Region description	No.	Code	Region description
1	ANZ_Oceania	Australia, New Zealand & Oceania	16	NorthAmerica	North America
2	China	China and HK	17	Mexico	Mexico
3	Japan	Japan	18	Argentina	Argentina
4	SKorea	South Korea	19	CaribCentrAm	Central America
5	Taiwan	Taiwan	20	Brazil	Brazil
6	OtherEAsia	Other East Asia	21	Chile	Chile
7	Cambodia	Cambodia	22	NSAmerica	Northern South America
8	Indonesia	Indonesia	23	EU27	Euro Union
9	SouthAsia	South Asia	24	OthEurope	Other Europe
10	Myanmar	Myanmar	25	Russia_FSU	Russian Federation & Former Soviet Union
11	Malay_Singap	Malaysia& Singapore	26	MiddleEast	Middle East
12	Philippines	Philippines	27	NAfrica	North Africa
13	Thailand	Thailand	28	NoCstlAfrica	No Coastal Line Africa
14	VietNam	Viet Nam	29	SAfrica	South America
15	OtherSEAsia	Other South East Asia			

Table 3. Table 3 Sectors in the model

No.	Sectors	No.	Sectors
1	Paddy rice	10	Processed meat products
2	Wheat	11	Vegetable oil and fat
3	Other cereal grains	12	Sugar
4	Vegetables and fruits and other crops	13	Other processed food
5	Oilseeds	14	Beverage and tobacco
6	Sugar cane and beets	15	Coal, oil, and gas
7	Processed rice and flour	16	Other manufacture
8	Animal products	17	Other services
9	Forestry		

Table 4. Percentage change in domestic production and price: China and Thailand

	China		Thailand	
	Dom. production	Dom. price	Dom. production	Dom. price
Paddy rice	0.209	11.689	0.388	1.011
Wheat	-0.659	5.398	-0.768	0.348
Coarse grain	-0.319	3.128	-0.028	0.734
Oil seeds	-1.697	2.256	-0.305	0.534
Processed rice	-0.691	7.368	0.425	0.817

Table 5. Percentage change in the volume of China's grain imports

	Crop yield decline	Pop. Growth	Cropland loss to urbanization	All considered
Paddy rice	37.09	5.62	5.14	55.32
Wheat	15.31	3.90	2.89	23.70
Coarse grain	0.74	2.43	0.63	3.87
Oil seeds	-0.11	0.64	0.14	0.67
Processed rice	11.67	3.51	1.70	17.86

Table 6. Percentage change in global import prices

	Crop yield decline	Pop. Growth	Cropland loss to urbanization	All considered
Paddy rice	0.539	0.178	0.146	0.812
Wheat	0.138	0.077	0.058	0.268
Coarse grain	0.074	0.098	0.071	0.246
Oil seeds	0.044	0.143	0.08	0.269
Processed rice	0.281	0.118	0.082	0.483

Table 7. Impact on countries that are also dependent on Thai rice (processed) exports

	Imported Thai processed rice (million USD)	% change in rice import price %	% change in rice import volume %
China	395	0.766	17.864
Indonesia	160	0.564	-0.375
Malaysia_Singapore	235	0.457	-0.097
Philippines	149	0.448	-0.198
Middle East	524	0.226	-0.068
North Africa	983	0.618	-0.597
Total Thai exports	3686		
% export in Thai production	48.94%		

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計畫成果自評

本研究計畫成果已於 2013 年 10 月 Elsevier 出版社所舉辦之 First Global Food Security Conference 發表。目前正在改寫成期刊論文以進行投稿。

國科會補助專題研究計畫出席國際學術會議心得報告

日期：2014 年 1 月 20 日

計畫編號	NSC 100－2410－H－004－075－MY2		
計畫名稱	氣候變遷對亞洲開發中國家之經濟衝擊：可計算一般均衡模型之應用分析		
出國人員姓名	李慧琳	服務機構及職稱	國立政治大學經濟學系副教授
會議時間	Jun 26-29, 2012	會議地點	Bratislava, Slovakia
會議名稱	20th International Input-Output Conference		
發表題目	Do not judge a book by its cover: ecosystem service of the Kaomei wetland		

一、參加會議經過

In this conference, I was assigned to serve as the chair of the session, topic of which was “CGE and econometric input-output modelling”, and in which I also presented my paper, titled as “Do not judge a book by its cover: ecosystem service of the Kaomei wetland”. In addition to the conference, I also participated in the International School of IO Analysis (ISIOA), which was organized by the IIOA as a whole-day workshop on the Input-Output Analysis, prior to the conference. Topics of the ISIOA included: (a) Historical roots and theoretical background of Input-Output Analysis, (b) Dynamic econometric input-output modelling, and (c) Construction of Symmetric Input-Output Tables.

二、與會心得

The keynote speech of the conference was delivered by Heinz D. Kurz, Full Professor of Economics, University of Graz, and Director of the Graz Schumpeter Centre. The topic of Prof. Kurz's lecture is "INPUT-OUTPUT ANALYSIS QUO VADIS?". Here is the abstract of the lecture:

"As early as in his Presidential Address to the American Economic Association in 1970 Wassily Leontief had warned the economics profession of being in danger of taking the wrong road. His warnings were echoed by several contemporary commentators who argued that parts of modern economics share some responsibility for the current financial and economic crisis. Severe economic crises request the economics profession to reconsider its doctrines, abandon views that can no longer be sustained, return to views that can, or create new ones appropriate to the situation under consideration. As an integral part of economics, input-output analysis cannot possibly avoid to respond to this request. It is argued that input-output analysis is a child of the classical approach to the theory of production, income distribution and relative prices. This is illustrated in terms of two papers by Leontief: In his 1928 maiden paper he adopted a circular flow framework and explained relative prices in terms of the distribution of the surplus product amongst different social classes. In his 1985 paper he dealt with the problem of technological change and the involved choice of technique problem in strictly classical terms. It is shown that in such a framework there is no presumption that the amount needed of a particular input per unit of a particular output will fall with an increase of the price of the input, or at most stay the same. Hence the conventional concept of "substitution" between inputs need not hold and the equally conventional downward sloping demand function for an input cannot generally be sustained. It is argued that this fact has nothing to do with the well-known phenomena of "reswitching" of techniques and "capital reversing", but is of much wider importance. This has important consequences for economic theory and applied economics, including input-output analysis."

The themes of this year's IIOA conference that really interested me included: (a) Input-Output analysis of disasters, (b) Environmental IO models, (c) Input-output analysis for policy making, (d) Special

WIOD-session: Environmental Aspects of International Trade, (e) CGE and econometric input-output modelling. It was very helpful for me to attend these sessions and to get the up-to-date development in these fields. These interesting presentations later attracted me to direct my research interest towards policy assessment with both IOA and CGE on natural and un-natural disaster impact.
Also at the conference were the MRIO-showcase, organized by the University of Sydney team and various national teams that compiled MRIO, and the WIOD (World Input-Output Database), which was a EU-funded FP7 project. These were impressive presentations and also research output of tremendous policy significance for the input-output based studies. IIOA is the best and first place where these good IOA work be showcased.

三、發表論文全文或摘要

In this study we attempted to illustrate a way of linking the value of ecosystem services with the economy and thus revealing the economic significance of ecosystem service which has long been overlooked in human economic activities. We chose as the study object the Kaomei Wetland in Central Taiwan—which is rated as ‘wetland of national importance’, based on the Ramsar Convention treaties. We first conducted field survey and experiments to identify the Kaomei Wetland as a land use type of low landscape development intensity (LDI) and assessed the latent economic value of the ecosystem services Kaomei Wetland provides, based on the conceptual framework as proposed by the TEEB. We then incorporated the latent economic value—in the form of "avoided cost" and "replacement cost" as implied by the Kaomei ecosystem services while maintaining it as a low LDI land use type—to a bottom-up multi-regional computable general equilibrium (CGE) model of Taiwan to see how far-reaching the avoided/replaced costs, if spared for other non-wastewater treatment use, could alternatively affect the economy of the local and other domestic regions through inter-region linkage and the input-output relationship in the production and consumption processes. We aim to demonstrate the significant economic contribution of the seemingly low-economic-value land use type like the Kaomei Wetland could

potentially make to the human wellbeing in the perspective of economics.

四、建議

Quite some statisticians from OECD countries attended this IIOA meeting, and they also actively participated in the advancement of the compilation methodology of the IO accounts as well as policy analyses with the IOA model. It will be good that our government statisticians in charge of compiling the IO accounts also attend this sort of international conferences so as to get connected with the international research and statistics communities and to get updated with current development in the field.

五、攜回資料名稱及內容

Material brought back from the conference was the Conference Booklet. Proceedings of the conference are available electronically from the IIOA website: http://www.iioa.org/conferences/conferences.html .

六、其他

Here is a snapshot of one of the plenary speeches by the EU official on the contribution of Input-Output Analysis to economic policy/planning analysis.

國科會補助專題研究計畫出席國際學術會議心得報告

日期：2014 年 1 月 20 日

計畫編號	NSC 100－2410－H－004－075－MY2		
計畫名稱	氣候變遷對亞洲開發中國家之經濟衝擊：可計算一般均衡模型之應用分析		
出國人員姓名	李慧琳	服務機構及職稱	國立政治大學經濟學系副教授
會議時間	Oct. 19 – 20, 2012	會議地點	Singapore City, Singapore
會議名稱	The Thirteenth International Convention of the East Asian Economic Association		
發表題目	To Mitigate or Not to Mitigate, That is the Question		

一、參加會議經過

In this conference, I presented the papers titled as “To Mitigate or Not to Mitigate, That is the Question” at the session of “CGE and Multi-Sector Modeling” on the first day of the conference, chaired by Prof. Shinichi Ichimura, who is Professor Emeritus of Kyoto University, and Honorary Counselor of the International Centre for the Study of East Asian Development (ICSEAD), Kitakyushu, Japan. The conference arranged a discussant for each paper. The discussant for my paper was Prof. Ken Itakura from Nagoya City University. On the second day of the conference, I was invited to serve as the discussant for the paper authored by Prof. Hiro Lee of Osaka University and Prof. Ken Itakura of Nagoya City University on the topic ”Asian Track or Trans-Pacific Track? General Equilibrium

Estimates for Alternative FTA Sequencings".

The theme of the Convention was "Opportunities and Challenges for Asian Economies in the New Millennium." Nevertheless, the topics of papers presented at the conference were quite comprehensively covering all fields of economics and issues involving economic development particularly of Asian economies.

二、與會心得

An impressive keynote Address was arranged and delivered by Prof. Lim Chong Yah of Nanyang Technological University, Singapore, on "The Trinity Growth Theory". The speech was based on Prof. Lim's paper (Lim, 2012). The Trinity Growth Theory, as proposed by Prof. Lim, consists of three parts: (a) the EGOIN Theory, (b) the Triple C Theory and (c) the S Curve Theory. Prof. Lim used the Trinity Growth Theory to explain (1) why levels and rates of economic growth differ among nations, (2) why these two important world economic phenomena also exist among different provinces and cities within the same nation, and (3) why the world economy, viewed against world economic history, has grown so unprecedentedly in the last 60 years after World War II. Using the Trinity Growth Theory, Professor Lim explained for the transformation of various Asian economies, Japan, Singapore, and China. The paper is appended at the end of this document, as shared by Prof. Lim.

As a first-time participant in this East Asian Economic Association convention, I learned a lot from this conference. It was very helpful for me to attend the conference and to get the up-to-date development in these fields. These interesting presentations later attracted me to direct my research interest towards development economics with IOA and CGE modeling.

三、發表論文全文或摘要

The south region used to be the production center of Taiwan's traditional and heavy industries in its miraculous economic development since the 1970s. However, the South is now losing its

economic luster as cheap and abundant labor supply of China keeps luring away traditional industries of this region. Such hollow-out is driving the per capita income of the southern Taiwan below the national average and the regional economy towards long-term recession. Yet air quality in the South is among the worst of the nation, owing to the high concentration of pollution-intensive heavy industries in this region such as steel and petrochemical industries. A recent medical survey finds that air pollution alone has claimed residents of the South 4-5 years short of the national average life longevity. Municipal governments of southern Taiwan recently proposed a new policy scheme aiming to mitigate such plaguing air pollution but not the economy. The policy proposal entails a good combination of raised rates of pollution taxes and command-and-control tactics. In this study we used a multi-regional computable general equilibrium (MR-CGE) model of Taiwan to evaluate the effectiveness of the proposed policy scheme in achieving its dual purposes—pollution mitigation and a boost to the regional economy. We conducted survey to glean firm-level strategies to cope with the proposed regulations on industrial pollution and incorporated such parameter into the aforementioned MR-CGE model. Our simulation results indicate that the proposed mitigation policy is quite effective in improving air quality with just mild impact on the regional economy of southern Taiwan. It is, therefore, possible to reduce air pollution at a reasonably mild expense as long as the policy is properly prescribed for the regional economy.

四、建議

This is a very organized conference, involving a variety of fields in economics. In particular, the studies focused on economic development of the national economies. Strategies for economic development were discussed with empirical investigations based on sound theories. This offers a good example for economics sciences to contribute to and to advise economic development policies. Japan and Singapore have had such a tradition established. It would be good to see in the near future in Taiwan that we can have such like environment for economics researchers really advising economic policies with sound empirical analyses based on practical and

functional theories that are capable of explaining and offering insight and advice for the economic issues our society faces now and into the future.

五、攜回資料名稱及內容

Material brought back from the conference was the Conference Booklet. Proceedings and agenda of the conference are available electronically from the East Asian Economic Association conference website: http://www.eaeaweb.com/3-eaea-conventions.html .

<<Appendix>>

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The Trinity Growth Theory: A Theory of Wealth and Poverty

LIM Chong Yah

19 October 2012

EGC Report No: 2012/03

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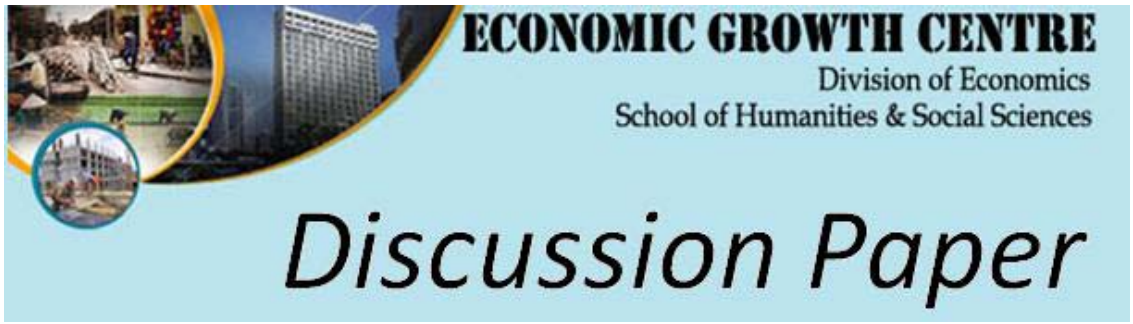


THE TRINITY GROWTH THEORY: A THEORY OF WEALTH AND POVERTY[1]

Professor LIM Chong Yah
Emeritus Professor of Economics, Nanyang Technological University
Emeritus Professor of Economics, National University of Singapore

Abstract

A presentation of the Trinity Growth Theory, decomposed into its three parts, is made: the EGOIN Theory, the Triple C Theory and the S Curve Theory. Professor Lim Chong Yah uses the Trinity Growth Theory to explain why growth levels and why growth rates differ among nations, why these two important world economic phenomena also exist among different provinces and cities within a nation, and why the world economy, viewed against world economic history, has grown so unprecedentedly in the last 60 years after World War II.

Keywords: Growth theory

JEL Classification: O40

[1] Keynote Address presented at the 13th International Convention of the East Asian Economic Association (EAEA) on 19th October 2012 at the Grand Copthorne Waterfront Hotel, Singapore.

FIVE FUNCTIONS

The Trinity Growth Theory has two basic functions: one, to explain why growth levels differ among nations, and two, to explain why growth rates differ among nations. Three additional important corollary functions of the theory will be added: one, to explain why growth levels and growth rates are different among provinces and cities within a nation; two, why growth rates differ over time within a nation; and three, taking the world as a whole, why growth levels and growth rates differ inter-temporally. These five phenomena are central to the study and understanding of growth and development economics. Another way of putting the five functions is: why do growth levels and growth rates differ and differ so much between and among different economic entities over space and over time? Is there a formula or theory for the explanation? Economic entities here refer to nation states, provinces and cities within a nation and the world economy as an entity. Differences in achievements of companies or firms, though important to know, are outside the purview of this research and inquiry.

THREE PARTS

The Trinity Growth Theory has three parts: Part I, the EGOIN Theory; Part II, the Triple C Theory; and Part III, the S Curve Theory. The commonality of the three parts is the EGOIN.

EGOIN THEORY

My half-a-century old research and study concludes that growth levels differ because their ΣEGOINs differ and growth rates differ because their ΔEGOINs differ. But what is EGOIN? It is a composite concept for total factor input. It is the quantity and quality of this total factor

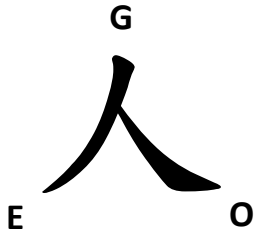
input that determines the level of output or GDP. The higher the EGOIN, the higher the output, and vice versa. From total factor input, one gets total factor input productivity, which is the input side of the equation for total output or GDP. One must expect ΣEGOIN to be several times higher, maybe 2 to 5 times higher than the output, GDP, as the corresponding narrower concept of incremental capital-output ratio (ICOR) shows.

EGOIN COMPONENTS

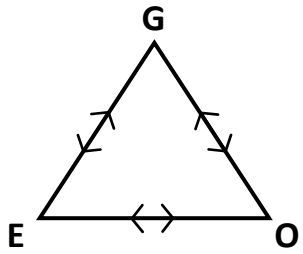
EGOIN may be decomposed into five parts. E stands for entrepreneurship, G for government, O for ordinary labour, I for investment in physical capital and N investment in natural capital. O denotes ordinary labour, E and G special labour. Together, they constitute the neo-labour theory of value. E, G, and O constitute total human capital, I physical capital and N, natural capital. Together, EGOIN may also be called total economic capital, and reflects the economic capability of a nation.

E, G, AND O AS CO-DETERMINANTS

The three human components of EGO may be expressed with a Chinese word 人, meaning human, thus:



Note that G is the head, and E is the left-hand entrepreneurship and O the right-hand ordinary labour. Without G, the economy or country becomes a headless chicken. It will initially dance round and round and soon collapse. Similarly, without E and O, the head (G) has no body, no framework. It can neither walk nor run, far less lay eggs. The three E, G, O are integral social partners. They constitute the whole of the human society, though the parts each play differ and may differ widely. Their symbiosis, in totally different degrees in different economic entities, is there. The three parts and their relationship can also be presented in a triangle diagram, thus:



Together, the three social partners form the economic pyramid. Removal of any one pillar, the economic pyramid collapses. Because of the importance of all the three human determinants, the EGOIN may also be termed the human theory of development and underdevelopment, or the human theory of wealth and poverty. The assumption is that the economy is man-made. Man forms the core in the EGOIN Theory. The aptitude and attitude of man constitutes the core of the EGOIN Theory. In parts, it would be the aptitude and attitude of the government (G), and the skills and orientation of the people (E and O).

The apex of G is the critical political leadership. The body is the often omnipotent accompanying and supportive bureaucracy or Civil Service. Together, they produce public goods and services, normally mainly or wholly services, such as the all-important public law and order,

judicial services, defence, and external relations. They also formulate and implement economic policies, including monetary and fiscal policy. They might even run and manage economic and social agencies. G, in short, may be referred to as public governance. In my book *Development and Underdevelopment* (1991), I tried to differentiate between good G and bad G:

> *"What is a good G? The first best scenario is that it must be competent, it must be frugal, it must be humane, it must be trustworthy and above all, it must put public interest above self-interest. In short, in the economic sphere, it must promote the development and E, O, I and N; a conducive environment for investment and development. This is particularly important for low-income countries. Conversely, a bad G is inept, spendthrift, corrupt, inhumane and promotes neither E and O nor I and N. Colonial regimes tended to promote I and N, but not E and O. Ancient potentates tended to promote their own self-preservation and seek their own self-glorification. The remains of their activities today, such as the still imposing forts and palaces of Maharajahs in Rajistan, the Ming Tombs and the Summer Palace in Beijing and the Pyramids in Egypt are but several examples of their undoubted achievements in self-preservation and self-glorification."*

The short-term for E is employer, or entrepreneur. Employer normally owns the firm and brings the factors of production together. His (or her) functions include organization, co-ordination and management. Many employers are also entrepreneurs. Any of the following four functions or innovations would describe entrepreneurship adequately: (1) discovering a

new market for the product or service, (2) discovering a new and cheaper factor of production or material input, (3) producing a new product or service, and (4) reorganizing or re-arranging of factors of production to reduce costs. Inventions per se are not entrepreneurship, unless they are put to commercial use. And entrepreneurship, as Joseph Schumpeter (1934) pointed out, can come from different ethnic, class or academic disciplines, and I would add probably more so from the modern hard sciences, particularly engineering, and social sciences, including law, accountancy and economics. To me, entrepreneurs are shinning stars in the economic firmament. They are the starting point in the EGOIN.

Labour or ordinary labour is normally used as a denominator for measuring productivity with the use of real GDP as the numerator. This measurement is labour productivity, not total factor input productivity, which should include the important and indispensible contributions by government (G) and employers (E). Differences in labour productivity are often shown as differences in the talent pyramid, which is often used to reflect the educational pyramid of a country.

I AND N AS CO-DETERMINANTS

Though economies are built by man, but man's ability to build an economy is a function of its accumulated capital investment (I), or more precisely ΣI, which refers to existing physical infrastructure such as roads, bridges, mass rapid transit, airports and airplanes, seaports and ships, dams and irrigation facilities, schools, polytechnics, universities, and other institutions of learning, hospitals and other healthcare centres, factories and shops, and not to forget, computers, mobile phones and tablets. Indeed, when one visits a developed country, one is

struck by the better development of its physical capital (ΣI), or infrastructure, and vice versa. Similarly, when the growth rate of a country is high, inevitably its additional investment (ΔI) is high. The following growth formula, of the Harrod-Domar Model variety, has validity.

$$\frac{\Delta Y}{Y} = \frac{S}{Y} \cdot \frac{\Delta Y}{I}$$

where $\frac{\Delta Y}{Y}$ refers to the rate of growth, $\frac{S}{Y}$ refers to the rate of savings, and $\frac{\Delta Y}{I}$ the inverse of the capital-output ratio or the productivity of capital. Here *S* is assumed to be the same as *I*, so the higher is $\frac{S}{Y}$ or $\frac{I}{Y}$, the higher is the growth rate, given the ICOR, $\frac{I}{\Delta Y}$.

To complete the EGOIN, we must bring in the N factor, the natural resources or natural capital. Here, we refer to utilized N. Unutilized N remains unutilized, and does not contribute to GDP growth level and growth rate. Natural resources normally refer to wasting assets like fossil oil, gold, tin, coal, iron-ore and diamond mines, and non-wasting or renewable natural resources like palm oil, rubber, sugar, wheat, rice, soya beans, corn, etc. However, we must also include location as a natural resource. Locational advantages like proximity to a river mouth or the cross-roads of shipping routes also confer certain advantages to the economic centres concerned.

In assessing the EGOIN of a centre, we cannot as a rule assign equal weightage to each of the five co-determinants, as they can be different across centres and over time. N is quite obvious. Natural resource endowment varies among centres. They can also vary over time in the same centre. New oil fields may be discovered or old gold mines have exhausted their gold. Similarly, one locational advantage emerges because of changes in trade routes such as the

building of the Suez Canal or Panama Canal. Similarly, the O factor plays a much more important role in a centre after enormous investment in human capital than before when illiteracy was rampant. Changes in the G factor through changes in policy options can play a critical role in GDP growth rates, such as after Deng Xiaopeng's opening up of China and the decades before it under Chairman Mao, or decades before Chairman Mao when G in China went on an unending downward tailspin.

EGOIN AND CAUSALITY

In short, to restate, growth levels differ because ΣEGOIN differ. Growth rates differ because ΔEGOIN differ. Note that Government (G) is an integral part of the EGOIN Theory, so is natural resource (N).

Among nations the quality of G can differ enormously. But within a nation, when comparisons are made among different provinces and cities, the role of a common G is also there in addition to the provincial G or city G, and these may differ in aptitude and attitude. With a common national G, the differences among centres within a nation may be thus attributed to differences in E, O, I, N and provincial G or city G, or more commonly, different combinations of the five variables. The commonness of such well-developed cities beginning with the letter S such as Singapore, Shanghai, Sydney, San Francisco, Stockholm and Santiago, has much to do with their locational advantages as initial and present seaports, rather than because of the common S letter beginning in the English language. Coincidental commonness is not common causality, as in ΣEGOIN or ΔEGOIN.

EGOIN is a multi-causal theory, not a uni-causal one. Though the contributions of different determinants differ from centre to centre and from time to time, none can claim to be the only determinant.

Is there technology in the EGOIN Theory? Yes, of course. The all-important technology is embodied not just in O, but also in E, G, I and N; technology is frozen with past physical investment (ΣI) though. E, G and O, it should be noted, are active agents, whereas I and N are passive agents. Of the five co-determinants, the volatility of G is the most notable, as compared with E and O. The volatility of G often accounts for short-term and even long-term changes in the GDP and employment level. As for O, the Chinese have a saying “十年树木，百年树人” serves to drive home this point of relative stability of O very well. The Chinese proverb claims that it takes 10 years to grow trees, but 100 years to nurture a generation of well-educated man. In other words, the attributes of factor O (and E too) are much more stable than the co-determinant G. It is the relative stability of O and E that constitutes enormously to the stability in growth levels and growth rates in economic entities. But when G changes drastically, it may have its important impact on I (investment) and maybe on O (migration) and N (operation) as well. The chain reaction, both positive and negative, may be there and should not be ignored.

EGO may be construed as a theory of motivation. But this paper deals with the wherewithal of wealth creation, rather than the motivation or the will to progress, which is assumed to be there in G, E and O, particularly following the huge investment in human capital after the World War II in the form of mass education. When we speak of the aptitude and

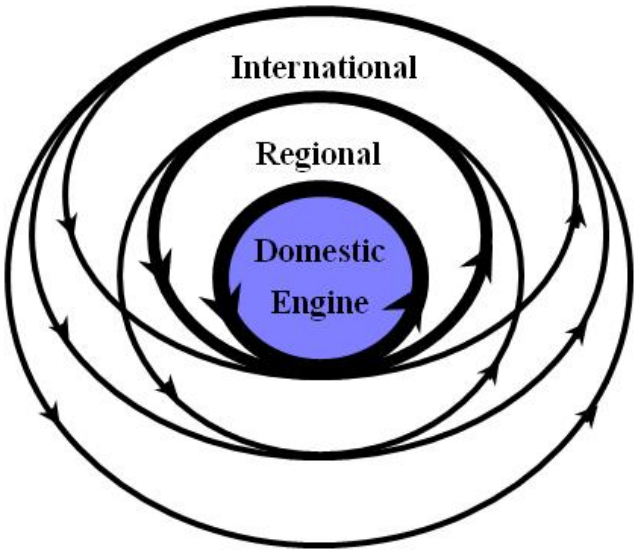
attitude of E, G, and O, we imply differences in the collective will to progress in different economic entities over space and over time.

TRIPLE C THEORY

The EGOIN Theory thus far presented does not emphasize enough on the increasingly globalized nature of the world economy. Different nations in varying degrees are connected through transportation and communication links, through trade, visible and invisible trade, capital flow, short-term and long-term capital flow like FDI, and the rather invisible but crucial and critical flow of knowledge, especially technological and institutional knowledge. The following diagram shows the linkages: linkages within the nation, regional linkages, and global linkages among nations. Thus, as the diagram shows, a national economy is run by three engines: the domestic engine (the EGOIN), the regional engine and the global engine, which is the sum of all national EGOINs: ΣΣEGOINs.

Triple C means circular cumulative causation. The circular cumulative causation factor can operate over space and over time. The initial stimulus or investment can spread from the original centre to the other centres and vice versa. It can also spread over a time period through the combined multiplier and accelerator process.

Diagram 1: The Triple C Theory (The C Factor)



When East Asia had an exchange rate crisis in 1997-98, it witnessed the negative or reverse working of the regional engine. When East Asia went into a crisis in 2008, it saw the negative or reverse operation of the global engine. When Sri Lanka, Myanmar and North Korea experienced stagnation in their economy in recent decades, it was essentially the malfunctioning of the domestic engine (EGOIN). The positive global and regional growth engines just passed them by, and still passed it by in the case of North Korea.

Thus, we may say that the higher the ΣC (cumulative connectivity factor), *ceteris paribus*, the higher is the growth level; and the higher is ΔC, the higher is the growth rate of an economic entity. Alternatively, one may explain such differences by their differences in their EGOIN and their connectivity, ΣC for levels and ΔC for rates.

S CURVE THEORY

The S Curve Theory divides the world's numerous national economies into three very broad entities. Well-known and much adored and much-loved three animals are used as separate identities. They are turtles, for the lowest income group; horses, for the rising income group, and elephants for the highest income group. My research shows that the turtle economies have poor ΣEGOINs, consequently, they are economically poor. They also have poor ΔEGOINs, consequently, they have low growth rates. If both levels and rates are persistently poor, they are in the low-level equilibrium trap.

The horse economies exhibits high growth rates, because they have higher ΔEGOINs and one may add, high Δ connectivity or ΔC factor.

The elephant economies have high growth levels but slow growth rates. They have, in other words, high ΣEGOINs and high ΣC factor but low ΔEGOINs and low ΔC factor. Examples of such economies are the USA, the European Union and in Asia, Japan. If those economies have persistent low ΔEGOINs and low ΔC factor, they are in the high-level equilibrium trap.

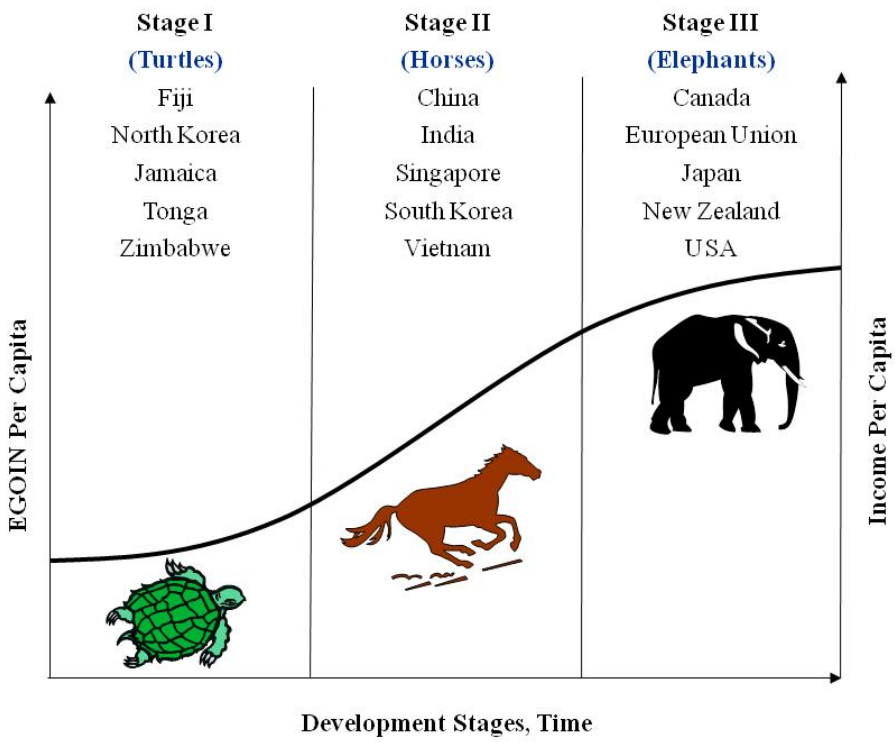
Table 1 shows the detailed salient features of the three types of economy by their EGOIN level. The stages of industrialization is one of the common delineating features with turtles classified as pre-industrial economies, horses industrializing economies and elephants, post-industrial economy. Another common delineating feature is the rate of capital formation (ΔI) with horses displaying high ΔI, and elephants and turtles low ΔI. Diagram 2 shows the S Curve in a graphical form. There is much more development potential, both in physical and

human capital development, in the horse (and turtle) economies than in the elephant economies.

Table 1: Differences in Characteristics

Turtles	**Horses**	**Elephants**
Low growth rates	**High growth rates**	**Low growth rates**
Low consumption society	Medium consumption society	High consumption society
High population growth rate	Transition population growth	Low population growth rate
Low savings and investment rates	**High savings and investment rates**	**Low savings and investment rates**
Pre-industrial	**Industrializing**	**Post-industrial**
Low knowledge-based	Advancing knowledge-based	High knowledge-based
Low ΣEGOIN	Medium ΣEGOIN	High ΣEGOIN
Low ΔEGOIN	High ΔEGOIN	Low ΔEGOIN
Low ΣTC	Medium ΣTC	High ΣTC
Low ΔTC	High ΔTC	Low ΔTC

Diagram 2: S Curve Theory



A word of caution: although only three animals are used in the metamorphosis process, it does not mean overnight or over a year or two, the economy changes from a turtle to a horse or a horse to an elephant, as a caterpillar suddenly changes into a butterfly. The transition process is not normally abrupt. It is normally a slower, less perceptible process. Normally, if there is a collapse of a government and no viable government succeeds, the horse economy can slide down or take a U-turn. The rider (G) may fall from the horse. The new rider may, however, gallop the horse to its former speed. Thus, of the EGOIN co-determinants, G as stated earlier, can be the most volatile, and in specific locations, one cannot rule out N in volatility either. Normally, however, the EGOIN of a nation or a province or a city is quite stable, in a

descending order of stability from the globe, the nation, the province or the city. There is the averaging process to be considered.

The S Curve is not an iron-law. It is only a tendency. And different economies have different S Curves, but we maintain that increasing returns to scale and increasing externalities (horse economies) are followed by decreasing returns and declining externalities (elephant economies). Why turtles remain as turtles is in fact a theory of poverty or underdevelopment, and why economies metamorphose to become horses is a theory of affluence. Why horses converge with elephants is a theory of convergence. Why horses diverge from turtles is a theory of divergence.

PREDICTIVE VALUE

A theory should have three values: (1) diagnostic value, (2) prescriptive value and (3) predictive value. A predictive value often precedes a prescriptive value.

In our Trinity Growth Theory diagnosis, we not only have a prominent existence of horse economies but also the continued expansion of this group in the post-World War II world. In Asia, it started with the galloping growth rates of Japan in the 1950s, 1960s and 1970s, followed closely by the quartet horse economies of South Korea, Taiwan, Hong Kong and Singapore, and then by the other newly emerging horse economies, in random order, of China, India, Malaysia, Thailand, Indonesia, Vietnam and others. What is the causality? The Trinity Growth Theory attributes this to the ascendency of their EGOIN and the rise in their C factor. But if one factor in their EGOINs that stands out above others in the long-run perspective, it must be the

common rise in the O factor, the talent pyramid. Never in the history of the developing world had there been so much investing in human capital than after World War II, following the desire of these nations to catch up with the West, and to catch up with each other. The will to progress has been there, though the intensity varies from country to country.

Of course, improvement in corporate governance (E) and public governance (G) must have also contributed importantly to economic progress of the economic entities. It means the EGO has been uplifted over the years and over decades. The enormous advance in EGO has enabled more of I and N to take place, both quantitatively and qualitatively. The world too has become more globalized, which means in our terms, more and better connectivity (C). And the great contributions of E, G and O should be acknowledged. Similarly, public governance (G) in a globalized world should not overlook the enormous contributions to world development of post-WWII world institutions like the World Bank, IMF, ILO, WTO, and the United Nations, and in Asia, the Asian Development Bank.

Looking ahead, since O, and together with it E, is relatively stable and very likely to continue improving, one can expect a continuation of high growth rates in these Asian economies, except Japan, which has in the last two decades or so graduated to the elephant class.

But will the West and Japan continue to display slow growth rates in the foreseeable future? If we go by the Trinity Growth Theory, it will be because both ΔEGOIN and ΔC have found it difficult to have impressive growth rates. The eurozone scheme should be viewed as a serious attempt to break away from the high-level equilibrium trap but with disastrous

consequences. So, with the relative stability of the EGOIN and also the C factor, one should expect the elephant economies, found mainly in the West, to cruise along at the elephant speed of 1% to 4%, instead of the horse speed of 5% to 10%.

Singapore should be classified as an elephant economy if we use persistent very high per capita income as a yardstick. But if we use GDP growth rate as a criterion, then she should still be classified as a horse economy, having, for example, 6.4% average growth rate per annum for the last 10 years. She has been able to retain her high growth rates, as a prescriptive strategy, through the change in her ΔEGOIN, by attracting not just more foreign investment (ΔI) but more distinctively, importing more foreign labour (ΔO); the last factor is not the policy option followed by, say, Japan.

As for the turtles, my research shows that their numbers are decreasing by the decades, because of the rise in their ΔEGOIN and the ΔC factor. One must therefore expect their incidence of poverty to decline notably as they move into the horse camp, following the lead taken by the East Asian economies like Japan, South Korea, Taiwan, Hong Kong, Singapore, China, Malaysia, Thailand, Vietnam and Indonesia. The most prominent of the non-East Asian nation that is speeding up very rapidly in the last few decades or so is undoubtedly India.

If we go by the rapid rise in the EGOIN and the C factor in the horse economies, and the increasing tendency for more and more turtle economies to metamorphose into horse economies, including outside Asia, one should remain optimistic about world economic development, notwithstanding the current serious setbacks facing many developed elephant economies. But this prognosis is for the medium-term and long-term, which some of us, like the

writer, would not be able to see or know. But that does not need to dampen the optimism and sanguineness for the future, a future for the world without abject poverty, and that would be for the first time in the history of mankind. Hallelujah. Who says economics is a dismal science?

Angus Maddison (2007) pointed out with statistical evidence in "*Contours of the World Economy, 1-2030 AD"*, that the world economy has grown much more rapidly in the last 50 years after 1950 than in any other periods of human history.

CONCLUSION

Why do nations differ in growth levels? It is because, in my diagnosis, they differ in ΣEGOIN and in ΣC. Why do nations differ in growth rates? Because they differ in ΔEGOIN and in ΔC. Why do provinces and cities differ in growth levels and growth rates? Because they differ, in the extension of my diagnosis, in ΣEGOIN and in ΣC, and in ΔEGOIN and in ΔC respectively. Why do national growth rates change inter-temporally? Because the stages of development change over time, with low ΔEGOIN and low ΔC to begin with (turtle economies) and high ΔEGOIN and high ΔC at the horse stage and then decline in ΔEGOIN and ΔC at the elephant stage. What about the world economy? Taking the averaging process into consideration, my prognosis is that it would continue to grow at a respectable speed, because both ΣΣEGOIN and ΣΣC have shown sure signs of moving at respectable speeds, taking the world as a whole as in the past 60 years after WWII, though the centres of growth have shifted and diversified and will continue to shift and diversify, as is to be expected under The Trinity Growth Theory.

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國科會補助專題研究計畫出席國際學術會議心得報告

日期：2014 年 1 月 20 日

計畫編號	NSC 100－2410－H－004－075－MY2		
計畫名稱	氣候變遷對亞洲開發中國家之經濟衝擊：可計算一般均衡模型之應用分析		
出國人員姓名	李慧琳	服務機構及職稱	國立政治大學經濟學系副教授
會議時間	July 7 - 12, 2013	會議地點	Kita-Kyushu, Japan
會議名稱	21st International Input-Output Conference		
發表題目	Economy-Wide Impact Analysis of the Agricultural Extent Loss to Sea Level Rise: An Application of a Multi-regional Computable General Equilibrium Model		

一、參加會議經過

In this conference, I served as the chair of the session, topic of which was “CGE Modelling of Environmental Problems”, and in which I also presented my paper, titled as “Economy-Wide Impact Analysis of the Agricultural Extent Loss to Sea Level Rise: An Application of a Multi-regional Computable General Equilibrium Model”. In addition to the conference, I also participated in the International School of IO Analysis (ISIOA), which was organized by the IIOA as a whole-day workshop on the Input-Output Analysis, prior to the conference. Topics of the ISIOA included: (a) Updating Supply, Use and Input–Output Tables, (b) The GTAP Data Base and Contributing I-O Tables to the GTAP Data Base, (c) Environmental Input-Output Analysis, (d) Applied CGE modelling, and (e) Learning to use REAL I-O for regional and global analyses.

二、與會心得

The keynote speech of the conference was delivered by Prof. Richard E. Baldwin, Graduate Institute of International and Development Studies, Geneva, Switzerland. The topic of Prof. Baldwin's lecture is "Mis-thinking Globalization", in which he used *Factory Asia* as a typical example. The presentation "looked at the underlying interconnected processes that drove Factory Asia's development from the mid-1980s. There are two complementary trends: fractionalization of the manufacturing process into stages, and the dispersion of these stages around Asia. The speaker introduced the TOSP (tasks, occupations, stages, products) framework. The TOSP framework views the production of goods as the performance of a range of tasks that are organized into occupations (collection of tasks) and stages (collections of occupations). Geography is an important determinant of the ease of participating in Factory Asia." This keynote speech complements well with the prevailing global value chain research.

The themes of this year's IIOA conference that really interested me included: (a) Special Session on Disaster Analysis, (b) Special Session on Scenario Analysis and 21st Century Sustainability, (c) Special Session on Interregional Input-Output Analysis in China, (d) IDE Special Session on Global Value Chains, and (e) Key Sectors and Network Analysis. It was very helpful for me to attend these sessions and to get the up-to-date development in these fields. These interesting presentations later attracted me to direct my research interest towards policy assessment with both IOA and CGE on the inter-regional dimension.

三、發表論文全文或摘要

Climate change affects regional agricultural production and food security in complex ways. In this study we used a better and more realistic approach that recognizes agro-ecological dissimilarities in land characteristics for agricultural purposes in a multi-regional, multi-sectoral computable general equilibrium model (the GTAP-AEZ model) and apply such model to investigate the implications for agricultural production of regionally diverse impact

of climate change induced sea level rise, as estimated by Dasgupta et al. (2009). By considering crop suitability of land and region-differentiated agricultural extent loss to sea level rise, the framework of our economy-wide impact study in this paper hopes to provide a new perspective for the global concern on socio-economic consequences of climate change. Our study provides an integrated economic assessment on rice in the global and regional context. Among Asian countries, Viet Nam is likely to be hit hard due to agricultural extent loss to sea level rise, as its cultivating zones of paddy rice such as the Mekong Delta are prone to inundation once the sea level rises. This affects countries near and far that depend on Vietnamese rice exports. Countries of this category include Malaysia and Singapore, The Philippines, Middle East, North Africa, and Caribbean and Central America. Luckily, Thai rice would be able to supplement to reduce partially the shortfall due to the retreat of Vietnamese rice exports. In addition, the wheat sector would also be adversely affected, though not directly, in the Asian rice-growing countries. The Asian rice sector would draw more land away from wheat and other crops sectors due to land competition from a steadfast demand for the staple rice crop. Wheat- and grains-growing countries such as North America, EU, Russia, Australia and New Zealand, and Argentina thus reap the benefit of improved terms of trade in the occasion of sea level rise infliction on the Asian rice-growing regions. Although rice is relatively less traded across borders, agricultural land claimed by sea level rise, especially in lower-latitude Asian developing countries, would widen the gap between rice supply and demand of the rice-consuming countries. This suggests an urgent need for establishing safety nets of food security in Asia. Particularly for agriculture of developing countries, sufficient efforts are also needed, in addition to poverty elimination, to brace for and to adapt to climate change, so as to secure their productivity and capacity of food supply.

四、建議

Quite some statisticians from OECD countries attended this IIOA meeting, and they also actively participated in the advancement of the compilation methodology of the IO accounts as well as policy

analyses with the IOA model. It will be good that our government statisticians in charge of compiling the IO accounts also attend this sort of international conferences so as to get connected with the international research and statistics communities and to get updated with current development in the field.

五、攜回資料名稱及內容

Material brought back from the conference was the Conference Booklet. Proceedings of the conference are available electronically from the IIOA website.

國科會補助專題研究計畫出席國際學術會議心得報告

日期：2014 年 1 月 20 日

計畫編號	NSC 100－2410－H－004－075－MY2		
計畫名稱	氣候變遷對亞洲開發中國家之經濟衝擊：可計算一般均衡模型之應用分析		
出國人員姓名	李慧琳	服務機構及職稱	國立政治大學經濟學系副教授
會議時間	Sept 29 – Oct. 2, 2013	會議地點	Noordwijkerhout, The Netherlands
會議名稱	First International Conference on Global Food Security		
發表題目	1. (Oral presentation) Grain self –sufficiency policy shift in China posing a real challenge to global food security: A multi-regional economy-wide impact assessment with the GTAP model 2. (Poster presentation) Will sea level rise threaten food security in Asia?: A multi-regional economy-wide assessment with the GTAP model		

一、參加會議經過

In this conference, I presented two papers, one in oral and the other in poster, titles of which are as stated above. My oral presentation was scheduled into the session of “Global and local analyses of food security” on the first day of the conference program. A snapshot of the poster presentation can be found at the end of this document.

In addition to the plenary sessions of keynote speeches, the conference also covered the following topics of parallel sessions:

(a) Global and local analyses of food security,

(b) Enabling policies for local and global food security,

(c) Sustainable intensification of food production systems,
(d) Novel ways of feeding 9 billion,
(e) Learning from the past to understand the future,
(f) Land sparing, land sharing and trade-offs,
(g) Agricultural production as feedstock for renewables,
(h) Lost harvest and wasted food,
(i) Nutritional security, and
(j) Labelling, certifying and striving for quality and sustainability of food production.

As the major organizer of the conference was the Elsevier Publishing Co., an author workshop was arranged to introduce about scientific publishing, as well as the dos and don'ts in scientific research publication as Elservier advised. Ag. industries like Monsanto, Unilever, Fertilizer Europe also set up exhibitions at this conference.

二、與會心得

This interdisciplinary conference on global food security invited state-of-the-art analysis, inspiring visions and innovative research methods arising from research. I learned a lot from this conference. Food security involves economic, social, biophysical, technological and institutional aspects simultaneously. It is an issue that is affecting the current generation and will also run into the future, with all countries' food policies affecting each other due to the highly globalization in agricultural trade. The conference was nicely arranged with a balanced composition of disciplines that addressed food production and access, and the trade-offs between competing environmental, economic or social objectives and outcomes.

The keynote speakers included (a) Prof. Chris Barrett from Cornell University, USA, on "the global food security challenge: Constraints, consequences and opportunities ahead"; (b) Prof. Louise Fresco from University of Amsterdam, The Netherlands, on "where we stand in understanding global food security".

The AgMIP (Agricultural Model Intercomparison and Improvement Project) teams also made presentations at this conference. AgMIP is an international effort to link the dimensions of climate, crop, and economic modeling with cutting-edge information

technology to produce improved crop and economic modeling and the next generation of climate impact projections for the agricultural sector (Rosenzweigh et al., 2012). The AgMIP aims to improve the characterization of world food security due to climate change and to enhance adaptation capacity in both developing and developed countries. AgMIP involves multiple disciplines and conducts trans-disciplinary analyses on the agricultural impacts of climate variability and change for which climate scenarios and agronomic and economic models are bundled for the purposes of a holistic analysis on the food security issue.

It was very helpful for me to attend the conference and to get the up-to-date development in these fields. These interesting presentations later attracted me to direct my research interest towards food security policy assessment with CGE on the adaptation dimension.

三、發表論文全文或摘要

1st paper:

Current studies on China's food security are mainly based on the perspective of grain self-sufficiency that discusses whether China's grain production and grain stock system can feed itself at the national level. As a result, the Chinese grain self-sufficiency policy of keeping a self-sufficiency rate above 95% tends to be regarded as a benchmark to evaluate China's food security status. For the world, this remarkably high rate of self-sufficiency in China has also helped significantly maintain the global food security. As consistently attained with the Chinese government's good efforts since the 1980s, this 95% grain self-sufficiency rate target therefore has been perceived as untouched and presumed to be adhered to in the future, like in the past.

However, according to the World Bank's projection for China's grain demand by 2020, the total requirement to feed China will be 607.9 million tons, increasing from 502 million tons in 2010. As the Chinese grain production is projected to be as much as 568 million tons by 2020, the self-sufficiency rate will be reduced slightly to 93%. Another projection by the United States Department of Agriculture also presents a similar prospect which forecast an even lower rate of

89% in China's grain self-sufficiency by 2020. Reasons for such a lower grain self-sufficiency rate in China could be attributed to its accelerated industrialization and urbanization which both damage and compete away cropland at a rate of 2% per annum.

Seeing the increasing food demand and shrinking cropland due to its rapid economic development and urbanization, China is currently changing its food policy by taking advantage of global agricultural trade liberalization to import foreign farm products on the one hand, and actively acquiring farmland overseas on the other hand, so as to bolster its food security. The International Food Policy Research Institute (IFPRI), a think-tank in Washington, DC, points out that between 2006 and 2009 China purchased up to 2.8 million hectares of farmland from poor countries in Africa, the Middle East, Eastern Europe, and South America. Such size of the grabbed foreign farmland is unprecedentedly large, as compared with other counties' purchase packages. Putting a conservative figure for the land value, IFPRI calculated these Chinese deals to be worth 3.7 - 4.2 billion—almost as much as the biggest ever emergency package for agriculture announced in 2009 by the World Bank, and 1.5 times more than the American administration's annual fund for food security in 2009. The targets for China's overseas land grabbing after the 2008 financial crisis have been further extended to developed countries, such as Australia, New Zealand, Canada, and even the United States.

This practice of importing more food from the Chinese acquired farmland abroad will eventually shake China's long-standing norm of the 95% grain self-sufficiency rate. In response to this developing and ongoing story of China's policy shift in grain self-sufficiency, this paper aims to assess the global food security challenge resulting from China's adjustment in the grain self-sufficiency policy. We use a multi-regional computable general equilibrium (CGE) model—the GTAP model, which describes in detail the global food supply/demand system, inter-linked with other sectors of the world economies—to simulate for global food security prospects against the backdrop of various scenarios of undertakings for China's grain self-sufficiency prospects. The simulation results indicate that while China is inclined to relax its long-standing adherence to the high self-sufficiency rate through trade, the global food security would be

burdened with spiked prices—with the developing and least developed countries particularly bearing heavily the brunt of such elevated food costs. Our study also provides an in-depth multi-sectoral economic assessment on the consequences of the various Chinese food security scenarios. Such understanding would be desirable and informative for formulating effective strategies to cope with the possible challenges posed to global food security. Adaptation strategies are also assessed for countries whose food security are affected by a more foreign food dependent China.

2nd paper:

Climate change affects agricultural production and food security in complex ways. In this study we use a multi-regional, multi-sectoral computable general equilibrium model (GTAP as described in Hertel (1997)) and a satellite land use database compiled by Lee et al. (2009) to address the agro-ecological dissimilarities in land characteristics for agricultural production in a global and open economy context. Assuming one-meter sea level rise induced by climate change, information of which is taken from the World Bank estimates (Dasgupta et al., 2011), we investigate its regionally diverse impacts on the production of major land-based staples. Our results suggest that food security impact inflicted by sea level rise should be responded from policy agenda for both developing and developed countries, in particular, for net food importing developing economies. Insights derived from our simulation results are summarized as follows. Among Asian countries, Viet Nam is most significantly affected country due to agricultural extent loss to sea level rise, as its major paddy rice is cultivated in the Mekong Delta flood zone. This affects countries near and far that depend on Vietnamese rice exports including Malaysia, Singapore, the Philippines, as well as countries in Middle East, North Africa, and Caribbean and Central America. Thai rice would only be able to supplement partially the shortfall due to the retreat of Vietnamese rice exports. The wheat sector in the Asian rice-growing countries would also be adversely affected, though not directly, due to land competition from the domestic demand to secure rice crop. Wheat- and grains-growing countries such as North America, EU, Russia, Australia and New Zealand, and Argentina thus

reap the benefit of improved terms of trade in the occasion of sea level rise infliction on the Asian rice-growing regions. Although rice is relatively less traded across borders, agricultural land claimed by sea level rise, especially in lower-latitude Asian developing countries, would widen the gap between rice supply and demand of the rice-consuming countries. This suggests an urgent need for establishing safety nets of food security in Asia. Particularly for agriculture of developing countries, sufficient efforts are also needed, in addition to poverty elimination, to brace for and to adapt to climate change, so as to secure their productivity and capacity of domestic food supply

四、建議

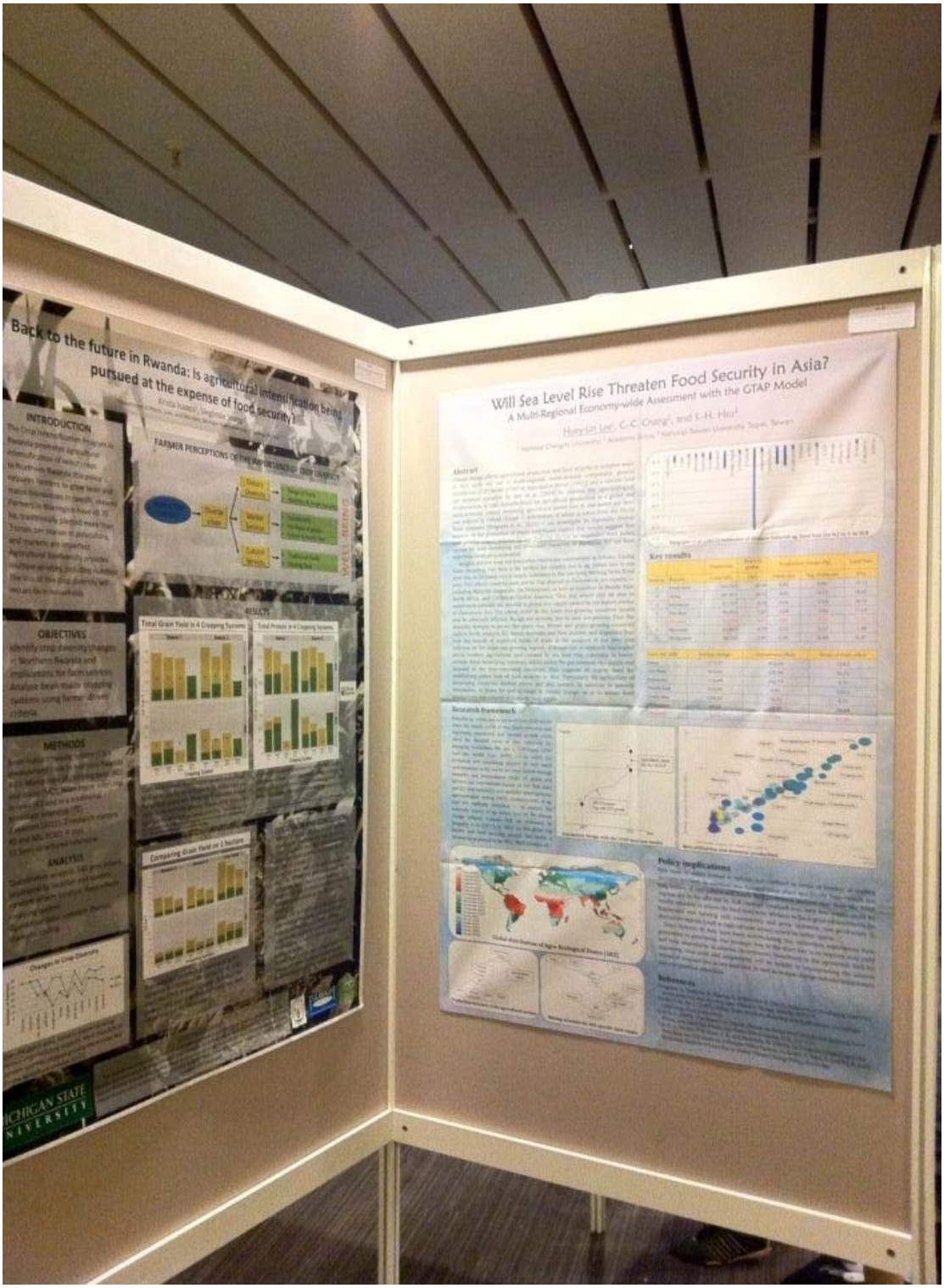
This is a very organized conference, involving a variety of disciplines of agriculture, ranging from soil sciences, agronomy, ag. chemistry, ag. business and economics, and governance, and even sociology regarding rights to food. This conference fostered a good inter-disciplinary platform for researchers and experts to interact and brainstorm on the issues food security from each discipline's perspectives. It would be good that in Taiwan we can have such like platform for researchers of all agriculture-related disciplines for meetings and communication over the food security and other agriculture-based issues.

五、攜回資料名稱及內容

Material brought back from the conference was the Conference Booklet. Proceedings and agenda of the conference are available electronically from the Elsevier conference website: http://www.globalfoodsecurityconference.com/ .

六、其他

Here is a snapshot of the poster I presented at this conference.



國科會補助計畫衍生研發成果推廣資料表

日期:2014/03/24

國科會補助計畫	計畫名稱: 氣候變遷對亞洲開發中國家之經濟衝擊：可計算一般均衡模型之應用分析
	計畫主持人: 李慧琳
	計畫編號: 100-2410-H-004-075-MY2　　學門領域: 農業與自然資源經濟學

無研發成果推廣資料

100 年度專題研究計畫研究成果彙整表

計畫主持人：李慧琳	計畫編號：100-2410-H-004-075-MY2
計畫名稱：氣候變遷對亞洲開發中國家之經濟衝擊：可計算一般均衡模型之應用分析	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	2	2	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	1	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	2	2	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	無。

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

科技部補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：□已發表 ■未發表之文稿 □撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：(以 100 字為限)

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）(以 500 字為限)

In this study we used a better and more realistic approach that recognizes agro-ecological dissimilarities in land characteristics for agricultural purposes in a multi-regional, multi-sectoral computable general equilibrium model and apply such model to investigate the possible consequences of China's relaxation on its efforts in sustaining grain self-sufficiency and how this would imply for the world, particularly for countries that are competing food imports with China. We focus particularly on rice, the most importance of staple crop in China and the Asian developing countries that could possibly be affected by China's reduced self-sufficiency.

Our results find that even for the least traded rice, China's policy shift can have far reaching effect, passing through the spatial dimension with countries competing for same source of export supply, as well as the sectoral dimension with land-based sectors competing for land resource. If policy efforts cease to further advance crop yield for counteracting the climate impact, China's demand increase for imported rice would end up aggravating food insecurity in Indonesia, Malaysia, The Philippines, Middle East, and North Africa by driving up both domestic and global prices of all the food staples: rice, wheat, and coarse grains. On the other hand, wheat-producing EU, North America, Australia, which are also exporting

countries would gain, as wheat and coarse grains lose in the land competition in the affected Asian rice-consuming and -importing countries. Based on our analysis, it is important for China to sustain policy efforts for advancement of crop yield, for the sake of global food security, especially in a highly probable scenario of climate change which the world is projected to incur.