Supply and Demand Analysis for Rice in Peninsular Malaysia
- With special reference to direct seeding in the Muda Area -

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Abstract

Malaysian economy has grown remarkably, and the rice sector has drastically changed. In order to forecast the future direction of the rate of self-sufficiency in rice, we analyzed the factors that affect the supply and demand by constructing an econometric model. The results showed that the wage rate and per capita income are the key factors that exert strong negative effects on the planted area and demand, and that the direct seeding method introduced in the 1980s exerts a slightly negative effect on the yield. The simulation performed until the year 2003 year indicates that the self-sufficiency rate will decline to 55%, assuming the growth rate of GDP and population are 8% and 2.5%, respectively.

Additional key words : rice, self-sufficiency rate, supply, demand, direct seeding, econometric model, simulation, Muda Area

Introduction

The rice policy in Malaysia can be divided into the following three phases: 1) after independence up to the introduction of the New Economic Plan (NEP) in 1971; 2) rice policy under the NEP up to the enactment of the National Agricultural Policy (NAP) in 1984; and 3) rice policy under the NAP up to the present [1, 2]. In the first phase, single cropping under rainfed conditions was prevalent in all the rice growing areas. In the second phase, double cropping was widely adopted by farmers who cultivated improved varieties in well-irrigated paddy fields. Yields have steadily increased from the early 1970s and a relatively high level of self-sufficiency was achieved [8]. During the third phase, most farmers substituted transplanting for direct seeding [3]. This change is noticeable in certain rural areas where the wage rate had increased due to the shortage of labor associated with the rural-urban migration of youth [7].

The latest statistics published by the Department of Agriculture show that the country's total area planted to paddy in Peninsular Malaysia was 440,000 ha for the first (dry season) and second (wet season) crops combined, with a production of about 1.0 million tons of rough rice. The Muda plain under MADA's jurisdiction accounts for 40% of the total in terms of area planted and 60-70% in terms of rough rice production. As of the early 1990s, the area of paddy fields under direct seeding culture in the plain reached 82% for the first crop and 76% for the second crop.

Needless to say rice has played an essential role in the enhancement of the economic status of Malay farmers and in providing staple food for the people. However, various reports indicate that the rice sector accounts for a minor part of the national economy due to the rapid pace of economic growth and changes in the industrial structure since the oil crisis in 1979. The rate of self-sufficiency in rice is declining, while areas where rice cultivation is being discontinued are gradually increasing. As a whole, it appears that Malaysian agriculture, especially the rice sector has faced similar problems to those encountered by most of the developed countries in their development process[6]. Therefore, the trend of the Malaysian rice sector is considered to be a barometer to forecast the trend of agriculture in other Asian countries with an economic growth as rapid as that experienced by Malaysia.

Objectives and Methods

Taking into account the drastic changes surrounding rice production since the 1960s this report attempts to assess the general trend of rice production in the Muda area and Peninsular Malaysia by using various sets of time-series data. Main objectives are to:

1) estimate the degree of demand for rice based on the demand function;
2) identify the relationship between the area harvested and other factors such as farm-gate price, price of fertilizer and wage rates, particularly for workers in the manufacturing sector;
3) evaluate the effects of prices of input materials and adoption of direct seeding technology on the changes of yield of rough rice; and
4) determine the trend of the area harvested under direct seeding culture by logistic functions.

For the econometric analysis, we collected various time series data from MADA in Alor Setar, Kedah, the Bureau of Malaysian Statistics (Jabatan Perangkaan Malaysia) and Department of Agriculture in Kuala Lumpur. Data and period used for the analysis are indicated in Table 1. Data were mainly analyzed by Ordinary Least Square (OLS) methods except for the logistic function which is used to estimate the ratio of the area under direct seeding.

Results and Discussion

1. Demand and supply relation of rice

1) Demand for rice

Rice consumption per capita tends to decrease along with the changes in eating habits. Recent study also indicates that rice in Asia tends to be an inferior good among other food commodities[5]. How about the demand situation for rice in Malaysia ?

For the estimation of the demand function, we calculated the (formal) consumption of rice per capita by dividing the gross amount of rice (Domestic production + (formal) Import - Export) by the population size. Therefore, this quantity does not include the amount of rice smuggled mainly from Thailand, whose record is not reliable though the latter may correspond to the world/domestic rice price ratio. Stock of rice was also not considered because estimates derived

Table 1. Variables and sources of data in Peninsular Malaysia, 1970-90.

Variable		sources or Calculation Formula
C	per capita consumption of rice (kg/person)	CT/N
CP	real retail price of rice [(cent/kg)/CPI]	Ministry of Agriculture
CPI	consumers' price index (1980=100)	Bureau of Malaysian Statistics
CT	total consumption of rice (t) (excluding informal import)	Q+IM-EX
D	dummy variables	after 1984=1, others=0
D78	〃	1978=1, others=0
D83	〃	1983=1, others=0
D84	〃	1984=1, others=0
DI, DI_{md}, DI_{mw}	direct seeding rate of rice (%)	MADA
GDP	index of per capita GDP (1970=100)	Bureau of Malaysian Statistics
IM	import of rice (rough rice) (t)	Ministry of Agriculture
M$	value of Malaysian currency (US$/M$)	Bank Negara Malaysia
N	population (1,000 persons)	Bureau of Malaysian Statistics
NGDP	per capita nominal GDP	GDP*CPI
NW	nominal wage in manufacturing sector (1,000M$/person)	Bureau of Malaysian Statistics
$PEDU_{md}$, $PEDU_{mw}$,	discharge from Pedu dam (mm) (converted to precipitation)	MADA
Q, Q_{md}, Q_{mw}	production of rice (rough rice) (t)	Ministry of Agriculture, MADA
$RAIN_{md}$, $RAIN_{mw}$	precipitation in Muda area (mm)	MADA
S, Smd, Smw	harvested rice area (mm)	MADA
SSR	self-sufficiency rate of rice (%)	Q/TC
T	trend variable (1971=1)	
TREXP	export price of Thai rice (US$/t)	Ministry of Agriculture
TRP	import price of Thai rice (M$/t)	TREXP/M$
W	real wage in manufacturing sector	NW/CPI
Y, Ymd, Ymw	yield of rice (ton/ha)	Q/S

note 1) Data from the Bureau of Malaysian Statistics are recorded in "Economic Statistics -Time Series" and "Year Book of Statistics (each year)".

2) Data from the Ministry of Agriculture are recorded in "Paddy Statistics (each year)".

3) Data in source column "MADA" were recorded by the MUDA Agricultural Development Agency.

4) Subscripts "m"=Muda area, "d"=dry season, "w"=wet season.

from the demand function indicate the general tendency of consumption in the long term. The amount of stock is consumed as food or feed in any case.

Demand function (Table 2-A) indicates the relationships between per capita formal consumption of rice (C_t) that is per capita consumption minus per capita informal import, and other three independent variables such as retail price (CP_t), per capita real gross domestic product (GDP_t) and world/domestic rice price ratio (TRP_t/CP_t).

Retail price was omitted from the equation because the coefficient was not statistically significant. The results show that the income elasticity of demand increased in the negative zone,

Table 2. Various equations derived for the simulation analysis.

	Dependent Variable	Independent Variables						R2	D.W.(or h)	period
A: Demand Function:		Constant	1/GDPt	In(TRPt/CPt)						
	1n Ct	5.572	68.788	0.204				0.69	2.36	1970-89
		(8.74)	(5.37)	(2.50)						
B: Area Function:		Constant	1nSt-1	In Wt	D84	D85				
Peninsular Malaysia	1n St	9.110	0.414	-0.291	-0.065	0.042		0.96	0.27*	1970-89
(dry+wet)		(5.94)	(4.08)	(-6.10)	(-2.69)	(1.67)				
C: Area Function:		Constant	1n St-1	1n Wt						
Muda(dry)	1n Smd, t	4.462	0.638	-0.067				0.94	-0.42*	1971-89
		(10.68)	(15.14)	(-1.20)						
D: Yield Function:		Constant	DIt	D*DIt	T	D78	D84			
Peninsular Malaysia	1n Yt	0.558	-0.004	0.002	0.020	-0.371	-0.183	0.91	2.17	1970-90
(dry+wet)		(31.76)	(-3.97)	(2.40)	(7.41)	(-10.55)	(-5.27)			
E: Yield Function:		Constant	DImd, t	D*DImd, t	T	D78	1n (RAINmd, t+PEDUmd,t)	0.99	1.60	1970-90
Muda(dry)	1n Ymd, t	-1.262	-0.0136	0.0091	0.0075	-5.951	0.358			
		(-1.28)	(-5.62)	(4.59)	(1.22)	(-66.46)	(2.65)			
F: Yield Function:		Constant	DImw, t	D*DImd, t	T	D83	1n(RAINmw, t+PEDUmw,t)			
Muda (Wet)	1n Ymw, t	0.148	-0.0037	0.0031	0.0080	-0.293	0.163	0.80	1.52	1970-90
		(0.27)	(-1.65)	(1.64)	(2.16)	(-3.81)	(2.15)			
G: Direct Seeding Function*:		Numerator	Denominaror							
Muda (dry)		Constant	exp(· *T)	T						
	DImd, t	94.64	7785	-0.624				0.94	2.01	1970-90
		(11.33)	(0.52)	(-4.26)						
H: Direct Seeding Function*:		Constant	exp(· *T)	T						
Muda (wet)	DImw, t	91.42	940	-0.437						
		(7.85)	(1.03)	(-5.55)				0.96	1.78	1970-90
I: Wage Rate Function:		Constant	1n NGDP							
Peninsular Malaysia:	1n NWt	0.656	0.917					0.99	1.72	1972-89
		(2.63)	(35.16)							

Note 1) When the lagged dependent variable is introduced in the dependent variables list, D.W. is replaced by the Durbins' h (equations B and C).

2) Direct seeding functions (equations G and H) are non-linear logistic forms represented as DI=a/(1+b*exp (*T)).

i.e. -0.29 in 1990, indicating that the consumption of rice per capita decreased by 0.29% when the income per capita increased by 1%. These results suggest that rice is an inferior commodity in Malaysia. In addition, formal consumption was estimated to decrease by 0.2% and to be replaced by informal import when the price of exported rice from Thailand decreased by 1% against the retail domestic price.

2) Supply factors of rice

Statistics show that the area cultivated in Malaysia has tended to decrease since the 1970s, mainly due to the rapid economic growth. However, the changes in the area cultivated may reflect various factors such as general trends of farm-gate price, price of fertilizer and wage rates in the manufacturing sector. Higher farm-gate price tends to act as an incentive for farmers to enlarge their area for planting more rice. On the contrary, the area may decrease due to the shift of the agricultural labor force to other sectors if the wages in the manufacturing sector tend to increase. In addition, it is widely known that the area cultivated in a particular year is closely related to that in the previous year, as it is difficult to switch rapidly to other land uses. We attempted to assess the supply factors in rice production by the following two functions: area harvested function and yield potential function.

Area harvested function:

Area harvested in the current year (S_t) is assumed to be affected by the area harvested in the previous year (S_{t-1}), real farm-gate price (P_t), real price of fertilizer ($P_{f,t}$) and real wage (W_t) in the manufacturing sector. In the case of Peninsular Malaysia, we combined the area of dry season cultivation with that of wet season cultivation. Area harvested was markedly reduced by outbreaks of brown plant hoppers in the wet seasons of 1983 to 1984. In order to cope with abnormal disturbances on the yields caused by insect damages, two dummy variables were used for 1984 and 1985. As the data in 1978 were not available because the supply of irrigation water was discontinued in the whole Muda Area, average of 1977 and 1979 was inserted into the set of time series data. Area in the wet season in the Muda Area was not analyzed because no changes occurred during the period observed. Results are presented as equations B and C in Table 2.

In the process of calculation, farm-gate price and price of fertilizer were deleted as independent variables because both coefficients were not statistically significant. In the case of Malaysia, variation of rice price is rather constant due to political control. In addition, fertilizer has been provided to all the rice farmers by the Government through the fertilizer subsidy programm since 1979. Due to the political support, the area harvested is not directly affected by the changes of farm-gate and fertilizer prices. Changes of wage rates in the manufacturing sector affected the harvested rice area more appreciably in Peninsular Malaysia than in the Muda Area. The effect of wage was relatively pronounced in the areas where paddy fields tended to be abandoned due to industrialization[4].

Yield potential function:

We considered that yield potential (Y_t) responds to farm-gate price (P_t), price of fertilizer ($P_{f,t}$) and adoption of direct seeding technology (DI_t) as well as to water supply consisting of rainfall ($RAIN_t$) and discharges from Pedu dam ($PEDU_t$). Dry and wet seasons were combined for the analysis in Peninsular Malaysia, while the analysis was separately conducted by season for the Muda Area. In order to evaluate the effect of the diffusion of direct seeding technology, the rate of the area under direct seeding culture in the Muda Area was calculated every year. Then, we used the annual rates for the analysis in both the Muda Area and Peninsular Malaysia under the assumption that direct seeding technology was disseminated at a similar level throughout the country.

Yields in 1978, 1983 and 1984 were reduced by Tungro as mentioned above. Due to the damage, yields in these three years showed fluctuations over the disturbance range of normal distribution. To avoid the abnormal effects, three dummy variables were used for the analysis. Yield functions (D, E and F in Table 2) indicate that the farm-gate price and price of fertilizer were not statistically significant for the same reason as that of area functions.

As for the effect of diffusion of direct seeding technology on yield, all the coefficients for the rate of direct seeding were significant when the dummy variable in 1984 onwards was set at 1.0. This fact indicates that it took about 4 years until most farmers became familiar with direct seeding culture. Adoption of direct seeding technology strongly affected the yield of the dry season in the Muda Area. The yield decreased by 1.36% before 1983 when the rate of adopion increased by 1.0%, whereas it decreased only 0.45% (-1.36%+0.91%) after 1984 for the dry season in the Muda Area.

Logistic functions representing the spread of direct seeding culture:

In Peninsular Malaysia, direct seeding was first introduced in two districts at almost the same time, during the mid-1970s: in the village of Sekinchan in Tanjong Karang along the central west coast; and in the Muda area. In the 1980s transplanting work which had traditionally been carried out by using exchanged labor (derau) and hired labor (upah) was almost totally replaced by direct seeding in most of the rice-growing areas.

The rapid spread of direct seeding culture in the Muda plain can be attributed to various factors. The nature of the irrigation system was one of the factors, as the farmers could not apply the level of water control they needed. The density of irrigation canals in the plain is only 7 to 10 meters per hectare, as compared with 100 to 200 meters per hectare in Japan. It is commonly pointed out that it was difficult to transplant rice at the proper time because presaturation was often delayed due to the high dependency on rainfall. Moreover, as the irrigation conditions were unfavorable, the area of fields per parcel was also rather large (0.3 to 0.5 ha). These conditions were therefore more suitable for direct seeding than for transplanting.

Apart from these facts, it appears that the spiraling wages for transplanting due to labor shortage were the key factor in the rapid spread of direct seeding culture. Since 1970, government policies have given priority to Malays in employment opportunities. In addition, rapid economic growth has occurred resulting in the outflow of labor from rural to urban districts. Rural women, who had been the major source of labor for transplanting then, enjoyed greater opportunities for employment in various factories. In addition, the promotion of education and influence of mass media appear to have brought about changes in people's views and attitudes toward rice farming.

Against this background, direct seeding culture in rice farming is being steadily disseminated in the Muda plain. Time series data from the 1st season in 1977 indicating the area cultivated by the direct seeding method are available at MADA. Using the data, two logistic functions by season were applied for tracing the process of diffusion of direct seeding technology in the Muda Area. Both functions on the area under direct seeding (DIt) are presented as G and H in Table 2. Functions were statistically well fitted and showed that direct seeding culture tends to spread constantly based on the past trend from 1980 to 1990 (Figure 1).

However, there are ponding areas where it is difficult to implement direct seeding culture due to poor drainage conditions, particularly for wet seeding. One problem associated with wet seeding is that difficulties in draining the land will seriously affect the subsequent establishment of seedlings. The Muda plain is situated on swampy ground extending to the coast bordering the Straits of Malacca. Therefore, the groundwater is high since the soil consists mainly of heavy clay. Such ponding situations are not considered in the direct seeding functions derived from the MADA statistics. It is assumed that future expansion of areas to be cultivated by direct seeding depends

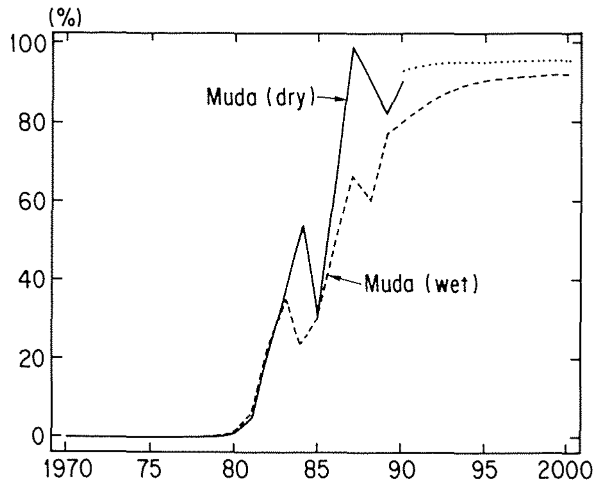


Figure 1. Increasing trend of area under direct seeding culture depending on season in the Muda Area, 1970-2000

mainly on two factors: the availability of improved varieties for which seedling establishment can be attained under ponding conditions; and the adoption of mechanized transplanting machines by farmers. In the former case, the area will be further enlarged unlike in the latter case.

3) Nature of wage

In Malaysia, wages in the manufacturing sector are mostly set up based on a nominal base. Hence, the real wage tends to decrease when the prices of goods are unexpectedly inflated after the wage was fixed. In this analysis, we assumed that the nominal wage (NW_t) per worker in the manufacturing sector is based on the nominal gross domestic product ($NGDP_t$) per capita. We obtained the best fitted function under the assumption that real wage in the current year shows a two year time-lag with the gross domestic product in nature (I in Table 2).

2. Prediction of demand-supply relation

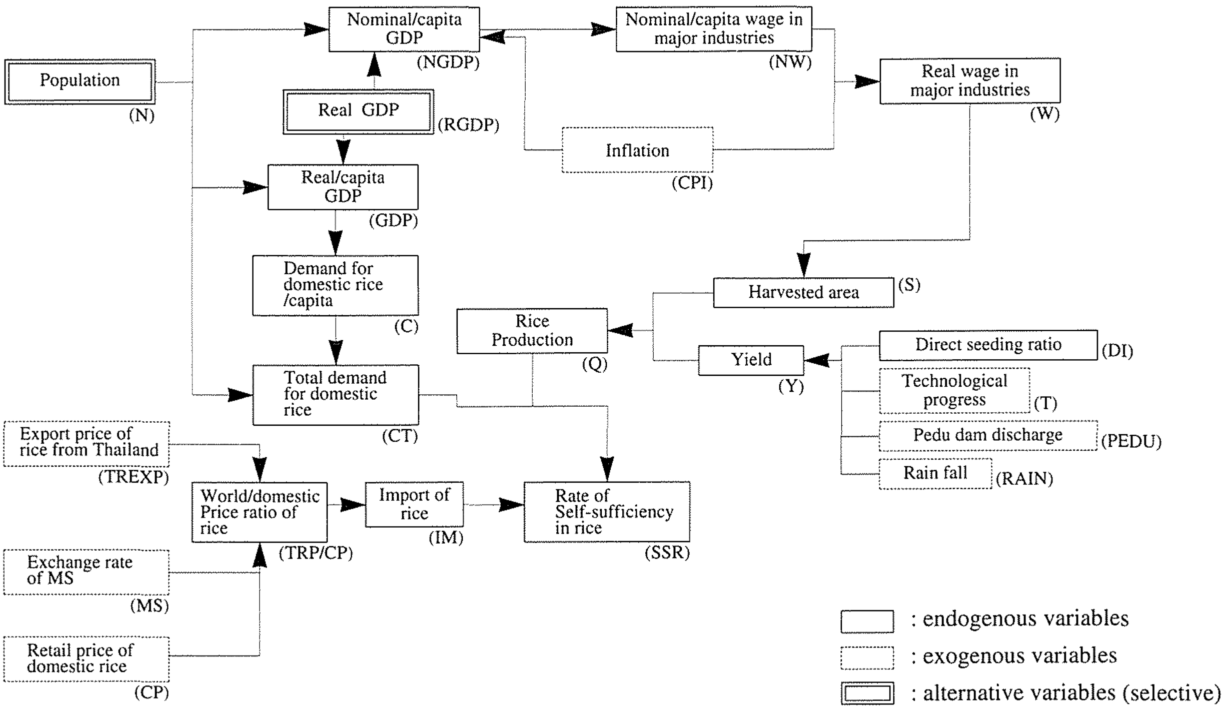
It was demonstrated that the general trend of rice production in Malaysia had not been directly affected by agricultural economic factors such as price of rice and fertilizers because both are continuously subsidized by the Government. Assuming that the rice supporting policy does not fundamentally change in the future, the most important factor affecting the rice sector may be the change of wages in the manufacturing sector. In addition, trend of national income will affect the future trend of rice production according to the wage function. Based on the results obtained, we attempted to predict the future trend of production, consumption and self-sufficiency by using simulation approaches (Figure 2).

For the simulation, we assumed that population and gross domestic product are manageable variables to some extent for Malaysia. In the case of a closed economy, investment (I) is determined as $I = sY$, where s is the saving rate and Y is the GDP. Therefore, the economic growth rate is represented as $\Delta Y/Y = (\Delta K/v)/Y = (I/v)/Y = (sY/v)/Y = s/v$, where K is the capital stock and v is the capital coefficient described as $v = K/Y$. For an open economy, I is also determined by foreign investment, which is controlled by the regulations in the host country. Similarly, the population growth rate can be managed by modulating the regulation for labor movement from neighboring countries. Accordingly, we combined the population growth rate and GDP growth rate, as follows:

	Population growth rate	GDP growth rate
Case a :	2.5%	8% and 6%
Case b :	2.0%	〃
Case c :	3.0%	〃

The average population growth was 2.5% during the period from 1970 to 1990. Average GDP growth rate in this period was 8%, but we set it at 6% because the global economy faces a depression now and the conditions of export market for Malaysia may be affected.

As exogenous variables, an annual increasing rate of 4% was set for the consumer price, and an area of 97,000 ha was used as the upper limit of paddy fields in the Muda Area. Pedu dam discharge and rainfall were set up to keep an average level for 20 years, and world/domestic price ratio of rice was set at the same ratio as that in 1990. Results for the 8% gross domestic product



*Only statistically significant variables and necessary variables by definition are listed in the deagram, though there mey be other factors.

Figure 2. Flow-diagram for the econometric analysis of rice production in Peninsular Malaysia

growth rate case are illustrated in Figure 3.

Consumption:

As the income elasticity is negative, consumption of rice per capita will continuously decrease in the three cases (Figure 3-A). The annual decreasing rate is estimated at around 1.1%. However, the total consumption will increase in any case because of the population growth, especially under the 3.0% population growth rate, it may increase by 1.9% per year (Figure 3-B).

Production:

Area cultivated in Peninsular Malaysia decreases at the rate of 2.1% per annum due to the increase of wage in the manufacturing sector (Figure 3-C). However, the decreasing rate of the area cultivated in the dry season will remain at about 0.5% in the Muda Area.

Yield is predicted to increase by 1.9% per annum in Peninsular Malaysia, while that in the Muda Area is estimated to remain at the 0.8% level, because the yield of rice in Peninsular Malaysia started from a low level and has a potential to increase (Figure 3-D). Total production of rice estimated by both area and yield functions will decrease by around 0.4% in Peninsular Malaysia and increase by around 0.3% in the Muda Area (Figure 3-E). These figures indicate that the share of rice production in the Muda Area is expected to expand from 70% to 75% toward 2003.

Self-sufficiency in rice:

Since the general trend of rice production is not directly affected by the population growth rate, self-sufficiency in rice is basically determined by the changes of the demand situation. Therefore, the self-sufficiency rate is likely to decrease to around 55% because of the increase in total consumption (Figure 3-F). In particular if the population growth rate reaches 3%, the self-sufficiency rate could decrease to 52% in 2003.

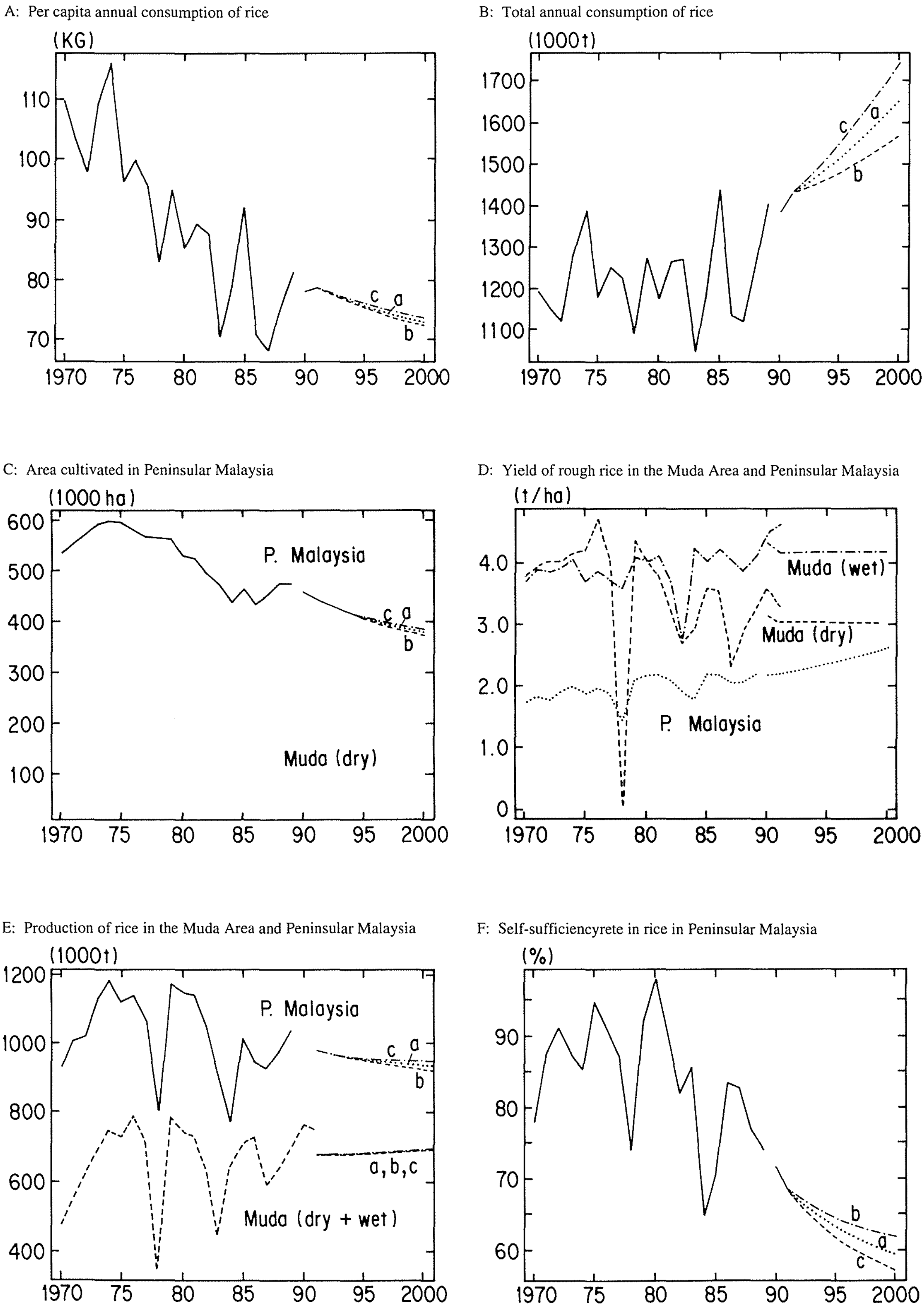


Figure 3. Trend of demand and supply of rice in Peninsular Malaysia, 1970-2000

When we changed the assumption on GDP growth rate from 8% to 6%, the results previously listed had to be slightly modified. The decrease in per capita consumption was moderate and the annual rate of increase of total consumption ranged from 1.1 to 2.3%. In this case, wage increase rate was slower, and the production took an upward direction after the middle of the 1990s. However, the effects of the consumption were dominant in this case also, and the projected decrease in the self-sufficiency rate in 2003 ranged from 54% to 60%. This value was slightly higher than in the case of the 8% GDP growth rate.

Conclusion

In Malaysia, the wage rate in the manufacturing sector has been rising rapidly because of the rapid economic growth and small population of about 18 millions. Therefore, direct seeding culture was adopted for rice production after the middle of the 1980s, and the yield declined temporarily. Though this effect has mainly ceased, migration of rural labor has resulted in a decrease in the area cultivated, and a reduction in rice production is likely to occur in the future. At the same time, per capita consumption of rice is decreasing with the rise in per capita income. However, the effect of population growth is dominant and the self-sufficiency rate is likely to fall to around 55% in 2003. For other Asian countries with a large population and scarce per capita cultivated land area, this forecast implies that the food demand-supply conditions will become critical in the future.

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マレイシアにおける直播稲作の普及と米の需給動向

ー経済成長と人口増加の影響ー

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摘　要

マレイシアにおける経済成長はアジア諸国の中でもめざましく，その農業，とりわけ稲作部門ではドラスティックな変貌を余儀なくされている。当国の稲作は1960年代には天水に依存していたが，食糧自給政策によって灌漑事業と高収量品種の導入を推進した結果，70年代には二期作が可能となり米の自給がほぼ達成されたかにみえた。しかし，近年においては製造業への労働力の流出によって耕作放棄田が増加し，自給率は70%に低下してきた。さらに，1980年代初頭から直播栽培が広く普及したことや水不足の影響があり米の単収は不安定になった。米の需要に関しては，一人当たり消費量は減少傾向にあり，1990年には80kgとなった。

このように，米の生産と一人当たりの消費が減少傾向にあることから，米の自給率の今後の動向を展望するためには，米の計量経済モデルを構築し，需給両面の要因を考察する必要がある。需給モデルを計測した結果，賃金率と一人当たり所得の上昇が作付面積と需要に対して強くマイナスに影響する要因であり，直播方式の導入は1980年代初頭には単収に対して無視し得ないマイナス要因であったが，半ば以降はほとんど影響ないということが解明された。

今後のマレイシア経済の動向に関して，ＧＤＰ成長率と人口増加率をそれぞれ過去20年間の平均値である８%，2.5%と想定し，2003年までのシミュレーションを行った結果，賃金上昇による生産の微減と人口増による総消費の増加によって自給率は55%まで低下するとの結果が得られた。シミュレーションの条件を変更し，ＧＤＰ成長率を６%，人口増加率を2.0%または3.0%に設定した結果，自給率に及ぼす影響は人口増加率の方が経済成長率よりも相対的に大きいということが明らかになった。

以上で示されたマレイシアの米需給に関する展望から，人口規模がマレイシアより大きく一人当たり耕地面積の狭小な他の発展途上アジア諸国における食糧事情が今後は一層タイトなものになると予想される。

キーワード：米，自給率，供給，需要，直播，計量経済モデル，シミュレーション，ムダ地区