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Modern rice technology and regional wage differentials in the Philippines

Keijiro Otsuka^{1,2}, Violeta G. Cordova¹ and Cristina C. David¹

¹*Agricultural Economics Department, International Rice Research Institute,
Los Baños, Laguna (The Philippines)*

²*Faculty of Economics, Tokyo Metropolitan University, Meguro, Tokyo 152 (Japan)*

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ABSTRACT

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Fear has been widely expressed that the modern rice varieties have created large disparities in regional income distribution, as the productivity gap between favorable and unfavorable rice-production environments widened due to differential technology adoption throughout South and Southeast Asia over the last two decades.

Technology affects the income of farm population directly through its effects on productivity and factor use, and indirectly through its effect on factor prices. In particular, the ultimate distributional impact of modern varieties will critically depend on the interregional labor-market adjustments through migration in response to regional wage differentials created by the differential technology adoption, since labor is the main resource of the majority of the rural population.

We studied favorable and unfavorable rice-growing villages in the Philippines, and found that adoption of modern varieties during the 1970s was positively related to population growth rate. Contrary to popular belief, no association was observed between wage rates and adoption of modern varieties as of 1986. These findings support the hypothesis that the differential adoption of modern rice varieties induced interregional labor migration toward equalization of wage income across different production environments.

1. Introduction

Accumulated evidence indicates that adoption of modern rice varieties (MVs) has been constrained primarily by environmental conditions, especially the degree of water control, and not by farm size, tenure, or other social and institutional factors (Ruttan, 1977; Barker and Herdt, 1985). As

a result, the productivity gap between favorable and unfavorable rice-production environments has widened throughout South and Southeast Asia over the last two decades (David and Otsuka, 1987). And fears have been widely expressed that modern rice varieties created large disparities in regional income distribution (Falcon, 1970; Ruttan, 1977; Lipton and Longhurst, 1989). Such a view is supported by a number of cross-sectional studies of rural labor markets in India, which commonly found significantly positive effects of MVs on wage rate (Johl, 1975; Lal, 1976; Bardhan, 1979; Dhar, 1984; Rosenzweig, 1984). These findings, however, are based on wage patterns during the early stages of technology introduction. Yet in the longer run, wage differentials initially created by differential technology adoption across production environments may induce interregional labor migration, both permanent and seasonal, to equalize wage rates across regions. The ultimate distributional impact of the modern varieties will critically depend on such labor market adjustments, since labor is the most mobile factor of production and the major resource of the rural poor (Evenson, 1975; Quizon and Binswanger, 1983).

Despite its importance, no systematic research effort has been made on the role of interregional labor migration in the equalization of wage income across different production environments. The purpose of this study is to explore whether and to what extent the differential adoption of modern rice varieties has induced differential growth in labor supply across different environments, so as to equilibrate wage rates in the case of the Philippines.

2. Theoretical framework

In our study, the observation units are villages, or the area surrounding the villages, with similar environmental characteristics and technology adoption patterns. For such relatively small geographical regions, paddy price and prices of purchased inputs can be safely assumed to be exogenous. On the other hand, wage rates can only be regarded as exogenously fixed if labor markets are well integrated over wide areas. If labor markets are geographically segmented because of high migration cost or market imperfections, wages will be endogenously determined.

For analytical purposes, we may distinguish conceptually between the short run, in which the village labor force is constant, and the long run, in which it changes by interregional migration until the marginal gain of migration is equated with the marginal cost.¹ We assumed there are two types of production environments, i.e., favorable areas, where MVs can be profitably grown, and unfavorable areas, where MVs are not suitable.

¹ In this study we focused on permanent migration rather than seasonal migration.

In a given region, labor demand and supply functions in the short run may be represented by:

$$L_d = L_d (W, T, P) \quad (1)$$

$$L_s = L_s (W, N) \quad (2)$$

where L_d and L_s stand for labor demand and supply, respectively; W refers to wage rate; T represents production technology which depends on adoption of modern rice varieties; P is the vector of exogenously given market prices of output and purchased inputs; and N is the village labor force. Assuming that there is competitive equilibrium in the village labor market, the reduced-form short-run wage function can be obtained from equations (1) and (2):

$$W = W (T, N, P) \quad (3)$$

Because the adoption of MVs increases labor demand by raising labor requirements for weeding, fertilizer application, harvesting, and threshing (Barker and Cordova, 1978; Joshi et al., 1981; Barker and Herdt, 1985; Herdt, 1987), we expect that T affects W positively. Thus, wage rate increases as modern varieties spread in the favorable areas in the short run.

If the migration cost is not prohibitively costly, migration will occur from unfavorable to favorable areas in the long run. In our framework, migration can be considered a response to the short-run disequilibrium in interregional labor markets. That is, the change in technology in favorable areas affects wage rates in the short run through equation (3), which in turn affects the labor supply in the long run through immigration in the following manner:

$$\Delta N_f = N_f (\Delta W_f) \quad (4)$$

where N_f indicates an increase in labor force through immigration when short-run wage rate, represented by W_f , increases in the favorable rice-production area. If this region is an unfavorable rice-production area, outmigration will take place because of the wage increase in favorable areas:

$$\Delta N_u = N_u (\Delta W_f) \quad (4)'$$

where ΔN_u indicates outmigration from unfavorable areas, i.e., $\Delta N_u < 0$.

Using the short-run wage function in equation (3), the immigration and outmigration functions can be rewritten as:

$$\Delta N_f = \Delta N_f (\Delta T_f) \quad (5)$$

$$\Delta N_u = \Delta N_u (\Delta T_f) \quad (5)'$$

where ΔT_f shows changes in technology in the favorable area.

In the long run, the increase in labor force in the favorable area and its decrease in the unfavorable area reduces the regional wage gap observed in the short run. If the migration cost is sufficiently small, we expect to observe no significant regional wage differential. If the migration cost is high, or the inter-regional labor market adjustment takes time, the observed wage rate will be higher in the more favorable areas relative to the unfavorable areas. In the succeeding sections, we examine the extent of labor market adjustment following differential technology adoption across different production environments by first estimating population growth-rate functions for the green revolution period (1970–80) and post-green-revolution period (1980–86), which conceptually corresponds to equation (5), and then wage function using post-green-revolution cross-section data in 1986 as in equation (3). However, in estimating the wage function, we did not consider explicitly the labor force variable in the estimation of the wage function, because it is endogenous in our framework.

3.1 *Environmental characteristics of sample villages*

We classified rice production environments for the purpose of stratifying them into irrigated, favorable rainfed, and unfavorable rainfed areas. The irrigated villages in our sample are covered by the gravity irrigation system constructed and maintained by the government. The favorable rainfed is defined as shallow rainfed, whereas the unfavorable rainfed refers to areas prone to severe flood or drought.

We sampled 50 villages, encompassing northern, central and southern Luzon, and Panay Island (see Fig. 1). The distribution of sample villages among the three production environments was predetermined to be roughly equal (see Table 1 for actual distribution). The sampling was stratified in that we attempted to select villages with representative environmental characteristics by making prior consultation with provincial and municipal government officials in charge of technology extension. Once representative environments were identified, the villages were selected randomly. Because of the high adoption of MVs in the lowland areas of the Philippines, the unfavorable rainfed villages are not necessarily representative of wide areas.

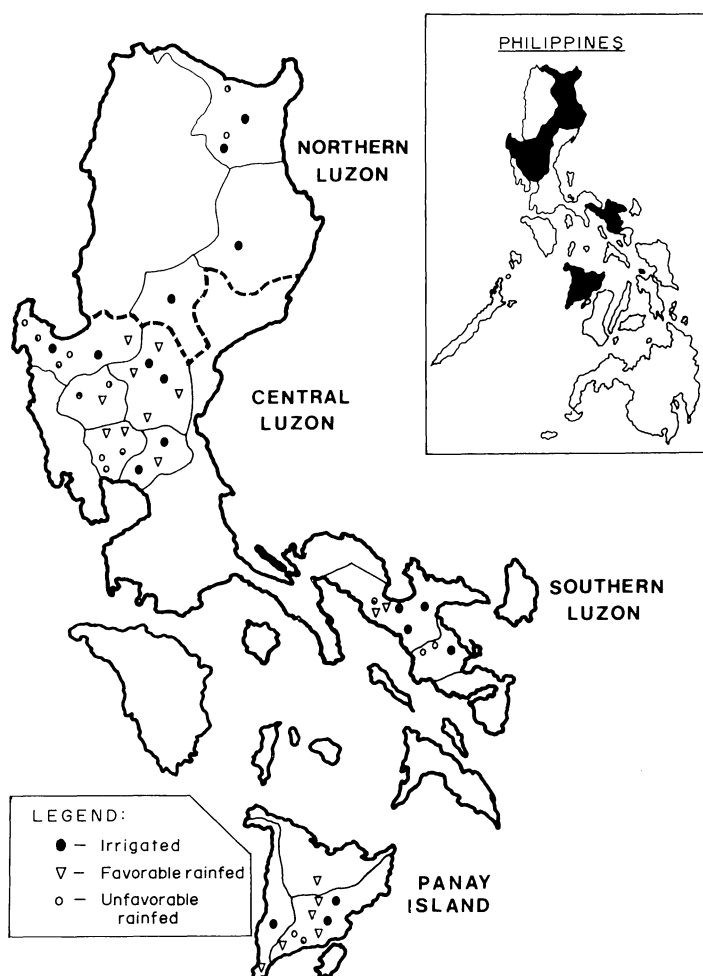


Fig. 1. Distribution of sample villages by environmental conditions in the Philippines, 1987.

3.2 Technology adoption and yields

Changes in the ratio of irrigated area and adoption rate of MVs by production environments are reported in Table 1, together with changes in rice cropping intensity and yield per ha during the wet season. The massive irrigation investments during the 1970s increased irrigation rates by 58% to almost 100% in the irrigated villages. In the rainfed areas, a small portion of the ricefield was irrigated by water pumps and natural creeks. Adoption of MVs was equally rapid and complete in the irrigated and favorable rainfed areas, indicating that the degree of water control did not differ

TABLE 1

Changes in ratio of irrigated area, adoption rate of modern varieties, cropping intensity, and yield per hectare, by rice production environment

	Irrigated	Favorable rainfed	Unfavorable rainfed
<i>Sample size</i>	17	17	16
Ratio of irrigated area (%)			
1970	58	4	1
1980	84	7	2
1986	97	8	2
Adoption rate of modern varieties (%) ^a			
1970	38	29	16
1980	89	95	41
1986	97	98	40
Rice cropping intensity (%)			
1970	148	108	97
1980	183	121	98
1986	195	123	98
<i>Yield (t/ha)^a</i>			
Traditional variety			
1970	2.2	2.1	2.1
1980	— ^b	—	1.9
1986	—	—	1.7
Modern variety			
1970	3.8	3.1	2.2
1980	3.5	3.3	2.7
1986	3.4	3.0	2.4

^a Wet-season data.

^b Observations are too few.

significantly between the two areas during the wet season. In contrast, adoption of MVs in the unfavorable rainfed area was slower and much less complete. In all areas, the rate of MV adoption had largely tapered off by 1980.

Because of the increase in irrigation rate and the photoperiod-insensitive nature of MVs, rice cropping intensity has increased in the irrigated area since 1970.² Moreover, the short growth duration of MVs made it possible to grow two crops of rice in some rainfed areas in Panay Island and southern Luzon, where the rainfall pattern is more even than in northern and central Luzon.

² Since our sample villages are basically rice-dependent, the total cropping intensity is only slightly greater than the rice-cropping intensity shown in Table 1.

In our sample villages, yield of traditional varieties (TVs) did not differ significantly among the three different production environments in 1970. The introduction of MVs raised yield significantly in the irrigated as well as in the favorable rainfed areas, but only marginally in the unfavorable rainfed areas. As a result, significant productivity differentials have emerged among the different production environments.

4. Technology adoption and demographic change

We now examine how the differential adoption of new rice technologies affected the village population in favorable and unfavorable areas. As in other countries, the dominant migration flow in the Philippines has been rural to urban.³ Under such circumstances, an important part of inter-regional labor market adjustments has been accomplished by the differential rates of rural-to-urban migration among different production environments corresponding to the differential growth of labor demand across rural areas. Moreover, the systematic difference in the natural rate of population growth between favorable and unfavorable areas may accentuate or lessen the labor-market adjustments by migration.⁴

Although it is obviously desirable to analyze migration data, no such data at the disaggregated level classified by rice production environments and technology are available. For this study, we focused on the change in village population between census years 1970 and 1980 as an indicator of the long-run labor supply adjustments.⁵ Because modern rice technology was more rapidly disseminated in the 1970s than in the 1980s, labor supply adjustments manifested in the changes in the population were hypothesized to be more pronounced in the 1970s.

4.1 Changes in population and person – land ratio

Although equation (5) shows absolute change in labor force, we consider population growth rates or changes in person – land ratio to adjust for differences in size of villages (Table 2). It is remarkable that, during the 1970s,

³ The average annual population growth rate in urban areas (4.4%) was much higher than in rural areas (1.9%) in the Philippines during the 1970s, mainly because of the migration from rural to urban areas.

⁴ Another possibly important mechanism that contributes to the equalization of regional wages is the adoption of labor-saving mechanical technology such as tractors and threshers, in the favorable area. In our sample villages, there is an indication that tractors were adopted more widely in the more favorable areas, but no such difference was observed with threshers.

⁵ In our survey we did not obtain consistent and reliable information on seasonal migration at the village level.

TABLE 2

Population growth rate, changes in man-land ratio, farm size, and ratio of landless households, by rice production environment

	Irrigated	Favorable rainfed	Unfavorable rainfed
Average annual population growth rate (%) ^a			
1970–80	2.9	2.0	1.1
1980–86	1.7	1.6	2.1
1970–86	2.5	1.9	1.5
Man-land ratio (persons/ha)			
1970	4.3	4.0	3.7
1980	5.6	4.9	4.1
1986	6.3	5.1	4.7
Average farm size (ha)			
1986	1.69	1.67	1.70
Ratio of agricultural landless households (%) ^b			
1986	30.6	18.1	15.1

^a Population data in 1970 and 1980 are taken from the Census of Population (Philipp. National Census and Statistics Office, 1970, 1980).

^b Ratio of the number of agricultural landless households to the total number of farming households.

when MVs were rapidly disseminated and irrigation investments accelerated, population growth rate was highest in the irrigated area and lowest in the unfavorable rainfed area. In the 1980s, as adoption of MVs largely tapered off, average population growth rates among the three production environments became more comparable.

Trends in person–land ratio, defined as the population per ha of cultivated area, followed the pattern of population growth, i.e., increasing most rapidly in the irrigated area and least rapidly in the unfavorable rainfed area. By 1986, the person–land ratio had become highest in the irrigated area and lowest in the unfavorable rainfed area, starting with more similar person–land ratios in 1970. There was, however, no significant difference in farm size among the three different production environments. On the other hand, the ratio of landless households was highest in the irrigated area in 1986. The majority of rural-to-rural migrants are reported to be landless not only in the Philippines (Kikuchi et al., 1983; Bautista, 1987) but also in other countries such as India (Lal, 1976; Dhar, 1984). Therefore, these

trends in demographic factors and its composition suggest that permanent migration from unfavorable to favorable rice production areas took place.

4.2 *Regression analysis*

Adoption of MVs depends primarily on the presence of irrigation and favorableness of rainfed conditions. Irrigation, however, increases labor demand not only indirectly through adoption of MVs but also directly by increasing cropping intensity. Thus, in estimating both population growth and wage equations, the MVs and irrigation ratio have been specified separately. The population growth functions were estimated two ways. First, because the natural environments and the presence of gravity irrigation can be considered exogenous, we regressed the average annual rate of population growth directly on the irrigated (IRGE) and favorable rainfed (FAVE) environment dummies and the change in the ratio of irrigated areas (Δ IRG). If the more rapid spread of MVs in the irrigated and favorable rainfed areas raised labor demand, and subsequently induced interregional migration, a positive coefficient for the two environment dummies would be obtained. Similarly, an increase in the ratio of irrigated area, which increases cropping intensity, would affect population growth rate positively.

Secondly, we estimated two-stage least-squares (TSLS) regression in which changes in the ratio of MV adoption (Δ MV) are regressed on IRGE, FAVE and Δ IRG in the first stage, and then population growth rate is regressed on Δ IRG and the predicted value of Δ MV in the second stage.⁶ In addition, person – land ratio (PLR) in the initial year, i.e., 1970 and 1980, and three regional dummies, Northern Luzon (NORTH), southern Luzon (SOUTH) and Panay Island (PANAY), are included to control possible effects of initial condition and various region-specific factors.

As expected, the fit of the regression equations is better for 1970 – 80 than for 1980 – 86 equations, because technology was more stagnant in 1980 – 86 (Table 3).⁷ It is remarkable to observe in equation (1) that the coefficients of IRG, IRGE and FAVE are positive and highly significant. Because MVs were adopted mainly in the irrigated and favorable rainfed areas and the cropping intensities rose in the irrigated villages as the ratio of irrigated areas expanded, these results strongly indicate the pervasive effect of modern rice technology on population growth. This interpretation is supported by the

⁶ If the MV-cum-irrigation technology induced the mechanization, which would have reduced the labor demand, the Δ IRG and Δ MV coefficients are expected to capture the net impacts of the MV technology on population change.

⁷ In the 1970 – 80 regression, we employed the adoption rate of MVs in 1980 rather than the change between 1970 and 1980, because MVs were newly introduced immediately before 1970.

TABLE 3

Regression coefficients for population growth rate and changes in rate of MV adoption, 1970–80 and 1980–86^a

	1970–80			1980–86		
	Population growth rate		ΔMV	Population growth rate		ΔMV
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	1.04 (2.31)	–0.09 (–0.01)	0.44 (4.31)	4.06 (3.89)	3.53 (2.64)	0.07 (0.76)
MLR	–0.01 (–0.07)	0.03 (0.35)	–0.01 (–0.39)	–0.23 (–1.27)	–0.17 (–0.88)	–0.01 (–0.72)
ΔMV		2.15** (3.10)			5.08 (0.42)	
ΔIRG	1.97** (3.06)	2.01** (3.20)	0.13 (0.88)	2.18 (1.02)	–0.66 (–0.09)	0.56** (2.84)
IRGE	1.30** (3.09)		0.45** (4.78)	0.26 (0.29)		0.07 (0.81)
FAVE	0.98** (2.63)		0.52** (6.19)	–0.30 (–0.33)		0.02 (0.26)
NORTH	0.27 (0.53)	0.70 (1.42)	–0.11 (–0.97)	–2.70* (–2.13)	–1.79 (–0.86)	–0.16 (–1.37)
SOUTH	0.08 (0.19)	0.08 (0.18)	0.06 (0.65)	–0.14 (1.39)	–0.97 (–0.71)	–0.09 (–0.96)
PANAY	–0.13 (–0.33)	–0.15 (–0.35)	0.02 (0.25)	–2.18* (–2.41)	–2.33** (–2.82)	0.01 (0.14)
R ²	0.47	0.45	0.57	0.22	0.24	0.21
F-value	5.43	5.77	7.81	1.52	2.09	1.45

^a Numbers in parentheses are *t*-statistics. * Significant at the 5% level; ** Significant at the 1% level.

results of the two-stage regressions shown in equations (2) and (3). In equation (3), MVs were introduced to irrigated and favorable rainfed villages almost equally rapidly regardless of the difference in irrigation. Equation (2), on the other hand, shows the highly significant effect of change in MV adoption and irrigation expansion on growth rate of population. These findings are consistent with historical comparisons of migration patterns of favorable and unfavorable rice villages in the Philippines (Kikuchi et al., 1983; Bautista, 1987). In India, large immigration to Punjab, when modern

wheat and rice varieties were rapidly adopted, has been reported (Johl, 1975; Lal, 1976; Ahluwalia, 1978; Oberai and Singh, 1980).

For 1980–86, as shown in equations (4) and (5), no estimated coefficient except for regional dummies is significant in the population growth rate equations. During this period, however, the adoption rate of MVs increased only slightly and the irrigated area expanded only in three locations. It seems that the interregional labor supply adjustments occurred mainly in the 1970s.

5. Technology and wage differential

Although population changes are observed to be consistent with the hypothesis of interregional labor market adjustments, the extent to which such adjustments lead to equalization of wages across regions is explored in this section.

5.1 *Structure of wages*

Table 4 compares paddy prices, task-specific daily wages, and rental of carabao (water buffalo) in irrigated, favorable rainfed, and unfavorable-rainfed areas. Because labor contracts are often on a piece rate or output-sharing basis, imputed daily wages were calculated by dividing total wage payments by the number of workdays to compare with ordinary daily wages.⁸

Not only paddy prices but also daily wages are generally similar across environments. The exception is transplanting wage, which is lowest in the most favorable area. The daily rental of carabao also differs across production environments, being highest in the most favorable area. Because wage rates generally differ by task, wage rate functions are estimated separately for land preparation, transplanting, harvesting, and threshing. Using the same set of independent variables, carabao rental equation is also estimated to compare the determinants of wages and carabao rental. The rental market for draft animals is known to be imperfect even within a village, because it is costly for the owner to supervise the proper care of the draft animal by a renter (Bliss and Stern, 1982). Such market imperfection, coupled with high relocation cost, leads to low geographic mobility of carabao, and hence its rental will be largely determined by local supply and demand conditions. Wage rates, on the other hand, will not be affected by local labor market conditions if labor is more mobile geographically.

⁸ In villages where different contracts coexist in the same task, we selected the wage of the dominant mode of contract.

TABLE 4

Paddy price, wage rates, and rental of carabao, by rice production environments, 1986 wet season^a

	Irrigated	Favorable rainfed	Unfavorable rainfed
Paddy price (₱/kg)			
Traditional variety	—	3.08 (5)	2.84 (16)
Modern variety	2.63 (17)	2.58 (17)	2.65 (13)
Land preparation with carabao (₱/day)			
Daily wage	35.5 (17)	34.6 (17)	33.8 (16)
Daily rental of carabao ^b	31.8 (17)	23.5 (17)	26.1 (16)
Transplanting (₱/day)			
Daily wage	22.1 (12)	24.8 (12)	29.2 (16)
Imputed wage ^c	25.8 (5)	21.4 (5)	—
Harvesting (₱/day)			
Daily wage	25.0 (2)	25.0 (2)	34.8 (8)
Imputed wage ^d	53.7 (15)	56.8 (15)	49.6 (8)
Threshing			
Imputed wage (₱/day) ^c	53.7 (17)	55.8 (17)	49.5 (16)

^a Numbers in parentheses are sample sizes.

^b Does not include carabao operator.

^c Total wage payment divided by work days under piece-rate contract based on area for transplanting and quantity for threshing.

^d Total wage payment divided by work days under output-sharing contract.

Conversion of pesos to U.S. dollars in 1986 is ₱ 20.39 = US\$1.00.

5.2 Specification of wage and carabao rental equations

Considering the endogenous nature of MV adoption, we applied TSLS in which the adoption rate of MVs in 1986 is regressed on village environment dummies in the first stage, and the logarithm of task-specific daily wage earning and carabao rental regressed on predicted MV and irrigation ratio in 1986 (IRG) in the second stage.

In addition to the technology variables, which are expressed in ratios, we added the logarithms of average farm size (FSIZE) and paddy price of MVs (QPRICE) as variables reflecting village characteristics. Other things being

equal, the higher the average farm size, the higher will be the demand for hired labor, which in turn will result in higher wages. To distinguish the skill-intensive and laborious work of plowing and harrowing under the *dukit* contract, where use of carabao is limited to the sides of ricefields after tractor operation, the dummy variable (CONT1) is included in land preparation wage and carabao rental regressions. The piece-rate contract dummy (CONT2) is inserted in the transplanting-wage regressions and the output-sharing contract dummy (CONT3) is added in harvesting wage regressions. As is well known in the theory of contract (Stiglitz, 1975; Roumasset and Uy, 1980; Otsuka and Hayami, 1988), daily wage workers are less motivated to work since wage payment is fixed regardless of their real efforts. Also, the more able workers will prefer the piece-rate or output-sharing contract to the daily-wage contract for its higher remuneration at higher level of effective labor inputs. For these two reasons, daily labor income will be higher for nondaily wage workers, so that the contract dummy variables are expected to have positive coefficients.

The logarithm of the distance (in km between village and large city (DIST), i.e., Manila for Luzon Island and Iloilo City for Panay Island, is included among the independent variables to capture, at least partially, the cost of migration between rural labor markets. Regional dummies are also included to take account of all other environmental variables not explicitly specified in the equation.

5.3 *Wage and carabao rental regressions*

Table 5 presents the results of the wage and carabao rental regressions as well as the first-stage result of the MV adoption function. Equation (7) shows that the rate of MV adoption is well-explained by the environment dummy variables.

With the exception of the transplanting wage, neither the adoption of MVs nor irrigation ratio has any significant coefficient, suggesting that wage rates are largely equalized between favorable and unfavorable rice-production environments. The significant and negative coefficient of MV in equation (2), which is contrary to our hypothesis, does not necessarily imply that MV adoption per se reduces wages. No difference can be observed in wage rates for transplanting MVs and TVs in the villages where both varieties were grown, nor is there evidence that adoption of MVs reduced the labor requirement for transplanting. It has been observed, however, that in the unfavorable environment where TVs are still grown, many farmers transplant on the same day immediately after rain, because of poor control of water. In other areas, transplanting dates are staggered. Therefore, the demand for transplanters will have a higher seasonal peak in the unfavorable

TABLE 5

Regression coefficients for wage rates, rental of carabao and mv adoption functions, 1986 wet season^a

	Log-wage			Log-rental		
	Land preparation (1)	Trans- planting (2)	Harvest- ing (3)	Thresh- ing (4)	Carabao (5)	MV (6)
Intercept	4.02 (10.15)	3.32 (6.28)	3.92 (7.92)	4.18 (9.06)	3.67 (12.43)	0.33 (1.04)
MV	0.06 (0.32)	-0.51** (-2.91)	0.13 (0.74)	0.09 (0.54)	-0.19 (-1.85)	
IRG ratio	0.06 (0.71)	0.03 (0.32)	-0.05 (-0.50)	0.01 (0.16)	0.18** (2.83)	
IRGE						0.57** (10.23)
FAVE						0.54** (9.25)
FSIZE	-0.07 (-1.26)	0.00 (0.06)	-0.01 (-0.17)	0.08 (1.33)	-0.01 (-0.21)	0.03 (0.58)
QPRICE	-0.08 (-0.75)	0.13 (0.84)	-0.12 (-0.83)	-0.11 (-0.84)	-0.08 (-1.01)	0.03 (0.35)
CONT1	0.17* (1.84)				0.42** (6.24)	
CONT2		0.07 (0.59)				
CONT3			0.53** (5.04)			
DIST	-0.09* (-1.68)	-0.02 (-0.22)	-0.10 (-1.55)	-0.10* (-1.67)	-0.07 (-1.65)	-0.02 (-0.57)
NORTH	0.02 (0.13)	-0.21 (-0.76)	0.20 (0.85)	0.27 (1.21)	0.16 (1.16)	-0.13 (-0.85)
SOUTH	0.07 (0.38)	-0.04 (-0.16)	0.05 (0.23)	0.26 (1.22)	-0.04 (-0.29)	0.12 (0.83)
PANAY	-0.08 (-0.35)	0.07 (0.24)	0.24 (0.81)	0.44 (1.61)	0.08 (0.46)	0.15 (0.78)
R ²	0.65	0.30	0.59	0.22	0.83	0.79
F-value	8.13	1.87	6.35	1.44	21.63	19.76

^a Numbers in parentheses are *t*-statistics. * Significant at the 5% level; ** significant at the 1% level.

area. Because transplanting in neighboring villages will also be done synchronously, short-distance migration will not occur. Seasonal migration from remote areas with different environments will not occur either, because

transplanting dates in the unfavorable areas are unpredictable. Moreover, the 'expected' daily wage will be lower than the actual wage in such a situation, because transplanting jobs are not always available during the transplanting season. Therefore, it is not surprising to find negative and significant coefficients of MV in the transplanting wage equation. For carabao rental (equation 5), the positive and significant coefficient of irrigation is due not so much to higher demand for carabao services but to the higher cost of maintaining draft animals as grazing land declines in irrigated area. The fact that wage rates are equalized but carabao rentals are significantly higher in irrigated area strongly supports the hypothesis advanced by Rao (1975), Day and Singh (1977), and Roumasset and Smith (1981), that the tractor is more widely adopted in irrigated areas, not necessarily because wage rates are relatively higher but because the draft animal is more expensive.

Farm size and paddy price do not affect regional wage patterns significantly. The significant coefficient of CONT1 in land preparation wage and carabao rental indicates the skill-intensive nature of plowing only the sides of rice fields by carabao. The highly significant coefficient for piece-rate contract in harvesting (CONT3), on the other hand, suggests that daily-wage laborers shirk more often, or they are of lower quality. The distance variables are also significant in equations (1) and (4). The uniformly negative coefficients in all regressions conform with expectations that wages may be higher near large cities. So long as large cities are centers of gravity in labor markets, these results can be explained by information and transportation costs for the geographical movements of labor.

6. Concluding remarks

This study indicates that differential adoption of modern rice technology between favorable and unfavorable areas induced interregional labor-market adjustments to equalize wage rates across different production environments. As far as wage income is concerned, therefore, there is no evidence that the location specificity of modern rice technology has worsened regional income distribution to a significant extent.

Our analysis is consistent with the migration model formulated by Harris and Todaro (1970) in which (expected) wage differential, arising from differential rates of technological change across production environments in our context, induces migration flow from low-wage to high-wage regions. The focus of our analysis differs from their model in that migration is considered an important force contributing to the reduction of regional wage differential. The significant association observed between changes in technology and population growth rate during the 1970s, but not between

technology and wage rates as of 1986, clearly supports the validity of our view.⁹

Whether our findings are unique to the case of the Philippines is an important issue to address. By now, unfavorable areas in which traditional varieties are still grown are mostly pockets surrounded by vast areas of relatively favorable environments in the Philippines. Comparative studies of regional wage differentials in other countries are required to generalize the role of labor market adjustments in mitigating in potentially inequitable effect of differential technology adoption across production environments on income distribution.

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⁹ Our result is also consistent with the recent study of rural-to-urban migration by Speare and Harris (1986), which found no systematic association between labor-earning differentials and migration flows because of the earning equilibrating effect of migration.

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