Howard N. Barnum and Lyn Squire

A Model of an Agricultural Household

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A Model of an Agricultural Household
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Foreword

I would like to explain why the World Bank does research work and why this research is published. We feel an obligation to look beyond the projects that we help finance toward the whole resource allocation of an economy and the effectiveness of the use of those resources. Our major concern, in dealings with member countries, is that all scarce resources—including capital, skilled labor, enterprise, and know-how—should be used to their best advantage. We want to see policies that encourage appropriate increases in the supply of savings, whether domestic or international. Finally, we are required by our Articles, as well as by inclination, to use objective economic criteria in all our judgments.

These are our preoccupations, and these, one way or another, are the subjects of most of our research work. Clearly, they are also the proper concern of anyone who is interested in promoting development, and so we seek to make our research papers widely available. In doing so, we have to take the risk of being misunderstood. Although these studies are published by the Bank, the views expressed and the methods explored should not necessarily be considered to represent the Bank's views or policies. Rather, they are offered as a modest contribution to the great discussion on how to advance the economic development of the underdeveloped world.

ROBERT S. McNAMARA
President
The World Bank
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Preface

The research reported here is part of a broader, continuing exercise at the World Bank to investigate agricultural household response to public intervention in input and output markets. The underlying theme of this effort is the explicit recognition of the dual role of agricultural households as both producers and consumers, not only of goods but also of leisure. This study is based on data drawn from the Muda Valley of Northwest Malaysia and collected under the direction of Roger Slade as part of the FAO-IBRD Cooperative Program. Additional studies of Korea and Nigeria are under preparation.

In completing this research we have benefited substantially from the comments and criticisms of our World Bank colleagues; Clive Bell, Mark Leiserson, and Inderjit Singh were especially helpful in reviewing earlier drafts. Comments received in seminars at Michigan and Yale universities also proved beneficial. Hiroko Miyata typed the manuscript with her usual efficiency and care. The final editing was done by Robert Faherty.

Howard N. Barnum
Lyn Squire
A Model of an Agricultural Household
Introduction and Summary

Governments in both developing and industrialized economies actively pursue various forms of policy intervention, but the effect of many of the most important policies is ultimately determined by the response of economic agents, whether households or enterprises, in the private sector. This is particularly so for policies designed to alleviate poverty and to foster economic growth in the agricultural sector of developing countries, because the relevant economic agent in this instance is both a household and an enterprise. In this case, the effect of any policy intervention must be traced through simultaneous changes in both the production and the consumption behavior of the farm household. For example, when a new technology, such as irrigation facilities, becomes available, production behavior will be immediately and directly affected, and the resulting increase in farm profits will lead to changes in consumption of goods and leisure. Therefore, the overall effect of the change in technology can only be assessed by reference to a model that integrates the decisionmaking process of the farm household with respect to both production and consumption.

Although the concept of the farm household is not new, significant
policy conclusions have not emerged for two reasons. First, at the theoretical level, prediction on the basis of comparative statics is nearly impossible because of the large number of interactions implicit in a model that incorporates both production and consumption behavior. Second, at the empirical level, the need to collect data covering the spectrum of major household activities (expenditure, farm management, and labor utilization) has severely limited the number of actual applications. This study presents the results of an empirical application based on data collected from the Muda River Valley in northwest Malaysia.

This introductory chapter presents a nontechnical summary of the theoretical framework for the analysis and an outline of the main empirical results. It also examines the salient assumptions and implied limitations of the analysis to help provide a balanced perspective on any policy implications that might be drawn from the empirical findings. The central expository chapters are necessarily technical, because the empirical application of the economic theory of the farm household is relatively new. To avoid the possibility that the estimated model would be applied to economic environments not having the characteristics of the Muda River Valley, a concise heuristic description of the model and the underlying assumptions is provided. The empirical findings presented for the Muda River Valley are tentative, as are any new scientific findings, and they are subject to confirmation by separate experiments.


Policy Issues

Although this study describes at length the theoretical underpinnings of the model and the techniques of estimation, the primary concern is the policy content of the results. The model is confined to the short run, and it allows an assessment of the policy significance of changes in five variables that are exogenous to the household:

- The price of the main agricultural output. Of interest here are the elasticities of both total output and market surplus.
- The wage rate for agricultural labor. In particular, attention is focused on the elasticities of household labor supply and demand for hired labor.
- The size of the family labor force. Although the model does not determine the size of the family labor force, it does allow an assessment of the impact of migration on the behavior of the remaining family members. This information is essential for estimating shadow wage rates designed to reflect the cost of supplying labor to the urban or industrialized sector.
- The number of dependents. The model does not determine the number of dependents, but it does allow an assessment of the impact of family-planning policies on household consumption and labor supply.
- Technology. Changes in farm technology are the basic ingredients of all rural development strategies, and they can be expected to have major repercussions on all production and consumption decisions.

The implications of the results for each of these policy issues are discussed in chapter 7, at both the household level and the sector level.

The Theoretical Framework

In order to answer the policy questions raised above, this study presents a theoretically consistent model of production and consump-

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3. The "short run" is defined here as the period during which area operated and family labor force may be treated as given, and it is interpreted as the duration of one agricultural season.
4. At the sector level, the wage rate becomes an endogenous variable and is determined by the interaction of labor supply and demand curves.
tion decisionmaking in farm households. The main features of the model are outlined in this section.

The Role of the Labor Market

An important aspect of the study is the analysis of the determinants of the demand and supply of agricultural labor and the effects of changes in those determinants which, through the labor market, have an impact on income distribution. Although the wage rate, which plays the central equilibrating role in balancing labor demand and supply, is determined in the labor market, the actual decisions underlying labor demand and supply are made at a disaggregated level; that is, at the level of the individual farm for labor demand, and at the level of the individual household for labor supply. In the case of the farm household, however, labor demand and supply decisions are made by the same entity.

The dual role of the farm household as both producer and consumer introduces a potential degree of complexity to the analysis that could have severely encumbered the estimation and theoretical analysis, were it not for the fact that an active labor market exists in the Muda River Valley. Although a few households in the original sample did not participate in the labor market either by buying or selling labor services, those households constituted a very small percentage of the total sample, are not characteristic of the preponderance of the farm households in the Muda region, and were omitted from the sample used in this study. (Evidence for the extent of labor market participation and evidence that the market is competitive are given in chapter 3.)

The important implication of an active labor market is that household decisions about the level of production and labor use can be made independently of household decisions about consumption. Explicitly, because the household has recourse to a labor market, the quantity of labor used in production activities does not depend on household preferences for leisure; rather, it depends only on the conditions of production. The household, like any competitive enterprise, decides the amount of output to produce given the wage, the prices, and the state of technology, with the objective of maximizing profits. This implies a certain demand for total labor (that is, hired and family) but does not imply any particular level of family labor input. The level of family labor input is determined by the household's preference for leisure, on the one hand, and its preference for
INTRODUCTION AND SUMMARY

commodities, on the other. That is, if the household chooses increased leisure, more labor must be hired, farm cash profits are reduced, and the household has less income to buy consumer goods. Alternatively, if the household chooses to supply more of its own labor to the farm enterprise, less hired labor is required, farm cash profits are higher, and the household has more income available for the purchase of consumer goods. In some cases, the household may even sell labor on the market, in which case hired labor can be thought of as being negative. Thus, whereas production decisions are made before, and independently of, consumption decisions, consumption decisions depend crucially on the level of profits generated by the farm enterprise. Accordingly, the estimation of the production side of the model is discussed first, and then the estimation of the consumption side for predetermined levels of farm profits.

Household Production

In chapter 4, output is estimated as a function of the amount of labor, land, capital services, and other variable inputs. Several questions can be answered solely on the basis of the estimated relationship between padi (paddy) output and the inputs into the production process. Do padi farmers employ optimum quantities of labor and other inputs—that is, do they maximize profits? Are tenant farmers any less efficient than owners? Similarly, are farmers who operate large parcels of land less efficient than farmers operating small parcels? And finally, does the length of time farms have been double-cropped have any implications for farm productivity?

The first question, that of profit maximization, can be answered by comparing the estimated increase in output accompanying an increase in factor input with the factor price. It is a well-known result of the competitive theory of the firm that, if a firm is making optimum use of productive inputs, output will be carried to the point at which the costs of additional inputs are equal to the value of additional output. When this comparison is made using the estimates in chapter 4, it is found that, for the two central inputs into the production process, labor and land, the farm household maximizes profits with respect to the former but uses the latter suboptimally. Whereas the value of additional output from extra labor would approximately equal the wage, the value of extra output from the use of additional land would exceed the rental price. This finding is consistent with the treatment of land as a fixed factor—that is, with
land allocation determined primarily by kinship and institutional relationships exogenous to the analysis. Further, the finding that farms maximize profits with respect to labor use is also consistent with the assumption of an active, competitive labor market, and it provides a sound basis for the analysis in chapter 7 of the effect on the labor market of changes in the conditions (prices, wages, and technology) of production.

With respect to the second question, that of the comparative efficiency of tenant-operated and owner-operated farm households, a substantial body of literature argues that owner-operated farms will be more efficient than tenant farms. Part of this literature deals with the behavior of tenant farmers under sharecropping, but the tenant households in the sample used for this study pay a fixed rental charge rather than a share of output. Thus, although the empirical question of relative efficiency under sharecropping cannot be elucidated here, the efficiency of fixed rents can be examined. When the results are submitted to statistical tests, it is found that tenant farms renting land for a fixed fee are as efficient as owner-operated farms. This suggests that tenurial systems which are not detrimental to total production do exist.

The third question, that of the comparative efficiency of small and large farms, arises because arguments for land reform have been based on the supposition that small plots will be operated more efficiently than large ones. The analysis reveals that there is no statistically significant difference in either the technical efficiency of production or the allocative efficiency of labor use for small and large farms. In applying this result, it should be observed that, compared with other regions of the world, farms in the Muda River Valley exhibit only small variation in size; large farms average 2.76 hectares, whereas small farms average 0.95 hectares. As a result of the analysis of economic efficiency for small and large farms, and of owners in relation to tenants, it can be concluded that in the Muda River Valley, where the prevailing tenurial system is a fixed rent and there are no substantial disparities in farm sizes, land reform is not warranted on economic grounds.

Finally, with regard to the fourth question, that of the comparative efficiency of farms double-cropped one year and farms double-cropped two or more years, it is found that the length of time a farm has been

5. One hectare equals 2.471 acres.
double-cropped is associated with a decrease in the technical efficiency of production. That is, at the same level of input use, farms that have been double-cropped less will be more productive. The estimates of the quantitative impact of double-cropping indicate that, if the decline in efficiency in the first crop is parallel to the estimated decline in efficiency of the second crop, then double-cropping will result, not in a doubling of annual yield, but in an increase of only 50 percent. Although further investigations would be needed to substantiate the conclusion, this empirical result is consistent with a decline in soil fertility and points out that concomitant programs, such as increased fertilizer application, may be required to offset the decline in soil fertility.

**Household Consumption**

A farm household provides the conceptual framework underlying this analysis. The household determines the levels of consumption of broad categories of goods, including leisure, that will provide a maximum of satisfaction to household members and that are possible subject to the availability of family income (part of which is farm profits) and time.

An implicit assumption is that household behavior is primarily the result of purposeful, rational decisions designed to provide the greatest possible level of satisfaction for household members, given the available resources. Some traditional or institutional restrictions on behavior may exist—for example, restrictions affecting land distribution—but they are not thought to be sufficient to preclude the application of a model based on the assumption of rational decisionmaking. In fact, tradition and rationality are not necessarily antithetical, and it is plausible that traditional behavior is the result of adaptation that provides optimum responses, in the sense of best use of resources, in many decision situations. The assumption of rational price and wage response in rural agricultural decisions has been tested extensively in various guises and contexts and is now widely accepted.

While other possible disaggregations of consumption could have been defined, three categories have been selected as being sufficiently detailed to answer the questions raised in the introduction yet simple enough to render the analysis tractable. The three consumption possibilities are retained farm production, market purchased goods, and leisure. Retained farm production is that part of farm output (rice) which is consumed within the household itself; market purchased goods are
both agricultural and manufactured goods that are purchased for household consumption; and leisure is that part of discretionary time not used in farm production or in off-farm work activities.

The complexity of choices open to the farm household is illustrated by the household's problem in allocating time. After obligatory uses of time for subsistence needs are deducted, family time can be used in production on the family farm, sold in the market, or consumed as leisure. By devoting more family time to work activities, the household enjoys a gain in income that can be used to increase the amounts of marketed goods or household production consumed. It can be expected that, if the family is attempting to maximize satisfaction, time would be allocated so that the satisfaction lost through the last unit of leisure sacrificed would be just offset by the satisfaction gained from the use of the added income derived from the additional work.

The extent to which additional work increases income depends on the market wage if the additional time is sold on the labor market, or on the conditions of production (such as wages, price of padi, and state of technology) if the additional time is applied to farm production. The degree of satisfaction obtained from added income is in turn dependent on the prices of the commodities consumed and the characteristics of the household (such as education and number of dependents). If the arguments noted above are followed through, the quantity of time devoted to leisure is likely to be a function of wages, prices for other commodities consumed, household characteristics, and conditions of production. A similar line of thought could be traced to argue that the quantity of farm output and the quantity of market goods consumed are also functions of wages, prices, household characteristics, and the conditions of production. This is the substance of the arguments developed in chapters 6 and 7, in which the three functions determining household consumption are derived and estimated. The estimated household consumption equations, when integrated with the estimated production behavior, then form the basis for evaluating the responses of the farm household to various changes in economic conditions.

For instance, on the basis of the estimated production and consumption segments of the household, it is found that the average individual household in the sample from the Muda River Valley will respond to a 10 percent increase in the price of rice with a 6 percent increase in the quantity of rice produced and a 20 percent increase in the quantity of market goods consumed. With regard to labor, it is found that a 10 percent increase in the price of rice will provide a 6
percent reduction in household labor supplied but a 16 percent increase in the demand for farm labor (in other words, part of the increase in potential farm income attributed to the padi price increase will be translated into an increase in leisure). Other household responses to changes in family labor force, dependents, and technical efficiency are given in chapter 7.6

A methodological consideration in the estimation of the consumption side of the model concerns the definition of leisure. Usually, the amount of time allocated to leisure is derived as a residual by subtracting total observed work time from total time available. The derived variable is then used as the dependent variable to estimate a demand function for leisure. This procedure, however, invariably results in the inclusion of a variety of work activities (such as household chores and the production of nonagricultural goods for on-farm consumption) in the definition of leisure. Alternatively, direct observations on the amount of time worked can be used as the dependent variable to estimate a supply curve of labor. For purposes of comparison, the results of this analysis are based on both the leisure demand approach and the labor supply approach. In addition, the role of nonagricultural goods and services produced and consumed on the farm is examined in the theoretical section (chapter 3) 7

Similarly, alternative specifications of the utility function are examined in an attempt to render the quantitative results as robust as possible. The two specifications employed are those underlying the linear expenditure system and the linear logarithmic expenditure system.8 Since each specification imposes a different set of restrictions

6. See table 16. The responses in that table are given in the form of elasticities. An elasticity gives the percentage change in one variable with respect to a percentage change in another. For instance, the elasticity of household padi output with respect to the price of padi is 0.6. Elasticities are useful because they are free of the units of measurement. Thus, one does not need to know whether the price is measured in U.S. dollars or Malaysian dollars, or whether the output is measured in gantang or bushels.


on the resulting expenditure system, they serve as a highly desirable means of cross-checking results. The choice of a preferred specification depends on the problem to be addressed: it appears that the linear expenditure system may be the more useful vehicle of analysis in this instance since the linear logarithmic expenditure system sets all expenditure elasticities identically equal to unity. This restriction is particularly severe when the theory of the farm household is applied. More generally, it can be concluded that specifications of the utility function which restrict the value of the expenditure elasticities should be avoided in analyses of this type. This and other methodological issues relating to the consumption side of the model are discussed in chapter 6.

**The Aggregate Effect of Household Responses**

Although the estimated responses of the individual farm households form the basis for the policy implications derived from the study, they cannot be used directly to calculate the effects on policy. Instead, the responses of all households need to be aggregated, under the assumption that all households will respond to a given change in the same way that the representative household is estimated to do; then the market interaction of the aggregate of household responses must be considered. To continue the example in the preceding section, although a 10 percent increase in price will lead to an initial effort by the representative household to increase labor hired by 16 percent and to increase output by 6 percent, the final impact on labor hired and on padi output will be negligible after taking into account the labor market interaction of the aggregate household response. This occurs because the market wage will increase as all households attempt to hire additional labor in order to increase output. The increase in wage makes the initial increase in household output less profitable and results in a downward revision of household production plans, as compared with what was planned before labor market interaction took place.

The aggregation of the household responses in this manner depends on the assumption that the estimated household is typical and can be considered representative of the households making up the entire market. Some support for this assumption is derived from the structure of the sample on which the analysis is based. Most agricultural households in the region are landed, produce padi, have only a moderate degree of educational attainment, and have at least two de-
pendents. If it is found, however, that a significant proportion of households do not behave like the representative household, then the results based on market aggregation would need to be rejected or given a tempered interpretation.

Policy Implications

The policy implications of the analysis are derived under the assumption that the labor market is the only market where the aggregation of the actions of the individual households will have a significant impact. The prices of the other inputs and the price of padi are determined in national or international markets, where the collective effect of Muda household behavior is negligible. Further, because the analysis is short run, the immediate effect of aggregate household behavior on area operated, technology adopted, number of dependents, and available household time is assumed to be negligible.

The market responses based on the aggregate of all household responses allow answers to be formulated to the policy questions raised above. These responses, and therefore the policy implications, contrast with the responses that would be obtained if the labor market effects were ignored.

A central assumption in incorporating the labor market is that the supply of nonhousehold labor forthcoming at the present wage is not unlimited. If it were, the labor market effects of collective household actions would not need to be considered, because there would be no associated change in wages. In this case, the responses on which policy analysis would be based would be those estimated directly for the individual households. It is assumed, however, that the response of hired labor to a change in wages is essentially nil. This is consistent with the observation that real wages in the Muda River Valley have increased rapidly since 1970, thereby suggesting a fairly restricted response on the part of hired labor to changing economic circumstances. The market responses are not highly sensitive to changes in this assumption. Thus, even if one rejects the assumption that the response of nonfarm households to a wage change is negligible and argues that the response is positive, the policy conclusions are apt to remain unaffected unless there is an endless supply of, say, migrant labor available to the Muda region. In many areas where one might conduct a household analysis of the kind reported here, there is a substantial supply of migrant labor; this is not, however, the case.
for the Muda River Valley, and the policy conclusions have been derived based on the assumption that the supply of labor at the prevailing wage is not unlimited.

**Rural-Urban Migration**

What is the cost, in terms of foregone rural production, of the movement of labor from rural to urban areas? Many attempts to answer this question have been based on a consideration of only the production side of the farm household. These attempts are focused only on the direct relationship between labor input and agricultural output. A major problem with this narrow focus is that it neglects both the reorganization of household consumption patterns (especially with regard to leisure) and the impact of the labor market on the agricultural wage. In contrast, in this study it is found that, after household reorganization and market interaction are taken into account, the cost of rural-urban migration will be less than 50 percent of the cost based only on the direct relationship of labor to agricultural production. In other words, the transfer of rural labor to urban areas will result in a net gain in output, provided the urban gain in output exceeds 50 percent of the direct estimate of the loss in agricultural output.

**Output Price Intervention**

During the 1965–72 period, the Malaysian government actively intervened in the market for rice to maintain a 7 to 13 percent premium in the price of rice. Estimates indicate that the effect of the intervention on output has been nil, but that the effect on income distribution may have been substantial. Because of the impact on market wages and the limited response of labor to wage increases, the higher price is translated into an increase in both the wage bill and farm incomes without any increase in padi production. From the point of view of nonfarm rural households, the welfare loss from higher padi prices is offset by the welfare increase from higher wages. The estimates presented indicate that wages will be increased by approximately 13 percent for a price increase of 10 percent, while employment will remain essentially unchanged. For other households, the welfare loss from higher padi prices is partially offset by the fact that consumption of nonfarm goods by farm households is estimated to increase by 20 percent for every 10 percent increase in the price of rice, thereby
increasing the incomes of households producing such goods. Thus, the income distributinal effects of a price increase are to give substantial benefits to farm households while giving smaller benefits to nonlanded rural households and possibly negative benefits to other households.

Changes in the Number of Dependents

Although many questions about the impact of changes in the number of dependents address the long-run effect of family planning on changes in fertility, there is also the question of the impact of a smaller number of dependents on short-run household behavior. The estimated household model confirms that the number of dependents is one of the determinants of the use and consumption of household time. The estimates indicate that a reduction in the number of farm household dependents will be accompanied by a small reduction in the supply and demand of agricultural labor. The impact on own consumption of padi by the producing household and on market surplus is greater, with a 10 percent reduction in dependents leading to a 5 percent increase in marketed surplus. A successful family-planning program might offset the loss in output from rural-urban migration. The estimates indicate that a 2 percent reduction in the number of dependents would release enough marketed surplus to offset the effect of a 10 percent reduction in the rural labor force.

Technological Change in Agriculture

The effect of technological change in padi production is to improve the welfare of both farm households and landless rural households. The household model illustrates that the impact of technological change goes further than the increase in labor demand stemming from the increase in labor productivity associated with the type of technological change considered here. Because of the considerable effects that even modest degrees of technological innovation have on farm profits, there is a sizable impact on household consumption, which

9. Neutral technological innovation, which increases the absolute level of productivity of all inputs without changing the relative productivity of inputs, is considered in this study. Improvements in seed varieties and irrigation are often considered as roughly neutral technological changes of this sort.
leads to a reallocation of time toward greater consumption of leisure. The increase in labor demand and the decrease in household labor supply lead to a substantial increase in the demand for off-farm padi labor. As a consequence, the wage bill increases markedly. Thus, the benefits of agricultural innovation accrue not only to landed households but are also transmitted through the labor market to nonlanded laborers.

Conclusion

The research reported here was designed with two objectives in mind. The first objective was to present a model of farm household behavior that incorporates in a theoretically consistent fashion the decisionmaking processes determining both production and consumption behavior. Much of the existing literature treats these processes separately. The second objective was to analyze a number of policy issues that are of current interest for development specialists not only in Malaysia but also in other countries. Although the model, and hence the policy conclusions, closely reflect the reality of the Muda River Valley, they are based on a set of assumptions that need to be kept in mind when the policy implications of the econometric results are assessed.
The Muda River Valley

The Muda River Valley, located in the extreme north-west section of peninsular Malaysia, comprises the state of Perlis and four administrative districts in the state of Kedah. Padi cultivation is the main occupation of more than 50,000 families in the area, which contains approximately 30 percent of the padi land in Malaysia and accounts for almost 50 percent of total padi output. The recent switch from single- to double-cropping, after completion of new irrigation facilities (the Muda Irrigation Project), has been accompanied by a significant increase in output, from 277,000 tons in 1965 to 678,000 tons in 1974.

According to a 1972–73 survey of 534 double-cropping households in the Muda River Valley by the Food and Agriculture Organization (FAO) and the International Bank for Reconstruction and Development (IBRD), mean family size in the area is 3.1 adults and 2.6 children, and mean farm size is 5.6 relong. Regarding tenurial status, owner-operators account for 41 percent of households and 38 percent


2. One relong equals 0.71 acres.
of the land, whereas pure tenants account for 37 percent of households and 30 percent of the land. The remaining land is operated by owner-tenants—that is, those who operate more land than they own.

Production and Incomes

Padi households in the Muda River Valley allocate a large share of their working time to padi cultivation, and they derive the major portion of their income from that activity. They also engage in non-farm wage-employment and produce cash crops and nonagricultural goods for on-farm consumption. A breakdown of the man-hours devoted to the various income-earning activities in 1972–73 and the net return for each activity are presented in table 1.

Clearly, padi cultivation is both the main labor activity and the main source of income. Wage-employment, although important in terms of labor utilization, produces only 3 percent of household earned income. The third income-earning activity, production of other cash crops, does not require much labor and contributes little to total household earned income. In addition, households devote 449 hours annually to the production of nonagricultural goods for on-farm consumption, and they have several other sources of unearned income. Regarding earned income, it can be concluded that Muda padi households are relatively well off; annual earned income is slightly more than M$860 a person.

Table 1. Net Returns to Family Labor by Activity, 1972–73

<table>
<thead>
<tr>
<th>Activity</th>
<th>Labor input</th>
<th>Net return</th>
<th>Labor productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Man-hours</td>
<td>Malaysian</td>
<td>dollars per man-hour</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>dollars</td>
<td>Percent</td>
</tr>
<tr>
<td>Padi cultivation</td>
<td>1,166</td>
<td>4,605</td>
<td>95</td>
</tr>
<tr>
<td>Wage-employment</td>
<td>601</td>
<td>125</td>
<td>3</td>
</tr>
<tr>
<td>Other cash crops</td>
<td>26</td>
<td>106</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>1,793</td>
<td>4,836</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: Sample size is 534 farm households.
Source. Data from the FAO-IBRD survey.
A rather surprising observation drawn from table 1 is the low level of labor utilization. For the average household, each adult works 723 hours a year (1,793 hours plus 449 hours divided by 3.1 adults per household), of which 578 hours a year are in income-generating activities. Such a low level of labor utilization may reflect either an absence of employment opportunities or a strong preference for leisure. The evidence is consistent in supporting the latter hypothesis over the former. In particular, Goldman and Squire demonstrate that access to an active labor market ensures that income-earning employment per adult is not constrained by area operated per adult:

For example, for households with a family labor force of between 2 and 4 adults, hours worked per adult in income-earning activities remains roughly constant as area operated increases: the relevant figures are 608 hours per adult for households operating <3 relong; 629 for households operating 3–6 relong; and 602 for households operating more than 6 relong. On the other hand, wage-employment per adult decreases rapidly with area operated: for the same groups of households wage-employment per adult is 334 hours, 220 hours and 124 hours respectively. The ability of households operating relatively small areas of land to obtain as much income-earning employment as households with larger areas of land by increasing off-farm employment is a clear indication that the total number of hours worked is not constrained by area operated but is determined in the light of the household’s income-leisure trade-off.3

Given the importance of padi cultivation, production techniques can be described in greater detail. Land preparation for the first crop (that crop which relies on rainfall) usually begins in September/October and is mainly performed by men. The fields may be prepared by hand, draft animal, tractor, or some combination of these. Transplanting follows immediately and is a task performed almost exclusively by women. Harvesting occurs in February/March and it, again, is a task for women, while the almost simultaneous operation of threshing is undertaken by men. The second crop (that crop which

3. “Income-earning activities” include padi cultivation, wage-employment, and production of other cash crops. Goldman and Squire include cash crops in wage-employment but, because the former is negligible, this does not weaken the force of their argument. See Goldman and Squire, “Technical Change, Labor Use and Income Distribution,” p. 11.
Table 2. Seasonality, Labor Utilization, and Labor Market Participation, November 1972 to November 1973

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<tbody>
<tr>
<td>Labor utilization per household (manhours)</td>
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<tr>
<td>1. Total padi labor input</td>
<td>101</td>
<td>112</td>
<td>320</td>
<td>135</td>
<td>88</td>
<td>198</td>
<td>123</td>
<td>71</td>
<td>144</td>
<td>328</td>
<td>252</td>
<td>224</td>
<td>114</td>
</tr>
<tr>
<td>2. Hired padi labor input</td>
<td>18</td>
<td>60</td>
<td>191</td>
<td>78</td>
<td>29</td>
<td>99</td>
<td>36</td>
<td>7</td>
<td>79</td>
<td>190</td>
<td>117</td>
<td>107</td>
<td>33</td>
</tr>
<tr>
<td>3. Family padi labor input</td>
<td>93</td>
<td>52</td>
<td>129</td>
<td>57</td>
<td>59</td>
<td>99</td>
<td>87</td>
<td>64</td>
<td>65</td>
<td>138</td>
<td>135</td>
<td>117</td>
<td>81</td>
</tr>
<tr>
<td>4. Family wage-employment</td>
<td>30</td>
<td>46</td>
<td>50</td>
<td>37</td>
<td>32</td>
<td>52</td>
<td>36</td>
<td>45</td>
<td>61</td>
<td>69</td>
<td>55</td>
<td>53</td>
<td>34</td>
</tr>
<tr>
<td>5. Nonpadi, nonwage labor use</td>
<td>46</td>
<td>43</td>
<td>32</td>
<td>43</td>
<td>32</td>
<td>27</td>
<td>38</td>
<td>47</td>
<td>44</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>39</td>
</tr>
<tr>
<td>6. Total family labor use</td>
<td>159</td>
<td>141</td>
<td>211</td>
<td>137</td>
<td>123</td>
<td>178</td>
<td>161</td>
<td>156</td>
<td>170</td>
<td>235</td>
<td>219</td>
<td>200</td>
<td>154</td>
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<tr>
<td>Proportion of households participating in the labor market</td>
<td></td>
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<tr>
<td>7. Households hiring in labor</td>
<td>0.05</td>
<td>0.10</td>
<td>0.26</td>
<td>0.22</td>
<td>0.33</td>
<td>0.24</td>
<td>0.13</td>
<td>0.06</td>
<td>0.10</td>
<td>0.22</td>
<td>0.31</td>
<td>0.21</td>
<td>0.12</td>
</tr>
<tr>
<td>8. Households hiring out labor</td>
<td>0.46</td>
<td>0.50</td>
<td>0.32</td>
<td>0.37</td>
<td>0.21</td>
<td>0.27</td>
<td>0.40</td>
<td>0.63</td>
<td>0.53</td>
<td>0.24</td>
<td>0.16</td>
<td>0.26</td>
<td>0.39</td>
</tr>
<tr>
<td>9. Households hiring in and hiring out labor</td>
<td>0.05</td>
<td>0.14</td>
<td>0.35</td>
<td>0.23</td>
<td>0.35</td>
<td>0.41</td>
<td>0.15</td>
<td>0.06</td>
<td>0.21</td>
<td>0.48</td>
<td>0.48</td>
<td>0.43</td>
<td>0.14</td>
</tr>
<tr>
<td>10. Total labor market participation</td>
<td>0.56</td>
<td>0.74</td>
<td>0.93</td>
<td>0.82</td>
<td>0.89</td>
<td>0.92</td>
<td>0.68</td>
<td>0.75</td>
<td>0.84</td>
<td>0.94</td>
<td>0.95</td>
<td>0.90</td>
<td>0.65</td>
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Note: Each period is of four weeks' duration, commencing with the dates shown.
Source: FAO-IBRD survey.
relies on irrigation water) runs from April/May to August/September and more or less repeats the first crop cycle. The overlap in the two crop cycles reflects the different starting dates in different areas, depending on the release of irrigation water and the arrival of the monsoon rainfall.

Peak labor demands occur in February/March, when the first crop is being harvested, and again in August/September, when the second crop is being harvested. The slack months are December and June, when the only labor required is tending the growing plants in the first and second seasons. Total labor input is 186 man-hours per elong per crop. Over the entire agricultural cycle, hired labor is important (accounting for 45 percent of the total labor input), as is female labor (accounting for 52 percent of the total labor input), but the use of child labor (less than fifteen years of age) is essentially nil. Second-crop yields tend to be slightly better than first-crop yields, but the difference is usually small. The yield for the first crop in 1973 was 1.55 tons an acre, as compared with 1.62 tons an acre for the second crop that year.

**Labor Utilization, Labor Market Participation, and Seasonality**

Evidence on labor utilization and labor market participation in a seasonal context is presented in table 2, which also gives several employment indicators for thirteen periods of four weeks covering one calendar year, from November 1972 to November 1973. The first crop was harvested in the period beginning January 10 and the second crop in the period beginning August 22; demand for padi labor peaks in these periods. The table contains information on the last half of the 1973 first-crop cycle (periods November 15 through February 7), the entire 1973 second-crop cycle (periods March 7 through September 19), and the first half of the 1974 first-crop cycle (periods September 19 through October 17).

Total family labor supply (row 6) is the sum of family padi labor input (row 3), family wage-employment (row 4), and nonpadi, non-wage family labor (row 5), which includes time allocated to both cash crops and nonagricultural commodities. The coefficient of variation (0.20) is quite low, indicating that total family labor utilization is not subject to severe seasonal fluctuations. Similarly, off-farm wage-employment, with a coefficient of variation of 0.26, is spread fairly
evenly throughout the year and is not confined to the peak agricultural seasons (periods January 10 and August 22).

The coefficients of variation shown in rows 1 through 6 reveal that while total demand for padi labor is seasonal (coefficient of variation of 0.51), the family input into padi is less seasonal (coefficient of variation of 0.35), and total family labor supply is even less subject to seasonal influences (coefficient of variation of 0.20). Muda padi households offset the effect of a seasonal production process by using hired labor, on the one hand, and by obtaining outside employment, on the other, so that total family labor supply is largely free of seasonal fluctuations.

Table 2 may also be used to establish the quantitative significance of labor market participation. Thus, throughout the year, off-farm wage-employment is typically of the order of 20 to 25 percent of total family labor supply, and hired labor varies from more than 40 percent of total padi labor input in eight of the thirteen periods to less than 20 percent in only two periods. It may be concluded that Muda padi households both sell and buy labor services to a significant degree throughout the year.

Although it has been established that selling and buying labor services is an important activity for the average Muda household, it is still possible that many households do not participate in the labor market. To test this possibility, rows 7 through 10 indicate the proportion of households participating in the labor market at any time. The three categories (hiring in, hiring out, and both hiring in and hiring out) are mutually exclusive and, therefore, can be added to obtain total labor market participation (row 10). The coefficient of variation (0.16) is low, indicating that labor market activity is not confined to the peak agricultural seasons. In fact, more than 80 percent of the households participate in the labor market in eight of the thirteen periods, and the participation rate falls below 60 percent in only one period. During the course of the year, all households participate in the labor market in various ways. It can thus be concluded that labor market participation is an important activity for the vast majority of households throughout the year.

Product and Factor Markets

Since padi cultivation is the main occupation of Muda households, attention is focused on the market for padi output and the markets for the two main inputs into padi—labor and land.
Regarding the formation of the price for Malaysian padi, two aspects warrant discussion. First, although the increased output resulting from the Muda Irrigation Project has substantially reduced the country's dependence on imported supplies, imports still make up approximately 15 percent of consumption requirements. Changes in domestic production, therefore, do not influence domestic prices. Second, import prices only partially determine the domestic padi price level, because padi production benefits from a substantial, but variable, element of protection deriving from a combination of licensing restrictions and an import surcharge. Rice prices in Malaysia have continually been supported above the world market level since 1957, except during 1973-74. In those two years, the world price of padi increased greatly and protection was unnecessary, in fact, during those years, negative protection existed temporarily in the Malaysian market because of substantial import subsidies. When world prices fell in 1975 and 1976, however, Malaysia resumed its policy of providing protection to padi farmers.

Regarding the labor market, it has already been established that most padi households participate in the labor market both as buyers and as sellers. Two conditions of a competitive market are, therefore, likely to be met quite convincingly; that is, the market contains many buyers and many sellers, and information concerning wage rates is general knowledge. Nevertheless, the possibility remains that markets are localized and that labor market transactions are conducted mainly within kin groups. Although Muda farmers hire labor largely from their own village or those nearby, nearly 30 percent of the farmers reported using non-Muda, migrant labor in 1975. There was no positive evidence that Muda farmers hired exclusively from within kin groups. Even though local sources dominate, there is no reason to suppose that nonmarket forces are operating in the selection of hired labor, and there is sufficient migrant labor from Baling, Kelantan, and Sik in Malaysia, as well as from southern Thailand, to suggest the existence of a competitive market.

The presumption of a competitive market receives further support from a brief examination of the behavior of agricultural wage rates following the implementation of the Muda Irrigation Project. Evidence documented by Goldman and Squire reveals that hired

labor costs per relong increased from about M$8 for transplanting and M$24 for harvesting in 1967–68 (that is, in the preproject situation) to M$31 and M$58 in 1974–75 (that is, in the postproject situation). During the same period, the price of padi increased by over 100 percent for the reasons discussed above, and the consumer price index rose by approximately 40 percent. Although the relative factor price (the wage divided by the price of padi) has not increased greatly, the real return to employment (the wage deflated by the consumer price index) has increased substantially, suggesting that both a competitive labor market and a relatively inelastic labor supply exist.

The actual mechanism of wage payments warrants discussion because workers are rarely paid a wage for a unit of time. Transplanters and harvesters usually work in groups and are paid by the area completed. As a result, groups that work more efficiently can earn a higher daily wage. Unfortunately, no information is available either on the formation of the groups or on the way the group divides its earnings. It is probably safe to assume, however, that the effective wage rate per unit of time per worker varies considerably, especially among groups but probably also within groups. Wage data calculated from the FAO-IBRD survey confirm that earnings per unit of time from employment in the padi sector do vary considerably among individuals.

As with the labor market, the rental market for land is important in the Muda River Valley, with nearly 60 percent of all padi households operating some rented land. Unlike the labor market, however, there is ample evidence to indicate that the land market is confined largely to intrafamily transactions. Thus, “71 percent of the estimated 28,000 tenant households are actually renting their relatives’ lands. Nearly a quarter of these are operating padi lands which one day they will inherit from their parents.” It might be expected that land rentals do not obey the laws of supply and demand but are determined by a variety of noneconomic considerations, especially those concerning transfer payments between kin.

One other feature of the rental market for land warrants discussion: that is, the almost universal tendency to define tenurial contracts either formally or informally by fixed, cash rentals. According to theory, inefficiencies in allocating resources cannot arise from the

nature of the rental contract (whereas they may occur under sharecropping), because the fixed rental does not influence the marginal, profit-maximizing conditions. Although using fixed rentals does not ensure profit maximization, the absence of sharecropping does ensure that one important, potential cause of economic inefficiency has been eliminated.6

Conclusion

The above description of various aspects of the economic environment of the study area contains important information for selecting a model of household behavior suitable for estimation. In particular, three features of the economic environment underlie the eventual selection of a model. The first is the existence of an active market for agricultural and other types of labor. All households participate in the labor market either as buyers or as sellers. Most households both buy and sell labor. The second feature is the importance of padi. Padi is grown on all farms included in the sample to the virtual exclusion of other crops. The third feature is the practice of renting land by means of fixed charges rather than sharecropping.

The implications of these features can be illustrated briefly. First, the existence of an active labor market ensures that household consumption decisions can be taken independently of production decisions. Second, because the Muda River Valley is a monoculture, the model need contain only one production function. Third, the absence of sharecropping ensures that the marginal, profit-maximizing conditions are not distorted by the nature of the rental contract.

6. Tests for profit maximization are conducted in chapter 4.
A Theoretical Model of an Agricultural Household

A conventional approach to the theoretical analysis of household behavior is to maximize a utility function that is defined over a set of commodities and leisure and is subject to a number of technological constraints, an income budget, and a time budget. The application of standard consumer theory yields first- and second-order conditions that allow a comparative statics analysis, which can be used to restrict the parameters of the derived labor supply, output supply, and commodity demand functions. The value of this approach in the context of labor and output supply and commodity demand behavior in rural areas of developing countries, however, is severely circumscribed by the diversity of rational choices open to household decision-makers. For example, rural households may be producers and consumers of both marketed and nonmarketed commodities, and they may or may not participate in a labor market.

In view of the complexity of the issue, economists have resorted to a variety of simplifying assumptions in order to ensure analytical

solutions within the utility-maximizing framework. This chapter attempts to assess the theoretical significance of some of these simplifications regarding predictions of output and labor supply response. More specifically, it aims to assess the theoretical significance of introducing the production of nonagricultural goods into a model of household behavior, and to examine the role of labor market participation in determining output and labor supply response.

Thus, the chapter presents a general model of household behavior that draws on the analysis of nonagricultural goods developed by Hymer and Resnick but also allows for labor market participation. It is shown that, in the absence of household participation in the labor market, the sign of the agricultural output response to a price change (and hence the response of family labor supply to agricultural activities) cannot be predicted, although one can strongly presume that the sign will be negative. It is further shown that, if the household participates in the labor market, the output response will always be positive, but that the supply response of family labor will be negative.

A Model of the Rural Household

The household is assumed to maximize a utility function of the form:

\[
U = U(Z, L, C, M)
\]

subject to

\[
U_i > 0, \quad U_{ii} < 0,
\]

where the arguments of the utility function refer to aggregates, both over household members and over the agricultural cycle. Thus, both the distributional rules within the household and the role of seasonality are ignored. The arguments of the function are:

- \(Z\) = consumption of \(Z\) goods,
- \(L\) = leisure,
- \(C\) = own consumption of agricultural output, and
- \(M\) = consumption of market-purchased goods.

\( U \) is maximized subject to an income constraint and a time constraint:

\[
(2) \quad p(F - C) + wN + A = qM,
\]

and

\[
(3) \quad L + N + T + H = D,
\]

where

\[
\begin{align*}
p & = \text{price of } C; \\
q & = \text{price of } M; \\
F & = \text{total agricultural output}; \\
w & = \text{wage}; \\
A & = \text{nonwage, noncrop, net other income}; \\
N & = \text{quantity of labor sold if } N > 0 \text{ and quantity of labor purchased if } N < 0; \\
T & = \text{time allocated to production of } Z \text{ goods}; \\
H & = \text{time allocated to production of } C \text{ (including both family and hired labor time)}; \text{ and} \\
D & = \text{total available time}.
\end{align*}
\]

The symbols are self-explanatory, but \( Z \) and \( N \) may require further elucidation. \( Z \) goods are defined here as commodities that are produced and consumed by the household but are not marketed because no such market exists.\(^3\) By way of contrast, \( C \) goods, although produced and consumed by the household, are marketed, whereas \( M \) goods are consumed but are not produced by the household. Hired labor is assumed to be used in \( F \) production only; \( Z \) production is entirely by household labor. For a labor-buying household \( N < 0 \), whereas \( H \), the labor assigned to \( F \) production, exceeds by \( N \) the labor supplied to \( F \) production by household members. For a labor-selling household, however, \( N > 0 \) and all \( F \) production labor is supplied by household members. Finally, if the household does not

\(^3\) Hymer and Resnick include in this category: food and fuels processing; spinning; textile weaving; metal working; leather dressing and tanning, the manufacture and repair of tools and implements; pottery and ceremonial objects, as well as investment in housebuilding, fence repairing, and services such as recreation, protection, transport and distribution. The investment activities mentioned by Hymer and Resnick are not consistent with the definition of \( Z \) goods used here, nor with their own analysis in which \( Z \) goods appear directly in the utility function. See ibid.
participate in the labor market, either as a buyer or as a seller, then \( N = 0 \).

In addition, the model has two production functions:

\[ F = F(H), \]

and

\[ Z = Z(T). \]

Both functions have positive but diminishing marginal products and are written as functions of labor only, even though other inputs (for example, land) may be used. Decisions relating to the total stock of land and labor are treated as given. Migration, which affects total available household labor stock, is thus omitted from the analysis, as is the rent decision, which affects the total available household land supply. Therefore, land is treated as a fixed factor and is not determined within the model. This procedure is justified by limiting the planning horizon to only one agricultural cycle. Nevertheless, the rental contract could still play a role in the analysis if sharecropping is common. If, however, the land market is based on fixed rental contracts (as is the case in the Muda River Valley), the model need not treat explicitly the payment or receipt of land rent; the actual flow of rent payments or receipts can then be captured implicitly in \( A \) (nonwage, noncrop, net other income).

The emphasis in this model, therefore, is on the role of the labor market, the land market would assume importance in other situations (for example, where sharecropping is important) or in the face of other problems (such as the need to determine the area operated).

Other long-term decisions are also omitted from the analysis. In particular, it is assumed that the household has already made some decision about its desired level of saving and that this quantity is also included in the definition of \( A \). Finally, the analysis ignores risk,

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4. In the following chapters, the padi production function is expanded to include additional variable inputs, but this does not alter the general conclusions reached in the one variable analysis in this chapter.

5. This procedure needs modification if the rental changes, even if the area rented does not. This is unlikely within a single agricultural cycle but could be important if the analysis is extended beyond one cycle. It is shown in chapter 7 by means of sensitivity analysis that this is not a significant consideration, and it is therefore ignored at this point.
again on the grounds that, while risk may play a crucial role in the migration decision or the rent decision, it plays a less important role in the short term when it can be assumed that the longer-term decisions have already been made and that the household is, at least to some extent, committed to a fairly well-defined course of action for the duration of the agricultural cycle.\footnote{The significance of excluding risk for the estimation procedure is commented on briefly below.}

The household is assumed to choose the values of $Z$, $L$, $C$, $M$, and $\lambda$ that maximize the Lagrangian:

$$\mathcal{L} = U(Z, L, C, M) - \lambda(pF[D - N - T(Z) - L] + A + wN - pC - qM),$$

where the time constraint has been used to substitute for $H$, and $Z = Z(T)$ has been replaced by $T = T(Z)$ with $T' > 0$ and $T'' > 0$.

First-order conditions for a maximum are:

(6) \quad U_Z + \lambda pF'T' = 0,
(7) \quad U_L + \lambda pF' = 0,
(8) \quad U_C + \lambda p = 0,
(9) \quad U_M + \lambda q = 0,
(10) \quad \lambda(pF' - w) = 0,$$
(11) \quad pF[D - N - T(Z) - L] + A + wN = pC + qM.$$

Equations (8) and (9) are the standard first-order conditions from consumer demand theory, and equations (6) and (7) are similar in that $pF'T'$ and $pF'$ can be interpreted as the price of $Z$ and $L$, respectively. Equation (10) is the profit-maximization condition for labor transactions, and equation (11) is the combined income and time constraint. The multiplier ($-\lambda$) can be interpreted as the marginal utility of income.

Using equation (10) to substitute $w$ for $pF'$ in equations (6) and (7) and totally differentiating the resulting five-equation system, the solution for the vector $dx$ of differentials $dZ$, $dL$, $dC$, $dM$, and for $d\lambda$ can be expressed as:

(12) \quad dx = H^{-1} dy,$$

where $H$ is the bordered Hessian and
The individual solutions for the five elements of the vector $dx$ are:

$$dx_j = \frac{1}{D} \sum_i dy_i D_{ij}$$

where $D$ is the determinant of $H$, and $D_{ij}$ is the $i^{th}$ cofactor of $H$.

Theoretically, the individual solutions allow one to consider the effect of small changes in the parameters on the dependent variables. Dividing the individual equations by the differential of the parameter being considered, holding the values of all other parameters constant, and expressing the value of the determinants $D_{ij}$ explicitly in terms of their elements would allow a comparative statics analysis and, possibly, a prediction of the sign of the effect on the dependent variable. Unfortunately, the large order of the determinants of the cofactors renders algebraic reduction impractical for two reasons. First, the sign of the own-substitution effect and the income effect (usually assumed to be positive) may be different; and second, the cross-substitution effects cannot be signed a priori. The complexity of the problem, however, can be limited by omitting certain decision variables in order to arrive at a solution that has policy content.

In the following section, the model of an agrarian economy developed by Hymer and Resnick is adapted to an analysis of household behavior. In this model, the production of nonagricultural commodities plays an important role, but labor market participation is omitted. In view of the importance of labor market activities in the Muda River region, this omission is rectified later in this chapter.

A Model of an Agricultural Household Producing Nonagricultural Commodities

The basic assumptions of the $\zeta$ goods model in its simplest form are: (a) $C = 0$; (b) $N = 0$; (c) $L = \bar{L}$, a constant; and (d) $\zeta$ is an
inferior good. The first assumption implies that own consumption of $F$ production is zero. That may be acceptable for some types of $F$ production (for example, cotton or rubber) but not for others (for example, maize or rice). The empirical plausibility of this assumption is not at issue here: the assumption will be accepted throughout the analysis as a convenient simplification, but wherever necessary the significance of own consumption will be indicated in footnotes. The second assumption indicates that the household does not participate in the labor market. The third assumption implies that the total time devoted to work activities is fixed, that is, labor's supply is perfectly inelastic. The utility implications of this assumption are. if $L > \bar{L}$, then $U_L \to 0$, and if $\bar{L} < L$, then $U_L \to \infty$. Thus, the model makes a strong assumption regarding labor supply response. Moreover, the importance of this assumption is considerably magnified by the fourth assumption—that $Z$ is an inferior good. Together, they have significant implications for the model's predictive ability regarding output response and will, therefore, be examined in some detail.

For the $Z$ model, the response of output to price changes can be obtained by modifying the first- and second-order conditions to allow for the assumptions made above. The modification required for assumptions (a) and (c) is the deletion of the second and third rows and columns of the bordered Hessian. The modification required for assumption (b) is the deletion of equation (10) from the first-order conditions, which in turn requires that $d\omega$ be replaced by $Fdp - pF' TdZ$; that is, the total differential of $\omega$ is replaced by the total differential of labor's marginal revenue product in $F$ production, $pF'$. With these modifications:

\[
\frac{dF}{dp} = F' \frac{dH}{dp} = -T' \frac{dT}{dp} = -T' \frac{dZ}{dp},
\]

and

\[
(14) \quad \frac{dZ}{dp} = T' F' S_{ZZ} + FI_Z + (C_Z + T' C_F) \frac{d\omega}{dp},
\]

where

\[
S_{ZZ} = -\lambda \frac{D_{11}}{D},
\]

\[
I_Z = \frac{D_{12}}{D},
\]
A THEORETICAL MODEL OF AN AGRICULTURAL HOUSEHOLD

\[ C_Z = -\lambda \frac{D_{11}}{D} pF'T", \text{ and}\]

\[ C_F = -\lambda \frac{D_{11}}{D} pT'(-F") .\]

\( S_{ZZ} \) and \( I_Z \) are the own-substitution and income effects, respectively, of standard consumer theory. \( C_Z \) and \( C_F \) are described as curvature effects, the former arising from the nonlinearity of the \( z \) production function and the latter from that of the \( F \) production function. The terms on the right-hand side of equation (14) may be signed as follows: because the indifference curves are convex to the axis, \( S_{ZZ} < 0 \); \( z \) is assumed to be an inferior good so that \( I_Z < 0 \); and given \( S_{ZZ} < 0 \) and the assumptions about the production functions, \( C_Z < 0 \) and \( C_F < 0 \). Solving for \( dZ/dp \) yields:

\[ \frac{dZ}{dp} = \frac{T'F'S_{ZZ} + FI_Z}{1 - C_Z - T'C_F} < 0. \]

And if \( dZ/dp < 0 \), then \( dF/dp > 0 \)—that is, output responds positively to price changes.\(^8\)

If, however, leisure is introduced into the model in place of \( z \) goods, then:

\[ \frac{dF}{dp} = -F' \frac{dL}{dp}, \]

and

\[ \frac{dL}{dp} = \frac{F'S_{LL} + FI_L}{1 - C_L}, \]

where

\[ S_{LL} = -\lambda \frac{D_{11}}{D}, \]

\(^7\) The second-order conditions for a maximum require that \( D + \lambda D_{11} (pF'T'' - pT'F") > 0 \). This is fulfilled if \( D > 0 \), and because \( S_{ZZ} = -D_{11}/D < 0 \) and \( D_{11} = -q^2 < 0 \), \( D \) must be > 0.

\(^8\) If \( C > 0 \), then \( dZ/dp \) also includes the cross-substitution effect between \( z \) and \( C \), which is negative or positive depending on whether \( z \) is a complement or a substitute for \( C \). The assumption that \( C > 0 \) also introduces a distinction between total output and marketed output. See Hymer and Resnick, "A Model of an Agrarian Economy with Nonagricultural Activities," pp. 498–99.
As before, $S_{LL}$ and $C_L$ are negative, but it can be expected that $I_L$ is positive because leisure is usually considered a normal good.\(^9\) It follows that the possibility of a negative output (and labor supply) response now depends on the relative size of the (negative) substitution effect weighted by labor's marginal product, on the one hand, and the (positive) income effect weighted by total agricultural output, on the other. Given the two weights, the income effect can be expected to dominate, with the result that output response is negative.

The alternative models thus produce opposite predictions of output response; for several reasons, however, the underlying assumptions of the $\zeta$ model may be unacceptable. For example, the assumption that $\zeta$ is inferior is clearly crucial to the particular result derived above, and yet the evidence to support this assumption is far from overwhelming. The inferiority assumption is based on the following argument, as quoted from Hymer and Resnick:\(^{10}\)

- We hypothesize that in an agrarian economy isolated from trade, production of food is inhibited by the lack of a market and much effort is devoted to providing other conveniences and necessities of life.
- When an autarchic agrarian economy is opened up to trade with a manufacturing sector, domestic or foreign, it obtains a new set of transformation possibilities.
- It can now specialize in producing certain food items in demand in the city or abroad and can import manufactured goods to replace the previously domestically produced goods.

The first point suggests that $\zeta$ production, and hence $\zeta$ consumption, may well be an important facet of agricultural life. The second point indicates that trade brings with it new transformation possibilities, which lead in the third point to a reduction in $\zeta$ production.

\(^9\) Such a model is examined in Amartya K. Sen, "Peasants and Dualism With or Without Surplus Labor," *Journal of Political Economy*, vol. 74, no. 5 (October 1966), pp. 425–50

\(^{10}\) Hymer and Resnick, "A Model of an Agrarian Economy with Nonagricultural Activities," p. 504.
and hence in $Z$ consumption. Therefore, over time, as incomes increase with improved trade possibilities, $Z$ consumption decreases. This does not, however, establish that $Z$ goods are inferior. $Z$ goods decline in importance because of improved transformation possibilities that tend to occur simultaneously with increases in income. It is not clear that $Z$ goods would decline in importance if income is increased with no change in the transformation possibilities. Such a decline, however, is necessary if $Z$ goods are to be considered inferior.

$Z$ goods may well be an important part of rural life but, if it cannot be demonstrated that they are inferior goods, much of their significance in the context of the model presented above is lost. Moreover, even if $Z$ goods are inferior, the composite income effect of changes in $Z$ goods and leisure may, nevertheless, be positive if the fixed working-day assumption is abandoned. If leisure is now treated as a choice variable, then

$$\frac{dF}{dp} = -F'(T'dZ' + dL').$$

The effect on $F$, therefore, depends on the income effects for both $Z$ and $L$ as well as on cross- and own-substitution effects. If cross-substitution effects are ignored, then from equation (13):

$$T'dZ' + dL = \frac{F'S + FI}{1 - C},$$

where

$$S = \frac{T'T'S_{zz}}{1 - C_z} + S_{LL},$$

$$I = \frac{T'I_L}{1 - C_z} + I_L,$$

$$C = \frac{T'C_L}{1 - C_z} + C_L.$$

Thus, equation (17) is expressed in weighted averages of the individual substitution, income, and curvature effects in a form that

11. This is not to say, however, that $Z$ goods lose their significance in the context of long-term models of agricultural development in which allowance is explicitly made for the changed transformation possibilities.
parallels equations (15) and (16). As before, the substitution effect (S) and the curvature effect (C) are negative, but the sign of the income effect (I) depends on the relative importance of the income effect for Z (assumed to be negative) and the income effect for leisure (assumed to be positive).\textsuperscript{12} If the income effect for leisure dominates, then a negative output response is still possible even if Z goods are inferior. On the other hand, if the income effect of Z goods dominates and if Z goods are assumed to be inferior, then the model admits the possibility of a negative labor supply response \((dL/dp < 0)\) being consistent with a positive output response \((dF/dp > 0)\), when labor is switched from Z to F production. That is, total family labor supply is reduced, but the quantity of family labor assigned to agriculture is increased.

The thrust of the above arguments is to reduce the significance of introducing nonagricultural commodities into a model of household behavior. Because no reason has been established for assuming Z goods to be other than normal goods, and because the income effect of leisure, which is universally accepted to be positive, should be included in the model, it can be argued that the composite income effect of leisure and Z goods is positive; hence, the predictions of the model are similar to those of the standard labor-leisure model. For such models, there is a strong presumption that output response is negative. In the remainder of this study, these arguments are used to justify the absence of any explicit treatment of nonagricultural goods produced by the household. In other words, for purposes of estimation, the term leisure includes both pure leisure and the time devoted to the production of nonagricultural goods on the assumption that, at the margin, each activity is equally valuable.

The Importance of Labor Market Participation

In this section, labor supply and output response are examined in the context of a model in which the household participates in the labor market either as a buyer \((N < 0)\) or as a seller \((N > 0)\).\textsuperscript{13} In this

\textsuperscript{12} The income effect for Z is weighted by \(T'(1 - C_Z)\), which is greater than zero, but which may be greater or less than unity.

\textsuperscript{13} As noted above, Z goods are omitted from the remainder of the analysis. Their absence or presence, however, does not influence the prediction of output and labor supply response developed in this section.
case \( dH/dp \), and hence \( dF/dp \), can be derived immediately from equation (10), the profit-maximization condition. Differentiating equation (10) totally yields:

\[
dw = pF"dH + F'\,dp.
\]

From this it follows that, if \( dw = 0 \):

\[
\frac{dH}{dp} = -\frac{F'}{pF"},
\]

which, given the production function assumptions, is positive and holds for both labor-selling and labor-buying households.\(^\text{14}\)

This result hinges on the exogenous nature of the wage rate. If \( p \) increases, then labor's marginal revenue product will increase. To restore equality with the wage rate, the labor input must increase, given diminishing returns to a single factor, this reduces labor's marginal physical product and hence labor's marginal revenue product. The net result is an increase in the labor input and an increase in output. This result is independent of any assumption about the arguments or the shape of the utility function and signifies that the household can make its production decisions independently of its consumption decisions, including those relating to leisure and hence to household labor supply. Thus, the prediction of a positive output response to a price change does not depend on assumptions relating to the utility function, but it does require household participation in the labor market. This result is attributable to the conclusion that, with labor market participation, the profit-maximizing conditions governing factor use in household production activities are clearly separable from the utility-maximizing conditions governing the household consumption activities. In fact, factor use remains governed by the familiar conditions derived from the theory of the firm.

Consumption decisions, however, are obviously dependent on the assumptions defining the utility function. For example, labor supply response can be shown to depend on an income effect. If the assumption that own consumption of the agricultural commodity is zero (that is, \( C = 0 \)) is retained, then the change in household labor supply following a price change (that is, \(-dL/dp\)) depends solely on a

\(^{14}\) In this case, the result holds even if own consumption of \( F \) production is positive (\( C > 0 \)). Own consumption does, however, imply a distinction between total and marketed output.
positive income effect \((-F_{L})\), and hence labor supply response is negative. Thus, the labor market participation model predicts an increased demand for agricultural labor as a result of a price increase \((dH/dp > 0)\) but a reduced supply of such labor from agricultural households \((-dL/dp < 0)\). The model therefore predicts a significant increase in the demand for hired labor by labor-buying farm households and a decrease in the supply of such labor to the market by labor-selling farm households. This implies that the income benefits of an increased price for agricultural output will be distributed through the labor market to the landless members of rural society by means of either an expansion in employment, or a rise in the wage rate, or both. Because the landless are considered to be among the poorest groups in developing countries and, from a consumption point of view, because they suffer most from agricultural price increases, these results are of major significance for the equitable development of agriculture.\(^{15}\)

**Implications for the Muda River Model**

The theoretical discussion of different types of household models provides a basis on which to define a model suitable for estimation in the context of the Muda River Valley. The analysis of the \(\mathcal{Z}\) goods model led to the conclusion that \(\mathcal{Z}\) goods can be subsumed under the general label leisure without any loss of generality, because no reason has been established for assuming \(\mathcal{Z}\) goods to be inferior. The analysis of the labor market participation model led to the conclusion that production decisions are independent of the specification of the utility function. This conclusion is of considerable relevance for this study because, as was demonstrated in chapter 2, Muda households participate extensively in the labor market.

With these points in mind, it is concluded that the model, which best reflects household behavior in the Muda River Valley, can be derived from the general model on the assumptions that \(\mathcal{Z} = 0\) (that

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15. In their illustrative exercise using Indian data, Yotopoulos and Lau demonstrate that under certain circumstances the rise in the wage rate following an output price increase may be of sufficient magnitude to result in an overall negative output response. See Pan A. Yotopoulos and Lawrence J. Lau, "On Modelling the Agricultural Sector in Developing Countries," *Journal of Development Studies*, vol. 1, no. 2 (September 1974), pp. 116–18.
is, \( \mathcal{Z} \) goods are not explicitly analyzed) and \( N \neq 0 \) (that is, the household participates in the labor market). The inclusion of labor market participation in the model has important implications for the appropriate method of estimation. Thus, given an independent estimate of the production function, the profit-maximizing condition, equation (10), can be solved to yield the profit-maximizing labor input as a function of quantity of the fixed factor (land), price of the variable factor (labor), and the output price. Because each of these variables is determined exogenously, the profit-maximizing labor input is determined independently of the rest of the system. The profit-maximizing level of output is determined in a similar fashion by substituting the profit-maximizing labor input into the production function. Therefore, the production side of the model is determined independently of the household's consumption decisions.\(^16\)

This procedure requires profit-maximizing behavior by Muda farmers and an independent estimate of the production function. Accordingly, a number of production function estimates for padi farming in the Muda River Valley are presented in chapter 4, together with tests of the assumption of profit-maximizing behavior.

The remaining first-order conditions—equations (7), (8), (9), and (11)—define the consumption side of the model. Solving for \( \lambda \) and rearranging slightly, this system of four equations may be rewritten as:

\[
\begin{align*}
U_c/U_m &= p/q, \\
U_L/U_m &= w/q, \quad \text{and} \\
qM + pC + wL &= E,
\end{align*}
\]

where \( E = pF - wH + A + wD \). In deriving these equations, \( w \) has been substituted for \( pF' \) in equation (20), and the time constraint, equation (3), has been used to substitute for \( N \) in the budget constraint, equation (2). Equations (19), (20), and (21) now correspond to the standard consumer demand problem in which the three commodities (\( C, M, \) and \( L \)) are purchased at fixed prices \( (p, q, \) and \( w) \) subject to a total budget constraint \( (E) \). Because \( E \) is defined entirely in terms of exogenous variables, the system of three equations can

\(^{16}\) Nevertheless, it can be shown that, if an expected utility framework is adopted because, say, output is subject to risk, the separation of production and consumption decisions does not necessarily hold.
be solved to yield demand curves for the three commodities as functions of the three prices and total expenditure. In chapter 5, estimates of the three demand curves are presented for two specifications of the utility function.

For purposes of estimation, $E$ may be treated as an exogenous variable; more precisely, however, it is a function of several exogenous variables, including those that determine the major production quantities (that is, $H$ and $F$). It follows that exogenous changes which influence production will also influence consumption decisions through changes in $E$. This conclusion demonstrates that the importance of consistently combining production and consumption decisions can be assessed by examining the extent to which changes in the production variables affect total expenditure and hence influence household demand for consumption goods and leisure. Accordingly, in chapter 6 a number of consumption elasticities are computed: first, on the assumption that changes in production decisions are not allowed to affect total expenditure; second, when full allowance is made for the impact of the production side of the model on total expenditure. A comparison of these two sets of elasticities allows an assessment of the quantitative significance of the theory of the farm household in situations in which the household is assumed to participate in the labor market.

17. $H$ and $F$ have already been expressed in exogenous variables. $E$ is an augmented version of Becker's concept of full income. See Becker, "A Theory of the Allocation of Time."

18. Because $E$ is defined as $pF - wH + A + wD$, changes in output ($F$) and labor usage ($H$) will cause changes in $E$. The term $pF - wH$ can be interpreted as a measure of farm profits, since it represents gross revenue less the cost of the variable factor; that is, it represents the return to the fixed factors and is usually described as restricted profits.

19. If the household does not participate in the labor market, the production side of the model cannot be solved independently because the total labor input into on-farm agricultural work ($H$) equals the total time available to the household ($D$), less the time devoted to leisure activities ($L$).
A Production Function Analysis of Padi Farming in Northwest Malaysia

A production function for padi is presented in this chapter, and tests are conducted to establish the extent to which Muda padi farmers maximize profits. To allow for the possibility of a nonhomogeneous population—with respect to either technology or profit-maximizing behavior—tests of relative technical and allocative efficiency are conducted for three pairings of padi farms. These pairings are based on area operated, tenancy status, and the number of years the farm has been double-cropped.


2. One group of farms may be considered technically more efficient than another group if it can produce a given output with less of some or all inputs; one group of farms may be considered allocatively more efficient than another if it is more successful in equating marginal revenue product and factor cost for each of its variable inputs—that is, if it is more successful in maximizing profits.
Pairings of Padi Farmers

The first pairing is on the basis of area operated. It is by now well established that in many countries yield and labor intensity are inversely related to area operated. This result has attracted great attention for at least two reasons. First, it has obvious policy implications relative to land reform, in that, under certain circumstances, it signifies the possibility of simultaneously increasing output and improving the distribution of that output. Second, attempts to explain this phenomenon are crucial to the understanding of developing agriculture. Most of the empirical research on this question, however, has relied on Indian data relating to group averages and has taken the value of total crop production in multicrop situations as the dependent variable. By way of contrast, the results reported here are for Malaysia, are based on farm-level data, and relate solely to one crop (padi). This last is important because using the value of output in multicrop farms as the dependent variable implies that all results are subject to a “crop composition effect” that may bias results in unforeseen directions.

The effect of tenancy status on economic efficiency has also attracted considerable attention in the literature on development. The debate has centered mainly on the issue of whether or not sharecropping results in allocative inefficiencies. In the study area, however, virtually all land rental contracts are specified by a fixed cash payment. Theoretically, this implies that allocative inefficiencies cannot arise from the rental contract, because the fixed rental does not influence the marginal, profit-maximizing conditions. Nevertheless, it has been demonstrated that in this region of northwest Malaysia tenants and owner-tenants consistently have had higher yields than pure owners, and that, after standardizing for farm size, the differences in yields have become even greater. Accordingly, the possibility of


4. Ibid.

differences in economic efficiency are tested for farms grouped by tenancy status—with those renting in at least some of their land constituting one group, and owner-operators constituting the other.

The final pairing of farms is based on the number of years the farm has been double-cropped; it attempts to examine both the adaptive behavior of Malaysian padi farmers and the impact of repeated double-cropping on the technical efficiency of padi production. The area under study has recently benefited from irrigation facilities provided by the Muda Irrigation Project, which has enabled farmers to switch from single- to double-cropping. This new technology has had a marked effect on the demand for additional padi labor in a season that previously had no padi production. A modification of the initial impact on labor demand can be expected if the technical efficiency of production during the second crop cycle changes, or if the allocational efficiency of padi farmers changes with the length of time a farm has been double-cropped. The cross-section sample used in this study distinguishes between farms that have been double-cropped for one year and those that have been double-cropped for two or more years. A comparative analysis of these two groups of farms will illustrate the effect of farm experience on allocational and technical efficiency. This analysis is of particular interest because the distribution of the benefits of the new technology through the labor market will depend, at least to some extent, on the impact of the new technology on the efficiency of factor use in padi production.

Table 3 presents the basic information on mean input and output levels for the second padi crop for the three pairings of farms. The labor input decreases with farm size from 203 hours per relong on farms of five relong or less (small farms) to 164 hours per relong on farms of more than five relong (large farms).6 (This is in line with the results reported for other countries.) Similarly, yield decreases with farm size from 499 gantang per relong on small farms to 474 gantang per relong on large farms but, relative to the difference in labor intensity, the difference in yields is small.7 The joint influence of changes in labor intensity and yield is captured in the figures for labor productivity: one hour of labor produces 2.8 gantang on a small farm, as compared with 3.1 gantang on a large farm. The flow of capital services and the use of other variable inputs (mainly ferti-

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6. One relong equals 0.71 acres.
7. One gantang equals 5.32 pounds.
Table 3. Arithmetic Means of Inputs and Outputs for the Second Padi Crop

<table>
<thead>
<tr>
<th>Farm classification</th>
<th>Number of farms</th>
<th>Area operated (relongs)</th>
<th>Yield (gantang per relong)</th>
<th>Labor input (hours per relong)</th>
<th>Capital flow per relong</th>
<th>Other inputs per relong</th>
<th>Labor productivity (gantang per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (5 relongs or less)</td>
<td>223</td>
<td>3.3</td>
<td>499</td>
<td>203</td>
<td>18</td>
<td>11</td>
<td>2.8</td>
</tr>
<tr>
<td>Large (more than 5 relongs)</td>
<td>163</td>
<td>9.6</td>
<td>474</td>
<td>164</td>
<td>17</td>
<td>11</td>
<td>3.1</td>
</tr>
<tr>
<td>Owner-operators</td>
<td>173</td>
<td>5.1</td>
<td>478</td>
<td>199</td>
<td>18</td>
<td>10</td>
<td>2.8</td>
</tr>
<tr>
<td>Tenants</td>
<td>213</td>
<td>6.6</td>
<td>497</td>
<td>176</td>
<td>18</td>
<td>12</td>
<td>3.0</td>
</tr>
<tr>
<td>Double-cropped once</td>
<td>106</td>
<td>5.7</td>
<td>543</td>
<td>180</td>
<td>17</td>
<td>10</td>
<td>3.4</td>
</tr>
<tr>
<td>Double-cropped more than once</td>
<td>280</td>
<td>6.1</td>
<td>468</td>
<td>189</td>
<td>18</td>
<td>11</td>
<td>2.7</td>
</tr>
<tr>
<td>All farms</td>
<td>386</td>
<td>6.0</td>
<td>488</td>
<td>186</td>
<td>18</td>
<td>11</td>
<td>2.9</td>
</tr>
</tbody>
</table>

a. Area operated is measured in relong (1 relong = 0.71 acres) and is controlled for differences in soil quality by omitting all households operating acid land.
b. One gantang equals 3.32 pounds.
c. The labor of household members under 15 years of age is not included because information obtained from the survey indicated that the use of child labor is essentially nil.
d. The capital variable measures the flow of capital services to padi production in physical terms. That is, the flows of buffalo and two- and four-wheel tractors are aggregated to form a single measure of the flow of capital services. The weights used in the aggregation represent the relative time needed for each power source to bring a constant area to the same state of readiness for planting. To arrive at buffalo-equivalents, the flow of four-wheel tractor hours is weighted by 14 and that of two-wheel tractor hours by 3.5.
e. Other variable inputs include various fertilizers and pesticides in value terms (Malaysian dollars per relong).
lizer and pesticide), however, remain relatively constant as farm size changes. The following table shows the data on yield and labor intensity for a finer breakdown by farm size in relong:

<table>
<thead>
<tr>
<th>Less than 2</th>
<th>2-4</th>
<th>4-6</th>
<th>6-8</th>
<th>8-10</th>
<th>More than 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (gantang per relong)</td>
<td>523</td>
<td>465</td>
<td>505</td>
<td>459</td>
<td>504</td>
</tr>
<tr>
<td>Labor intensity (hours per relong)</td>
<td>225</td>
<td>204</td>
<td>174</td>
<td>163</td>
<td>168</td>
</tr>
</tbody>
</table>

The data in table 3 indicate that tenants use less labor per relong than owners, but they use more of other variable inputs and have similar yields. Rather surprisingly, however, tenants operate on average 6.6 relong, as compared with only 5.1 relong for owners. The observation that tenants have a higher yield and lower labor intensity (497 gantang per relong and 176 hours per relong) than owners (478 gantang per relong and 199 hours per relong) is in accord with results reported elsewhere for Malaysia.

The most striking result is in the breakdown by experience with double-cropping. Although operators of farms that have been double-cropped only once use similar quantities of inputs to operators of farms that have been double-cropped at least twice, the newly double-cropped farms achieve a yield of 543 gantang per relong as compared with 468 gantang per relong achieved on farms double-cropped over a longer period. The similarity in the input levels and yet the considerable difference in yields suggest that production is technologically more efficient on the more recently double-cropped farms, despite the other group's greater experience, which would be expected to improve allocational and technical efficiency. This curious result is addressed in the production analysis below.

Methodology

In the methodology adopted here, a direct estimate is made of the production function for each of the six groups of farmers and then these functions are compared. Tests are conducted first to determine
the factor-neutral and the factor-biased differences in technology for each of the three pairings of farms, and then to determine whether or not returns to scale are constant. Finally, marginal revenue products and factor costs are compared in an analysis of absolute and relative allocative efficiency. The basic estimating equation can be written as:

\[ F_j = e^{\alpha_0 + \sum_{i=1}^{4} \alpha_i X_i + D_j} X_1^{D_1} X_2^{D_2} X_3^{D_3} X_4^{D_4}, \]

where \( F_j \) = output of the \( j \)th farm, \( X_1 \) = area operated, \( X_2 (=H) \) = labor, \( X_3 \) = capital services, and \( X_4 \) = other variable inputs. The error term \( \epsilon_j \) is assumed to have a zero mean and a uniform variance, and to be distributed independently of \( X_i \). One regression is run for each of the three pairings: \( D \) is a dummy variable that takes the value of unity for large farms, tenant farmers, and experienced farmers; it takes the value of zero for small farms, owner-operators, and inexperienced farmers. The coefficients of the production function in each pairing for that group of farms for which \( D = 0 \) are then given by \( \alpha_0 \) and \( \alpha_i \), whereas the coefficients of that group of farms in each pairing for which \( D = 1 \) can be recovered from the sums \( \alpha_0 + \alpha'_0 \) and \( \alpha_i + \alpha'_i \).

For each pairing of farms, tests of the hypothesis that the two groups of farms face the same production technology are conducted, using an analysis of covariance, by reference to the statistical signifi-

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9. A more precise definition of the variables is presented in the footnotes to table 3. All variables, data base, and sample size are described in detail in the appendix.

10. The regressions reported in tables 4 and 5 were examined for a heteroskedastic relationship between the residuals and the farm size variable. When the Spearman Rank Correlation Test was used, the hypothesis of homoskedasticity (that is, the disturbances have the same variance) was not rejected at a 5 percent level of significance.
cance of the shift coefficients \( \alpha'_0 \) and \( \alpha'_1 \). If for the pairing of farms under consideration \( \alpha'_0 \) is statistically different from zero, then a shift in the neutral technical efficiency parameter is confirmed. Similarly, if for the pairing of farms under consideration the slope shift coefficients \( \alpha'_1 \) are significantly different from zero as revealed by a joint \( F \) test, it is concluded that there are factor-biased differences in technology. On the other hand, if neither the intercept shift coefficient nor the slope shift coefficients proves to be different from zero, it is concluded that both groups of farms face the same technology.\(^{11}\)

Depending on the results of the above exercise, the analysis is continued in one of two possible ways. If for any pairing of farms it is concluded that the technology is the same for both groups, then the production function is reestimated over the entire sample. Tests of returns to scale can then be based on the estimated coefficients of this regression: constant returns to scale is confirmed if \( \sum \alpha_i = 1 \).

The final set of tests concerning allocative efficiency is then conducted with respect to the ratio \( (k) \) of marginal productivity and factor cost. For example, regarding labor, the relevant equation may be written as:

\[
(23) \quad k = \frac{\alpha_0}{w} \left( \frac{F}{H} \right),
\]

where \( \alpha_0 \) is the exponent on the labor variable and is the same for both groups of farms and \( (F/H) \) and \( w \) (wage rate divided by output price) is specific to each group of farms. Tests are conducted first for differences in the configuration of input and output prices facing each group and then for allocative efficiency. Absolute allocative efficiency for either group is confirmed if \( k = 1 \) (that is, marginal product equals factor cost), and the two groups are considered to

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\(^{11}\) This procedure assumes that the error term has a uniform variance over the entire sample. An alternative procedure restricts the variances to be uniform within each subsample but allows them to differ among subsamples. The alternative test involves comparing the residual sum of squares from separate regressions with the residual sum of squares from a pooled regression. In the Muda sample, however, the alternative tests yield identical conclusions. The results are reported using the dummy shift alternative because it is more compact and provides information on the individual shift coefficients. For further discussion of these tests, see G. C. Chow, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions," *Econometrica*, vol. 28 (July 1960), pp. 591-605; and P. M. Rao and R. L. Miller, *Applied Econometrics* (Belmont, Calif.: Wadsworth Publishing Co., 1971).
have equal allocative efficiency if their respective $k$ values are the same.

An alternative procedure is adopted, however, if the technology for any two groups of farms is shown to be different. In this event, separate production functions are reestimated for each group of farms with the restriction that any coefficients shown not to be statistically different on the basis of the estimate of equation (22) are held constant for this new estimate. Tests of allocative efficiency are again based on equation (23), but now the possibility that the production function is different for the two groups is fully allowed for by admitting intergroup variations in the exponent of the labor variable, $a_2$. When the defining characteristic of the groups is area operated, intergroup variations in $a_2$ can be interpreted as an indication either of different production functions or of a single nonhomogeneous production function.

**Technical Efficiency**

The results of estimates of equation (22) for the three pairings of farms are presented in table 4. At this stage, the only interest is in the statistical significance of the shift coefficients. If the value of $F^*$ is examined, it can be seen that the hypothesis that the factor coefficients are the same cannot be rejected at a 5 percent significance level for these pairings of farms. This conclusion is further supported by employing a two-tail $t$ test to examine the significance of the coefficients on the individual factor shift variables. Finally, regarding the constant term, only the shift coefficient on the neutral technical efficiency parameter for the pairing of farms based on experience with double-cropping is significantly different from zero at a 5 percent significance level. It is concluded, therefore, that small and large farms as well as tenants and owners face the same technology; but farms that have been double-cropped for only one year are technically more efficient than farms that have been double-cropped longer, in that the neutral technical efficiency parameter ($a_0$) is larger.\(^\text{12}\)

\(^{12}\) Sidhu arrives at a similar finding as a result of his analysis of the shift from old wheat varieties to new ones in the Indian Punjab. In his case, the neutral technical efficiency parameter is 22.85 percent higher for those using the new
Table 4. Results of Estimates of Regression 1 (Equation 22)

<table>
<thead>
<tr>
<th>Coefficienta</th>
<th>Farm size</th>
<th>Tenancy status</th>
<th>Double-cropping experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(\alpha_0)</td>
<td>3.36</td>
<td>2.98</td>
<td>3.80</td>
</tr>
<tr>
<td>ln(\alpha_0D)</td>
<td>-0.95 (0.70)</td>
<td>-0.29 (0.18)</td>
<td>-1.41 (0.60)</td>
</tr>
<tr>
<td>Land</td>
<td>(\alpha_1)</td>
<td>0.72 (0.10)</td>
<td>0.72 (0.10)</td>
</tr>
<tr>
<td></td>
<td>(\alpha_1D)</td>
<td>-0.29 (0.18)</td>
<td>0.21 (0.14)</td>
</tr>
<tr>
<td>Labor</td>
<td>(\alpha_2)</td>
<td>0.19 (0.09)</td>
<td>0.22 (0.10)</td>
</tr>
<tr>
<td></td>
<td>(\alpha_2D)</td>
<td>0.23 (0.15)</td>
<td>0.19 (0.15)</td>
</tr>
<tr>
<td>Capital</td>
<td>(\alpha_3)</td>
<td>-0.02 (0.04)</td>
<td>0.01 (0.04)</td>
</tr>
<tr>
<td></td>
<td>(\alpha_3D)</td>
<td>0.10 (0.07)</td>
<td>0.06 (0.06)</td>
</tr>
<tr>
<td>Other variable</td>
<td>(\alpha_4)</td>
<td>0.08 (0.04)</td>
<td>0.08 (0.04)</td>
</tr>
<tr>
<td>Inputs</td>
<td>(\alpha_4D)</td>
<td>0.02 (0.06)</td>
<td>-0.02 (0.06)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.67</td>
<td>0.67</td>
<td>0.68</td>
</tr>
<tr>
<td>FTa</td>
<td>1.94</td>
<td>0.75</td>
<td>1.76</td>
</tr>
<tr>
<td>FB</td>
<td>1.55</td>
<td>1.44</td>
<td>4.18</td>
</tr>
<tr>
<td>FP</td>
<td>0.21</td>
<td>2.72</td>
<td>13.76</td>
</tr>
<tr>
<td>N</td>
<td>386</td>
<td>386</td>
<td>386</td>
</tr>
<tr>
<td>SEE</td>
<td>0.48</td>
<td>0.48</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Note: Standard errors are presented in parentheses after estimates.

a. \(D = 1\) indicates large farms (more than 5 relong), tenants, and farms double-cropped two or more years; \(D = 0\) indicates small farms (5 relong or less), owners, and farms double-cropped one year.

b. \(F^a\) tests the hypothesis that \(\alpha_i' = 0\) for \(i = 1, \ldots, 4\). That is, \(F^a\) tests the hypothesis that output elasticities are the same in separate regressions for each group. The critical value of \(F^a\) at a 5 percent significance level is 2.39. \(F^b\) tests the hypothesis that \(\alpha_i' = 0\) and \(\alpha_i'' = 0\) for \(i = 1, \ldots, 4\). That is, \(F^b\) tests the hypothesis that all coefficients are the same in separate regressions for each group. The critical value of \(F^b\) at a 5 percent significance level is 2.23. \(F^p\) tests the hypothesis that \(\alpha_i' = 0\) in a regression with \(\alpha_i'' = 0\) for \(i = 1, \ldots, 4\). The regression used to obtain \(F^p\) is not reported here. The critical value of \(F^p\) at a 5 percent significance level is 3.86. The maintained hypothesis examined in the text does not involve \(F^a\) and \(F^b\). These tests are included only to show that the conclusion reached in the text could be obtained using other formulations of the maintained hypothesis.

varieties than for those using the older ones. Regarding the size breakdown of farms, results for India using the profit function approach are mixed. Yotopoulos and Lau conclude that small farms in the 1950s were technically more efficient than large farms. Sidhu, however, finds small and large farms in the 1960s to be equally technically efficient. The tests based on the profit function, however, only allow for differences in neutral technical efficiency between the two groups; apart from that, the two groups are assumed to face the same technology. Surjit S. Sidhu, "Economics of Technical Change in Wheat Production in the Indian Punjab," *American Journal of Agricultural Economics* (May 1974), pp. 217-26; and Yotopoulos and Lau, "A Test for Relative Economic Efficiency", and Surjit S Sidhu, "Relative Efficiency in Wheat Production in the Indian Punjab," *American Economic Review*, vol 64, no. 4 (September 1974), pp 742-51.
Accordingly, the production function is reestimated over the entire sample for large and small farms and owners and tenants, but separate production functions are estimated for farms double-cropped once and farms double-cropped more than once, with the restriction that $\alpha_i = 0$ for all $i \neq 0$. These results are given in Table 5. For these regressions, all coefficients are statistically significant except that on capital. Land and labor are the most important inputs, and returns to scale are constant. From these results it is concluded that: (a) large and small farms are equally technically efficient (that is, they face the same linear, homogeneous production function); (b) owners and tenants are equally technically efficient (that is, they face the same production function); and (c) newly double-cropped farms are technically more efficient than farms double-cropped for two or more years.

13. It is possible that the capital input, which is required entirely for ploughing, is bringing land of different quality up to a common standard of readiness for planting. In this event, the contribution of capital to output would be captured in the coefficient on land.

14. This is contrary to Bardhan’s conclusion for padi farms in India. He finds diminishing returns to scale for padi farms but constant returns to scale for wheat farms. See Bardhan, “Size, Productivity, and Returns to Scale.”
years (that is, the neutral efficiency parameter is larger for newly double-cropped farms).

It can be concluded from (a) and (b) that yield and input intensity should be the same regardless of farm size or tenancy status, unless either the different groups of farms face different configurations of input and output prices, or they are not equally allocatively efficient. And it can be concluded from (c) that newly double-cropped farms should have yields approximately 22 percent higher and a labor intensity approximately 39 percent higher than farms double-cropped for two or more years, unless either the different groups of farmers face different configurations of input and output prices, or they are not equally allocatively efficient. Computed at the geometric means, the actual difference in yields between the two groups is 19 percent, indicating that the observed difference in yields is adequately explained by the neutral shift in the production function. Regarding labor intensity, however, contrary to expectation, farms double-cropped two or more times use 5 percent more labor than farms in the first year of double-cropping. This suggests that either they face different wages or the profit-maximizing ability of the two groups is different relative to the labor input.

The major decline in yields (22 percent) with experience of double-cropping warrants further investigation. An examination of table 3 reveals that productivity, both by unit of area and by man-hour, has decreased with duration of double-cropping in spite of the fact that labor, capital and other variable inputs per unit of area have increased slightly. An immediate explanation, which would be consistent with this pattern, is that the soil has become less productive with repeated double-cropping. The results of table 4 support this contention in that they show: (a) a decreasing constant term, which could be an effect of the increased drain on soil nutrients from the adoption of double-cropping; (b) a decreasing elasticity for the land input and an increasing elasticity for other variable inputs (mainly fertilizer), and (c) a marked increase in the responsiveness of output to labor, which might result from increased knowledge of the appropriate timing and mix for the various tasks associated with the second crop, but may also reflect the use of labor in additional soil preparation and in techniques

15. The ratio of yields is given by the ratio of the neutral technical efficiency parameters \( \alpha \) and, assuming profit maximization, the ratio of labor intensities is given by the ratio of the neutral technical efficiency parameters raised to the power of \( 1/\alpha \).
that are adopted to compensate for the deterioration in natural fertility.

Although the shifts in the coefficients of land, labor, and other variable inputs are consistent with the hypothesis of decreasing fertility, they are not strong enough to be confirmed statistically. A finer breakdown of the sample into three groups revealed essentially the same pattern. Farms that had been double-cropped only once had a higher constant term and coefficient for land but a lower coefficient for labor and other variable inputs than farms that had been double-cropped twice. The same trend was observed when comparing farms that had been double-cropped twice with those that had been double-cropped more than twice. In this case, a comparison of the group of farms with one year's experience double-cropping and the group of farms with more than two years' experience indicated a shift in the coefficients that proved significant at below a 5 percent level. The relevant coefficients are reported as follows:

<table>
<thead>
<tr>
<th>Years</th>
<th>lnα₀</th>
<th>Land</th>
<th>Labor</th>
<th>Other variable inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>3.85</td>
<td>0.80</td>
<td>0.10</td>
<td>0.02</td>
</tr>
<tr>
<td>Two</td>
<td>2.49</td>
<td>0.53</td>
<td>0.41</td>
<td>0.05</td>
</tr>
<tr>
<td>More than two</td>
<td>2.23</td>
<td>0.50</td>
<td>0.44</td>
<td>0.12</td>
</tr>
</tbody>
</table>

When a joint $F$ test is used, the null hypothesis that the coefficients for both the one-year group and the more-than-two-years' group are the same is rejected. The calculated value of $F$ is 4.79 with 5 and 245 degrees of freedom.

These results indicate a sharp decline in fertility after one year's double-cropping, which apparently levels off somewhat but continues to decline through the second year of double-cropping. The results carry significant implications for Malaysia's drive toward self-sufficiency regarding padi, in that if the almost continuous use of farmland implied by double-cropping reduces natural fertility, then not only will the yields of the second crop be reduced, but so also will those of the first crop. If the decline in yields of the first crop parallels those of the second, then double-cropping will result in an increase in annual yields, not of 100 percent, but more like 50 percent.

Although the results presented here are not conclusive, they are sufficiently persuasive to warrant the recommendation that further field investigations be undertaken to determine whether or not natural fertility is declining and, if so, whether or not the rate of decline is diminishing. The results also illustrate the value of the methodology—conclusions of the sort presented here can only be reached if other
possible causes of yield differentials (for example, different technologies and allocative inefficiencies) can be individually isolated and tested separately.

Allocative Efficiency

The tests of allocative efficiency are preceded by an examination of intergroup differences in the configuration of input and output prices. Unfortunately, the price data in the FAO-IBRD survey are not as reliable as the quantity data. Accordingly, in table 6 a breakdown of mean input and output prices drawn from the Doering survey, which was conducted earlier in the same area, is presented. Since this survey was completed only two years before the FAO-IBRD survey and contains carefully collected price information, it is considered a more reliable base for an intergroup comparison of prices.

The commercialized nature of padi production in the Muda River Valley leads to the expectation that markets are reasonably well integrated, and this is confirmed by the results presented in table 6. At a 5 percent significance level, it can be concluded that tenants and owners face the same set of relative factor costs for labor, ploughing, and land, and that small and large farmers face the same set of relative factor costs for harvesting labor, tractor ploughing, and land but that small farms face higher relative factor costs for transplanting labor and buffalo ploughing. Similar tests for experienced and inexperienced farmers were not possible, because the Doering study does not contain a breakdown of farms by double-cropping experience. Nevertheless, given the general level of variation in prices and the absence of any theoretical expectation that these two groups should face different prices, the analysis is continued on the assumption that inexperienced and experienced farmers confront the same set of prices. Accordingly, table 7 contains the estimates of prices in gantang that are assumed to confront all farms and that will be used in the analysis of allocative efficiency. These prices are drawn from the FAO-IBRD survey and are consistent with those presented in Doering.

17. The coefficients of variation range from 0.37 for two-wheel tractor hire to 0.92 for harvesting labor.
A MODEL OF AN AGRICULTURAL HOUSEHOLD

Table 6. Mean Input Prices in Gantang for Padi Production According to the Doering Survey

<table>
<thead>
<tr>
<th>Farm classification</th>
<th>Wage per man-day</th>
<th>Cost per relong for ploughing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rent per relong</td>
<td>Trans-planting</td>
</tr>
<tr>
<td>Small</td>
<td>180.3</td>
<td>4.53</td>
</tr>
<tr>
<td>Large</td>
<td>156.1</td>
<td>3.55</td>
</tr>
<tr>
<td>(1 52)</td>
<td>(2.03)</td>
<td>(0.28)</td>
</tr>
<tr>
<td>Owners</td>
<td>-</td>
<td>3.99</td>
</tr>
<tr>
<td>Tenants</td>
<td>165.7</td>
<td>3.90</td>
</tr>
<tr>
<td>(—)</td>
<td>(0.17)</td>
<td>(1.54)</td>
</tr>
<tr>
<td>All farms</td>
<td>165.7</td>
<td>3.94</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>0.42</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses are t-statistics.

Source: The price data presented here are from Otto C. Doering III, "1970 Muda Agric-Econ Survey," Muda Agricultural Development Authority (Malaysia, 1972). The survey contains superior price data to the FAO-IBRD survey and is, therefore, preferred. The survey was conducted in the Muda River region two years before the FAO-IBRD survey and is presented here, not as an indication of the prices actually facing farmers in the FAO-IBRD survey, but as a commentary on the nature of the input and output markets in the Muda River region.

Table 7. Mean Input Prices in Gantang for Padi Production According to the FAO-IBRD Survey

<table>
<thead>
<tr>
<th>Farm classification</th>
<th>Rent per relong</th>
<th>Wage per man-hour</th>
<th>Cost per buffer-hour</th>
<th>Other variable inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>All farms</td>
<td>157</td>
<td>0.66</td>
<td>1.29</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Source: These prices are taken from the FAO-IBRD survey and are used subsequently in the analysis of allocative efficiency. The price of padi used in arriving at prices in gantang is M$0.62 per gantang, the farmgate price prevailing in the major harvest month of September. The wage rate is the average wage prevailing during the second crop cycle.

Table 8 presents the results of tests of allocative efficiency. At a 5 percent level of significance, it can be concluded that all groups of farms are allocatively efficient (that is, \( k = 1 \)) with respect to the three variable inputs—labor, capital, and other variable inputs—but
Table 8. Marginal Productivities and Allocative Efficiency for Padi Production

<table>
<thead>
<tr>
<th>Farm classification</th>
<th>Land</th>
<th>Labor</th>
<th>Capital</th>
<th>Other variable inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal products a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>275 (31.1)</td>
<td>0.68 (0.16)</td>
<td>0.41 (1.0)</td>
<td>4.36 (1.6)</td>
</tr>
<tr>
<td>Large</td>
<td>263 (29.7)</td>
<td>0.80 (0.19)</td>
<td>0.43 (1.0)</td>
<td>4.07 (1.5)</td>
</tr>
<tr>
<td>Owners</td>
<td>260 (29.3)</td>
<td>0.66 (0.16)</td>
<td>0.43 (1.0)</td>
<td>4.61 (1.7)</td>
</tr>
<tr>
<td>Tenants</td>
<td>279 (31.5)</td>
<td>0.79 (0.19)</td>
<td>0.41 (1.0)</td>
<td>3.95 (1.5)</td>
</tr>
<tr>
<td>Inexperienced</td>
<td>302 (34.7)</td>
<td>0.92 (0.21)</td>
<td>0.67 (1.2)</td>
<td>5.10 (1.9)</td>
</tr>
<tr>
<td>Experienced</td>
<td>253 (29.0)</td>
<td>0.73 (0.17)</td>
<td>0.51 (0.9)</td>
<td>3.95 (1.5)</td>
</tr>
</tbody>
</table>

Allocative efficiency:

value of $k$ b

<table>
<thead>
<tr>
<th>Farm classification</th>
<th>Land</th>
<th>Labor</th>
<th>Capital</th>
<th>Other variable inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>1.75 (0.20)</td>
<td>1.03 (0.24)</td>
<td>0.32 (0.78)</td>
<td>2.71 (0.99)</td>
</tr>
<tr>
<td>Large</td>
<td>1.68 (0.19)</td>
<td>1.21 (0.29)</td>
<td>0.33 (0.78)</td>
<td>2.53 (0.99)</td>
</tr>
<tr>
<td>Owners</td>
<td>1.66 (0.19)</td>
<td>1.00 (0.24)</td>
<td>0.33 (0.78)</td>
<td>2.86 (1.06)</td>
</tr>
<tr>
<td>Tenants</td>
<td>1.78 (0.20)</td>
<td>1.20 (0.29)</td>
<td>0.32 (0.78)</td>
<td>2.45 (0.93)</td>
</tr>
<tr>
<td>Inexperienced</td>
<td>1.92 (0.22)</td>
<td>1.39 (0.32)</td>
<td>0.52 (0.93)</td>
<td>3.17 (1.18)</td>
</tr>
<tr>
<td>Experienced</td>
<td>1.61 (0.18)</td>
<td>1.11 (0.26)</td>
<td>0.40 (0.70)</td>
<td>2.45 (0.93)</td>
</tr>
</tbody>
</table>

Note: Standard errors are presented in parentheses after the estimates.
a. Marginal products are computed at the geometric means and are expressed in gantang. The production function coefficients are taken from the appropriate column of table 5.
b. The estimate of $k$ is obtained by dividing marginal productivity by the price in gantang as calculated from the FAO-IBRD survey and reported in table 7.

not with respect to the fixed factor—land. The results confirm the hypothesis that padi farmers in the Muda Valley maximize restricted profits: that is, land is viewed as a fixed factor and profits are maximized by the appropriate choice of the variable inputs subject to the given quantity of land.

It can be argued that these results reflect the fundamental differences in the markets for the two most important inputs, land and labor, described in chapter 2. It was noted there that the labor market is active, with enough seasonal migrant labor to indicate the presence of a reasonable degree of competition. By way of contrast, evidence was documented to indicate that the land market is confined largely to intrafamily transactions. As might be expected, for many operators land is not treated as an economic resource in the same way labor is. Also, these results may reflect the fact that those who are most anxious to rent land are usually those who least have the financial resources to do so. For these farmers, one would expect that the marginal
product of land would exceed its market price. In other words, the market rental of land is below the economic value of land because, on the one hand, many transactions involve kin and, on the other hand, imperfections in the credit market may prevent some operators from entering the land market.\textsuperscript{18}

The main result of table 3—that the yield of the second crop of farms double-cropped only one year is considerably higher than that of farms double-cropped two or more years—has already been accounted for in terms of a neutral shift in the production function. Given that shift, however, the labor intensities (that is, labor input per unit of area operated) of the two groups of farms should also be different, whereas table 3 indicates that they are almost the same. Computed at the geometric means, the observed ratio of labor intensity of farms double-cropped once to that of farms double-cropped more than once is 0.95. The ratio of the demand curves for labor per relong, however, was computed earlier to be 1.39. It is of some interest, therefore, to examine why the observed shift in the demand for labor (a decrease of 5 percent) differs so dramatically from the expected shift (an increase of 39 percent) given the neutral shift in the production function. The figure of 1.39 was calculated on the assumption of profit-maximization with respect to labor for both groups of farms; that is, \( k \) was set equal to unity for both groups. If, however, the observed values of \( k \) reported in table 8 are used to recompute the ratio of the demand curves, \( 1.39 \times 0.71 = 0.99 \) is obtained, which is approximately equal to the observed change in demand.\textsuperscript{19} Thus, it appears that changes in the neutral technical efficiency parameter are being offset by changes in allocative efficiency such that labor intensity remains roughly constant. Moreover, the change in allocative efficiency represents an improvement: the value of \( k \) falls from 1.39 for farmers who lack experience with the second crop to 1.11 for experienced farmers, indicating an improvement in allocative efficiency.\textsuperscript{20} The results indicate that farmers are adjusting

\textsuperscript{18} In table 8, \( k \) is consistently greater than unity for land, thus indicating underutilization of that input. This holds for both owners and tenants.

\textsuperscript{19} The adjustment factor required to obtain the ratio of demand curves for labor per relong is the ratio of \( k \) for farms double-cropped more than once to that for farms double-cropped once, raised to the power of \( (a_1 + a_2)/a_1 \).

\textsuperscript{20} This improvement, however, was not confirmed statistically because both inexperienced and experienced farmers were shown to be absolutely allocatively efficient.
very well, either by luck or by judgment, both to double-cropping itself and to the neutral shifts in the production function that occur because of continued double-cropping.

The final issue examined here is that of relative allocative efficiency. Because it has already been shown for the three pairings of farms that absolute allocative efficiency is confirmed for the three variable inputs, this analysis is confined to the fixed factor, land. At a 5 percent level of significance, it can be concluded that large and small farms, owners and tenants, and farms double-cropped one and two or more years are equally allocatively efficient regarding land (that is, they have the same value of $k$). Land is consistently underused ($k > 1$) regardless of farm size, tenancy status, or experience with double-cropping. As was argued earlier, this result may be attributed to imperfections in the land market, especially the tendency to treat land as a noneconomic factor in intrafamily transactions.

Conclusions

The above demonstration that small and large farms are equally economically (that is, both technically and allocatively) efficient implies that on efficiency grounds there is not a statistically significant case for land reform or for a ceiling on land ownership. Similarly, the fact that tenants and owners are equally economically efficient demonstrates empirically that tenurial systems exist which are not detrimental to economic efficiency, at least in a static sense. It follows that land reform policies that involve a redistribution of land ownership should be viewed primarily from a social or political perspective because, based on pure economic grounds, a fixed-rental tenurial system is equally efficient.

The above results also indicate that continued double-cropping leads to a neutral, downward shift in the production function; that is, farms double-cropped only once are technically more efficient than farms that have been double-cropped two or more years. If the downward shift is attributed to declining soil fertility, the results point to the need for an increased application of fertilizer to be introduced simultaneously with double-cropping if yields are to be maintained.

The most important conclusion from the point of view of this study, however, is that Muda padi farmers do maximize restricted profits, as was assumed in the theoretical model of chapter 3; that is, they
maximize profits with respect to labor, machinery, and other variable inputs and they treat land as a fixed factor. As a result, it is appropriate to express output, factor demands, and restricted profits ($\pi$) as functions of the quantity of the fixed factor (land) and the relative factor costs of the variable factors (labor, capital services, and other variable inputs). This is done by substituting the demand functions:

$X_i = \alpha_i (p_i / \bar{p}) F \quad i = 2 \ldots 4,$

into the production function to obtain:

$F = \left[ \alpha_0 X_1 \left( \frac{\alpha_2 p}{p_2} \right)^{\alpha_2 / \alpha_1} \left( \frac{\alpha_3 p}{p_3} \right)^{\alpha_3 / \alpha_1} \left( \frac{\alpha_4 p}{p_4} \right)^{\alpha_4 / \alpha_1} \right]^{1/(1 - \alpha_1 - \alpha_2 - \alpha_3)}$

where $F = \text{output}$, $X_1 = \text{land}$, $p = \text{output price}$, $p_i = \text{price of } i^{th}$ factor, and $\pi = \text{restricted profits}$. Finally, equation (25) can be substituted for $F$ in:

$\pi = p F - \sum p_i X_i \quad i = 2 \ldots 4$

or

$\pi = (1 - \sum \alpha_i) p F \quad i = 2 \ldots 4,$

to obtain the expression for restricted farm profits. Using the coefficients reported in table 5 for the case in which the production function is estimated without a dummy shift variable, equation (25) can be written as:

$F = 42.11 A (p/p_2)^{0.47} (p/p_3)^{0.12} (p/p_4)^{0.12}$;

equation (26) can be written:

$\pi = 0.62 p F$;

and the demand function for padi labor can be written:

$X_2 = 0.29 (p/w) F$.

These equations will be used subsequently in chapter 6 to provide the estimates of the production side of the household model. In order to answer some of the policy issues raised in chapter 1, it is necessary to derive a variety of elasticities based on equations (24), (25), and (26). In particular, elasticities of output, labor demand, and profits with respect to output price, wage rate, and the neutral technical
Table 9. Elasticities of Output, Labor Demand, and Profit with Respect to Selected Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Output (F)</th>
<th>Labor demand (H)</th>
<th>Profit (π)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output price (p)</td>
<td>0.61 $\left(\frac{a_2 + a_3 + a_4}{a_1}\right)$</td>
<td>1.61 $\left(\frac{1}{a_1}\right)$</td>
<td>1.61 $\left(\frac{1}{a_1}\right)$</td>
</tr>
<tr>
<td>Wage rate (w)</td>
<td>−0.47 $\left(\frac{-a_2}{a_1}\right)$</td>
<td>−1.47 $\left(\frac{-a_1 - a_4}{a_1}\right)$</td>
<td>−0.47 $\left(\frac{-a_2}{a_1}\right)$</td>
</tr>
<tr>
<td>Neutral technical efficiency parameter (α_0)</td>
<td>1.61 $\left(\frac{1}{a_1}\right)$</td>
<td>1.61 $\left(\frac{1}{a_1}\right)$</td>
<td>1.61 $\left(\frac{1}{a_1}\right)$</td>
</tr>
</tbody>
</table>

Note. The formulas for the elasticities are derived at the point where returns to scale are constant. To obtain the formulas at any other point, α_1 must be replaced throughout by $(1 - a_1 - a_2 - a_4)$.

Efficiency parameter of the production function are required. These elasticities are derived and reported here, but the discussion of their significance for the household model is postponed until chapter 6 and the discussion of their policy significance until chapter 7.

Because the formulas for these elasticities do not contain the neutral technical efficiency parameter, α_0, the elasticities presented in table 9 apply equally to all types of padi farms regardless of the duration of double-cropping. The elasticities are based on the coefficients reported in table 5 for the case in which the production function is estimated from the entire sample of 386 farms. For ease of reference, the elasticity formulas are given in parentheses after each estimate.
An Expenditure System for Muda Padi Households

Household demand functions for own consumption of padi, market-purchased commodities, and leisure are estimated in this chapter. Estimates of a household labor supply function are also obtained. The theoretical model underlying the procedure was described in chapter 3. The model presented here is modified only by additional detail—in the form of household characteristics—needed to tailor the model to the Muda River Valley. The discussion in this chapter, therefore, focuses on the specific estimating functions chosen for the analysis and on the robustness of the results.

Because the ultimate intention is to derive conclusions concerning a variety of policy variables, it is extremely important to ensure that the quantitative results are not dependent on the specification of the underlying utility function. Accordingly, estimates are presented for two different specifications of the utility function, each of which imposes a different set of restrictions on the estimated elasticities. Each specification, therefore, serves as a check on the restrictions imposed by the other. The two functions are the linear logarithmic expenditure system, which imposes the restriction that all expenditure (but not income) elasticities are unity, and the linear expenditure system,
which allegedly imposes the restriction that own-price elasticities
bear an approximate linear relationship to expenditure elasticities. This implies that, if variations in expenditure dominate price varia-
tions in the data, expenditure elasticities will be determined with
some precision, but price elasticities will be subject to considerable
doubt. Thus, the income elasticities derived from the linear expendi-
ture system are used to test the restrictions of the linear logarithmic
expenditure system, and the price elasticities from the latter are used
to test the restrictions of the former. In this way, it is hoped that
reasonably robust estimates of the elasticities, which are most im-
portant from a policy point of view, will be obtained. The linear
logarithmic expenditure system is estimated first, and then it is com-
pared with an estimate of the linear expenditure system. Also, the
results obtained here for Malaysia are compared with those of the
only other comparable study, that of Lau, Lin, and Yotopoulos for
Taiwan.

The Linear Logarithmic Expenditure System

It has been demonstrated that, under certain conditions for any
given direct utility function with consumption quantities as argu-
ments, there exists an indirect utility function with prices and income
as arguments. The usefulness of this fact lies in the ease with which

Logarithmic Expenditure System: An Application to Consumption-Leisure
Choice,” *Econometrica*, vol. 46, no. 4 (July 1978), pp. 843-68; J. R. N. Stone,
“Linear Expenditure Systems and Demand Analysis: An Application to the Pattern
of British Demand,” *Economic Journal*, vol. 64 (1954), pp. 511-27; and Angus
Deaton, “A Reconsideration of the Empirical Implications of Additive Preferences,”
*Economic Journal*, vol. 84, no. 334 (June 1974), pp. 338-48
*Economic Journal*, vol. 82, no. 328 (December 1972), pp. 1, 145-51, 236.
3. The sample subset used to estimate the expenditure side of the model consists
of 207 households, as compared with 386 households used as a sample to estimate
the production side of the model. The difference in the subsets is the result of
excluding households with inconsistent or incomplete responses to questions used in
formulating the variables. The exclusion criteria are explained in the appendix.
A comparison of the means of variables from the two sample sets did not reveal
statistically significant differences
demand functions, consistent with utility maximization, can be derived from a given specification of the indirect utility function. In addition, it has been demonstrated that the system of equations derived for an aggregate household is consistent with the underlying structure of preferences of the individual household members and that the system of equations need not be expressed in per capita terms.\(^6\)

On the assumption that the utility function is continuous, monotonic, and strictly concave, there exists an indirect utility function, which may be written as:

\[
V = V(p^*, q^*, w^*; a_i),
\]

where the asterisks indicate normalized prices obtained by dividing by total expenditure \((E)\), and the \(a_i\) represent household characteristics.\(^6\) The demand function for the \(i^{th}\) commodity is then obtained by applying Roy's identity, that is,

\[
X_i = \frac{\partial V/\partial p_i^*}{\sum p_i^* \partial V/\partial p_i^*}, \quad j = 1 \ldots 3,
\]

to a particular specification of the indirect utility function.\(^7\)

For this exercise, equation (27) is specified using a transcendental logarithmic form, homogeneous of degree minus one, which provides a second-order approximation to an arbitrary homogeneous function expanded around the point at which the logarithms of the variables equal zero.\(^8\) This function is written as:

\[
\ln V = \alpha + \sum \alpha_i \ln p_i^* + \sum \gamma_n \ln a_n
\]

\[
+ \frac{1}{2} \sum \sum \beta_{ij} \ln p_i^* \ln p_j^* + \frac{1}{2} \sum \sum \delta_{nm} \ln a_n \ln a_m
\]

\[
+ \sum \sum \epsilon_{in} \ln p_i^* \ln a_n.
\]

5. Lau, Lin, and Yotopoulos, "The Linear Logarithmic Expenditure System."

6. Notation here is the same as in chapter 3. All variables are also defined in the appendix.

7. A heuristic interpretation of the indirect utility function and a discussion of Roy's identity are presented in Phlips, René Roy, _De l'Utilité: Contribution à la Théorie des Choix_ (Paris: Hennan, 1942); and Louis Phlips, _Applied Consumption Analysis_ (Amsterdam: North Holland, 1974).

8. Lau, Lin, and Yotopoulos, "The Linear Logarithmic Expenditure System."
Applying Roy's identity, the consumption expenditure functions are given by:

\[ -p_i X_i = \alpha_i + \sum_j \beta_{ij} \ln p_j + \sum_n \epsilon_{in} \ln a_n, \]

where \( i \) and \( j \) represent \( M, L, \) and \( C, i \neq j; \) and \( n \) and \( m \) represent household characteristics, \( n \neq m. \)

The requirement that the indirect utility function be homogeneous leads to the following restrictions in a three-equation system.

\[ \sum_i \alpha_i = -1, \]
\[ \beta_{11} + \beta_{12} + \beta_{13} = 0, \]
\[ \beta_{12} + \beta_{22} + \beta_{23} = 0, \]
\[ \beta_{13} + \beta_{23} + \beta_{33} = 0, \]
and
\[ \sum_i \epsilon_{in} = 0 \text{ for all } n. \]

Since neither \( p \) nor \( q \) varies over the cross-section sample used in the analysis, these variables disappear from the estimating equation because the independent variables are measured in deviations from their means after taking logs. Using this information together with restrictions (32) and (33), the estimating equations can be written as.

\[ -w^* L = \alpha_{11} \ln w + \sum_n \epsilon_{1n} a_n, \]
\[ -p^* C = \alpha_{21} \ln w + \sum_n \epsilon_{2n} a_n, \]
and
\[ -q^* M = \alpha_{31} \ln w + \sum_n \epsilon_{3n} a_n. \]

Only two of the three equations to be estimated are stochastically independent; the parameters of the third equation can be derived from the condition that the sum of the three budget expenditure shares equals 1. Ordinary least squares provides a consistent and unbiased procedure for estimation, and thus equations (36) and (37)

9. As a result, it is not possible to derive the price elasticities of \( C \) and \( M \) with respect to \( q \) and \( p. \)
are estimated and equation (35) is derived. The data are described in detail in the appendix; here it is simply noted that the only household characteristics considered were the number of working family members \( (n_1) \), the number of dependents \( (n_2) \), the age of the household head \( (a) \), and the number of years of his education \( (e) \).

After a preliminary set of results was obtained, variables with coefficients that were not significant at least at the 90 percent confidence limit (using a one-tailed \( t \) test) were dropped and the system was reestimated. Specifically, education was dropped from the padi consumption equation and age from the nonfarm goods equation. The final estimates to be used for the response analysis are presented in table 10. All coefficients are significant at above the 95 percent confidence limit except \( e_{23} \), which is significant above the 90 percent level. In general, the signs conform to expectation; for instance, an increase in the number of dependents leads to an increase in labor supply, and an increase in the share of the budget going to manufactured goods and padi consumption.

Two weaknesses of the model warrant further discussion. First, all expenditure elasticities of the linear logarithmic expenditure system are identically equal to unity. This restriction is relaxed in the linear expenditure system, which is estimated subsequently. Second, in deriving the leisure variable, it is necessary to specify the total time available to the household, because leisure is computed as a residual after allowing for all time allocated to work activities. It follows that the estimated parameters and hence the response elasticities may be sensitive to the specification of the total time available to the household. Thus, the leisure variable used in the estimates reported in table 10 is derived from the following formula:

\[
L = \left( \frac{\text{Total time available in days}}{8} \right) - \left( \frac{\text{Total time worked in hours}}{8} \right)
\]

10. Because the error terms may be correlated across the separate expenditure functions, seemingly unrelated least squares \( (\text{suls}) \) suggests itself as a more efficient alternative if there is no specification error. If, however, each equation is estimated across the same set of independent variables, \( \text{suls} \) reduces to ordinary least squares. In the final set of regressions, to be estimated below, nearly the same set of variables is used in each equation. The potential gain in efficiency was judged to be insufficient to offset the possibility of specification error in a given equation redounding through the system through the use of \( \text{suls} \).
Table 10. Estimated Parameters for the Linear Logarithmic Expenditure System

<table>
<thead>
<tr>
<th>Variable</th>
<th>To consumption of leisure ($-w^L$)</th>
<th>To own consumption of padi ($-p^C$)</th>
<th>To consumption of nonfarm commodities ($-q^M$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant ($\alpha_1, \alpha_2, \alpha_3$)</td>
<td>-0.53</td>
<td>-0.13</td>
<td>0.33</td>
</tr>
<tr>
<td>(41.98)</td>
<td>(43.31)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage rate ($w$)</td>
<td>-0.20</td>
<td>0.07</td>
<td>0.13</td>
</tr>
<tr>
<td>($\beta_{11}, \beta_{12}, \beta_{13}$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(16.97)</td>
<td>(13.72)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family labor force ($n_{11}$)</td>
<td>-0.13</td>
<td>0.03</td>
<td>0.10</td>
</tr>
<tr>
<td>($\epsilon_{111}, \epsilon_{112}, \epsilon_{113}$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4.10)</td>
<td>(4.78)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of dependents ($n_2$)</td>
<td>0.03</td>
<td>-0.02</td>
<td>-0.01</td>
</tr>
<tr>
<td>($\epsilon_{121}, \epsilon_{122}, \epsilon_{123}$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6.05)</td>
<td>(1.56)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of household head ($a$)</td>
<td>0.03</td>
<td>-0.03</td>
<td>0</td>
</tr>
<tr>
<td>($\epsilon_{131}, \epsilon_{132}, \epsilon_{133}$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2.67)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education of household head ($e$)</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td>($\epsilon_{141}, \epsilon_{142}, \epsilon_{143}$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td></td>
<td>0.61</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Note: N = 207  The t-statistics are given in parentheses under each estimate
a. Derived from restrictions (30), (31), and (34)

Total time available for work or leisure was obtained after adjusting for sickness, absences, and fluctuations in the number of working household members over the survey period, so that the element of arbitrariness in the derivation of $L$ arises mainly through the specification of the average length of the workday.  

As a test of the assumption of an eight-hour day, the parameters were reestimated on the assumption of a six-hour day, because the FAO-IBRD survey reveals that the consumption of leisure is quite high and appears to be an important part of living standards in the study area. Thus, using a six-hour day provides an important comparison...

11. Because total time available is measured only for the working family members, the measure of $L$ omits the time allocated to leisure by dependents. That is, the leisure time consumed by dependents is assumed not to contribute to family welfare.
with the results obtained above and may actually provide more accurate estimates of the response elasticities.

A comparison of the parameters estimated on the assumption of an eight-hour day with those calculated on the assumption of a six-hour day indicated that the results are quite insensitive to the specification of the length of the working day. In deriving the supply curve of labor from the demand curve for leisure, however, it is necessary to make further use of the assumption concerning the length of the working day. It follows that, although the estimated functions may be insensitive to the specification of the working day, the derived labor supply curve may still be highly sensitive to this assumption. And because, from a policy point of view, it is the supply curve of labor rather than the demand curve for leisure that is relevant, this assumption warrants further analysis. Fortunately, the linear expenditure system estimated below allows a direct estimate of the labor supply curve, which provides a point of comparison for the indirect, derived labor supply curve of the linear logarithmic expenditure system. Accordingly, it is necessary to examine the estimation procedure for the linear expenditure system.

The Linear Expenditure System

For the present application, to differentiate between the use of time by dependents and working household members, the linear expenditure system is developed in per capita terms. For an individual member of the family the utility function is written as:

\[ U = \sum \beta_i \ln (x_i - y_i), \]

12. This is not surprising because the adjustment amounts to little more than multiplication of the leisure variable by a scalar, which does not affect the estimated parameters. In the case of the switch from an eight-hour to a six-hour day, the leisure variable changes from \( L \) to \((8L + 2D)/6\), which approximates a proportionate adjustment either if \( L \) and \( D \) bear a proportionate relationship or if the first term in the parentheses dominates the second. Because \( L \) and \( D \) are positively related and because at the mean \( L/D = 0.74 \), it can be concluded that changing the length of the working day is unlikely to affect the estimated parameters.

where \( x_i \) indicates per capita consumption of the \( i^{th} \) commodity, and \( \gamma_i \) are functions of a variety of household characteristics. Dependents are assumed to consume all their available time in the form of leisure and to consume the same quantities of other goods as do working family members. It is further assumed that the household utility function is identical for each member and additive across individuals, so that summing over the \( n_1 \) working family members and the \( n_2 \) dependents, the following maximand is obtained:

\[
\sum U = n_0 \beta_1 \ln (d - s - \gamma_1) + n_0 \beta_1 \ln (d - \gamma_1) \\
+ n_0 \beta_2 \ln (c - \gamma_2) + n_0 \beta_3 \ln (m - \gamma_3),
\]

where \( d \) is the total time available per individual, \( s \) is the quantity of time supplied to work activities, \( c \) is per capita consumption of padi, \( m \) is per capita consumption of nonfarm goods, and \( n = n_1 + n_2 \).

Dividing through by \( n \), the problem can be written equivalently as:

\[
\text{Max} \quad u = k \beta_1 \ln (d - s - \gamma_1) + (1 - k) \beta_1 \ln (d - \gamma_1) \\
+ \beta_2 \ln (c - \gamma_2) + \beta_3 \ln (m - \gamma_3) \\
\text{s. t.} \quad kw (d - s) + pc + qm = E/n,
\]

where \( k = n'/n \). Let \( \beta'_i = k \beta_i \) and \( w' = kw \), then it is apparent that the problem is that of the standard linear expenditure system, for which the solution is:

\[
(39) \quad p_i x_i = \gamma_i p_i + \beta_i \left( \frac{E}{n} - kw\gamma_1 - p\gamma_2 - q\gamma_3 \right)
\]

\( i = 1, 2, 3. \)

For purposes of estimation, the system expressed as equation (39) is modified in several respects. First, as indicated earlier, the measurement of leisure as a residual after deducting working time from total available time may introduce a specification error. To avoid this possibility, a modification is adopted, which involves substituting \( d - \gamma \) for \( \gamma_i \) in equation (39).\(^{14}\) This yields:

\[
(40) \quad w_i s_i = \gamma_i w_i - \beta_i (b + kw\gamma - p\gamma_2 - q\gamma_3)
\]

and
\[ p_x = \gamma_1 p_1 + \beta_1 (b + kw\tilde{y} - \rho \gamma_2 - q\gamma_3), \]

where \( b = -kws + \rho c + qm \).

Second, the parameters \( \gamma_1, \gamma_2, \) and \( \gamma_3 \) appear in each of the three expenditure equations and thus an estimation procedure is chosen that constrains the estimates of the \( \gamma \)'s to be consistent across equations.\(^{15}\) This is achieved by noting that, for the marginal budget shares to sum to 1, \( k\beta_1 + \beta_2 + \beta_3 \) must equal unity; that is, an estimate of \( \beta_1 \) can be obtained from estimates of \( \beta_2 \) and \( \beta_3 \). Accordingly, the system to be estimated in matrix notation is written as follows:

\[
T = B\beta' + P\gamma',
\]

where
\[
\begin{align*}
\gamma' &= \begin{bmatrix} \gamma_1 & \gamma_2 & \gamma_3 \end{bmatrix}^T, \\
\beta' &= \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix}, \\
B &= \begin{bmatrix} b & 0 \\ 0 & b \end{bmatrix}, \\
P &= \begin{bmatrix} k\beta_2 & p(1 - \beta_2) - q\beta_2 \\ k\beta_2 & p\beta_3 & q(1 - \beta_3) \end{bmatrix}.
\end{align*}
\]

Estimation of the system proceeds under the assumption that the disturbance terms in each equation are independent and have zero means and uniform variances. Ordinary least squares is applied using a modification of the iterative least squares procedure used by J. R. N. Stone.\(^{15}\) Setting \( \beta_2 \) and \( \beta_3 \) equal to their values obtained from unconstrained estimation, the \( P \) matrix is constructed and ordinary least squares is used to estimate the \( \gamma \) and \( \beta \) vectors. The new values of \( \beta_2 \) and \( \beta_3 \) are then used to reconstruct \( P \), and the procedure con-

---

\(^{15}\) Some indication that this procedure was desirable was given by the consistency of unconstrained estimates of the \( \gamma \)'s.

continues iteratively until convergence is obtained. In the cross-sectional sample, neither p nor q varied but, in the case of the linear expenditure system, variation is required in only one price (kw, in this analysis) for all price elasticities to be determined.

As noted earlier, the γ's are expressed as functions of household characteristics. In particular, the vector of γ's is written as:

\[ \gamma' = \alpha H' \]

where

\[ \alpha = \begin{bmatrix} \delta_1 & \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} \\ \delta_2 & \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} \\ \delta_3 & \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} \end{bmatrix} \]

\[ H' = \begin{bmatrix} 1 \\ n_1 \\ n_2 \\ e \end{bmatrix} \]

Thus, H is the vector of household characteristics. The final estimating equations, therefore, can be written as

\[ t = B\gamma' + PaH' \] (42)

In application, convergence occurred in less than ten iterations, and the resulting coefficients proved remarkably similar to the unconstrained estimates.

After a preliminary set of results was obtained, variables with coefficients that were not significant at least at the 90 percent confidence level (using a one-tailed t test) were dropped and the system was reestimated. Specifically, none of the coefficients on age (a) were found to be significant; only \( \alpha_{11} \) on family labor force \((n_1)\) was significant; and only \( \alpha_{12} \) and \( \alpha_{23} \) on education \((e)\) were significant. The final parameter estimates are given in table 11. All coefficients are significant at above the 95 percent confidence level.

The per capita expenditure functions can be obtained by substituting the results of table 11 into equation (40). The family expenditure functions can then be derived by multiplying the labor supply function by \( n_1 \) (the number of working family members) and the expenditure functions for padi and nonfarm goods can be found by multiplying by \( n \) (the number of family members). For future reference, the final set of household equations can be written as follows.
Table 11. Estimated Parameters for the Linear Expenditure System

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_1$</td>
<td>0.30</td>
<td>—</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>0.05</td>
<td>2.72</td>
</tr>
<tr>
<td>$\delta_1$</td>
<td>0.78</td>
<td>32.61</td>
</tr>
<tr>
<td>$\delta_2$</td>
<td>79.87</td>
<td>16.93</td>
</tr>
<tr>
<td>$\delta_3$</td>
<td>76.66</td>
<td>8.62</td>
</tr>
<tr>
<td>$\delta_4$</td>
<td>131.36</td>
<td>3.10</td>
</tr>
<tr>
<td>$\alpha_{11}$</td>
<td>-9.35</td>
<td>8.74</td>
</tr>
<tr>
<td>$\alpha_{12}$</td>
<td>2.18</td>
<td>2.45</td>
</tr>
<tr>
<td>$\alpha_{13}$</td>
<td>-1.83</td>
<td>4.72</td>
</tr>
<tr>
<td>$\alpha_{21}$</td>
<td>-5.02</td>
<td>2.09</td>
</tr>
<tr>
<td>$\alpha_{22}$</td>
<td>-20.53</td>
<td>2.06</td>
</tr>
<tr>
<td>$\alpha_{23}$</td>
<td>7.45</td>
<td>2.31</td>
</tr>
</tbody>
</table>

Note: $N = 207$. Estimates are for per capita functions.

a. Derived from the restriction that $k\delta_1 + \beta_2 + \beta_3 = 1$. In calculating $\beta_i$, $k$ was set at its mean value of 0.56.

\[
\begin{bmatrix}
  w S \\
  p C \\
  q M
\end{bmatrix} = (E - wn_{id})
\begin{bmatrix}
  k & 0 & 0 \\
  0 & 1 & 0 \\
  0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
  -0.30 \\
  0.05 \\
  0.78
\end{bmatrix}
+ \begin{bmatrix}
  (1 - 0.30k) & wk & 0.30 & kp & 0.30 & kq \\
  0.05 & wk & 0.95 & p & -0.05 & q \\
  0.78 & wk & -0.78 & p & 0.22 & q
\end{bmatrix}
\begin{bmatrix}
  79.87 \\
  76.66 \\
  131.36
\end{bmatrix}
\begin{bmatrix}
  9.35 \\
  -2.18 \\
  0
\end{bmatrix}
\begin{bmatrix}
  1.83 \\
  0 \\
  7.45
\end{bmatrix}
\begin{bmatrix}
  0 \\
  0 \\
  0
\end{bmatrix}
\begin{bmatrix}
  n_1 \\
  n_2 \\
  e
\end{bmatrix}
\]

All elasticities reported subsequently for the linear expenditure system are derived from equation (43).

Household Response with Total Expenditure Treated as an Exogenous Variable

The elasticities of household consumption of padi ($C$) and non-farm goods ($M$) and of household labor supply ($S$) relative to the price of padi ($p$), the price of nonfarm goods ($q$), the wage rate ($w$),
Table 12. Elasticities for the Linear Logarithmic Expenditure System
with Respect to Selected Variables, with Total Expenditure Assumed Exogenous

<table>
<thead>
<tr>
<th>Variables</th>
<th>Elasticity Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of padi ( \beta )</td>
<td>(-0.51)</td>
</tr>
<tr>
<td>Price of nonfarm goods ( q )</td>
<td>(-0.40)</td>
</tr>
<tr>
<td>Wage rate ( \omega )</td>
<td>(\beta_{12}/\alpha_{1}) (-\beta_{11}L/S_{a_{1}})</td>
</tr>
<tr>
<td>Family labor force ( n_{1} )</td>
<td>(\beta_{12}/\alpha_{1}) (-\beta_{11}L/S_{a_{1}})</td>
</tr>
<tr>
<td>Number of dependents ( n_{2} )</td>
<td>(0.12/\alpha_{2}) (-0.03/\alpha_{2}) (-0.14/\alpha_{2}) (-0.06/\alpha_{2}) (-0.11/\alpha_{2})</td>
</tr>
<tr>
<td>Age of household head ( a )</td>
<td>(0.19/\alpha_{3}) (-0.03/\alpha_{3}) (-0.14/\alpha_{3}) (-0.06/\alpha_{3}) (-0.11/\alpha_{3})</td>
</tr>
<tr>
<td>Education of household head ( e )</td>
<td>(0.12/\alpha_{4}) (-0.03/\alpha_{4}) (-0.14/\alpha_{4}) (-0.06/\alpha_{4}) (-0.11/\alpha_{4})</td>
</tr>
<tr>
<td>Total expenditure ( E ) (^{b})</td>
<td>(1.00) (-0.85) (-2.85) (-2.85) (-2.85)</td>
</tr>
</tbody>
</table>

Note: The elasticities are computed on the assumption that total expenditure is independent of \( \beta, \omega, \) and \( n_{1} \). Elasticity formulas are given under the estimates. All parameter values are from table 10.

1. a. Labor supply elasticities are derived by means of the identity. \( D = L + S \). At the arithmetic mean, \( D/S = 3.85 \) and \( L/S = 2.85 \).

1. b. The expenditure elasticities for \( L, C, \) and \( M \) are identically equal to 1.

The number of working family members \( n_{1} \), the number of dependents \( n_{2} \), the age \( a \) and the education \( e \) of the household head, and total expenditure \( E \) are presented in table 12 for the linear logarithmic expenditure system (LLES) and in table 13 for the linear expenditure system (LES). All elasticities are computed on the assumption that total expenditure on padi, nonfarm goods, and leisure remains constant; that is, the augmented version of Becker's concept of full income developed in chapter 3 is held constant.

In chapters 6 and 7, total expenditure will be made endogenous; at this point, however, interest focuses solely on the similarity of household con-

17. This does not imply that net household income is constant. That is, \( E = \pi + \text{work} + A \) (the augmented version of Becker's concept of full income) is held constant, but \( \pi + \omega S + A \) (net household income) varies as labor supply \( S \) varies.
Table 13. Elasticities for the Linear Expenditure System with Respect to Selected Variables, with Total Expenditure Assumed Exogenous

<table>
<thead>
<tr>
<th>Variables</th>
<th>Own consumption of padi (C)</th>
<th>Consumption of nonfarm goods (M)</th>
<th>Labor supply (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of padi (p)</td>
<td>-0.04</td>
<td>-0.27</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>$-1 + (1 - \beta_1)\gamma_1/C$</td>
<td>$-\theta \beta_1 \gamma_2/qM$</td>
<td>$\theta \beta_1 \gamma_1/\psi S$</td>
</tr>
<tr>
<td>Price of nonfarm goods (q)</td>
<td>-0.15</td>
<td>-0.77</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>$-\theta \beta_1 \gamma_2/pC$</td>
<td>$-1 + (1 - \beta_1)\gamma_1/M$</td>
<td>$\theta \beta_1 \gamma_1/\psi S$</td>
</tr>
<tr>
<td>Wage rate (w)</td>
<td>-0.32</td>
<td>-1.69</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>$-\theta \beta_1 \gamma_1/pC$</td>
<td>$-\theta \beta_1 \gamma_1/qM$</td>
<td>$1 + (\gamma_1 + \beta_1 \gamma_1)n_4/S$</td>
</tr>
<tr>
<td>Family labor force (n_1)</td>
<td>0.11</td>
<td>-1.78</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>$k + \phi \theta \beta_1 pC$</td>
<td>$k + \phi \theta \beta_1 qM$</td>
<td>$1 - (\beta_1 \psi - \theta \beta_1 \psi) n_4/\psi S$</td>
</tr>
<tr>
<td>Number of dependents (n_2)</td>
<td>0.24</td>
<td>-0.01</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>$(1 - k + \gamma_1 + \gamma_2 n_2)/pC$</td>
<td>$(1 - k + \psi_1 + \gamma_1 + \gamma_2 n_2)/qM$</td>
<td>$-\theta \beta_1 \psi_1 + \theta \beta_1 \psi_1 n_4/\psi S$</td>
</tr>
<tr>
<td>Age of household head (a)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Education of household head (e)</td>
<td>-0.07</td>
<td>-0.03</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td>$\psi \beta_1 n_2/QC$</td>
<td>$(\alpha_1 + \psi \beta_1) n_4/qM$</td>
<td>$(\alpha_1 + \psi \beta_1) n_4/\psi S$</td>
</tr>
<tr>
<td>Total expenditure (E)</td>
<td>0.52</td>
<td>2.74</td>
<td>-0.81</td>
</tr>
<tr>
<td></td>
<td>$E \beta_1 /pC$</td>
<td>$E \beta_1 /qM$</td>
<td>$k \beta_1 /\psi S$</td>
</tr>
</tbody>
</table>

Note: The elasticities are computed on the assumption that total expenditure is independent of p, w, and n_1. Elasticity formulas are given under the estimates. All parameter values are from table 11. The elasticities are computed at the arithmetic mean of variables and:

$\phi = (k - 1)\gamma_1 + n_1 \omega_11 - E/n_1$
$\theta = kw (\gamma_1 + n_2 \omega 11) - n_4 \alpha 11 - n_4 \alpha 12 - E/n_1$
$\psi = kw (\gamma_1 + \gamma_2) - n_4 \alpha 11 - n_4 \alpha 12 - E/n_1$.
sumption responses obtained from LLES and LES, and for this purpose it is more appropriate to abstract from the complications of allowing total expenditure to vary.18

For LLES, the elasticities are computed at the geometric means of the independent variables which, given the specification of the functions, implies that the elasticities are relevant at the arithmetic means of the dependent variables. For LES, the elasticities are computed at the arithmetic means of the independent variables which, as with LLES, implies that the elasticities are relevant at the arithmetic means of the dependent variables. The two sets of elasticities are only comparable, therefore, in the sense that they are both relevant at the arithmetic means of the dependent variables. In other words, the representative household considered here is defined in terms of the dependent variables and not in terms of the independent variables. Other definitions of the representative household are, of course, equally valid; if alternative definitions are adopted, however, the elasticities must be recomputed accordingly.

Elasticities of the demand for leisure are omitted from the comparison because, from a policy standpoint, only the supply curve of labor is relevant. The LES admits a direct estimate of the labor supply function, and hence labor supply elasticities can be derived immediately; for LLES, however, the labor supply elasticities are derived from the estimated leisure demand elasticities by means of the formula.

\[
\frac{\partial S }{ \partial y } \frac{y}{S} = - \frac{\partial L }{ \partial y } \frac{y}{L} \frac{L}{S} = - \frac{\partial L }{ \partial y } \left( \frac{D - S}{S} \right),
\]

where \(D\) is total time available to the family.19

The restrictions imposed on the parameters of the two systems are

18. This procedure is analogous to that employed in standard consumer demand analysis, where the effect of a change in price is analyzed under the assumption of a constant level of income. In the model presented here, leisure can be regarded simply as an additional commodity. The significance of making total expenditure endogenous is assessed in chapter 6.

19. Equation (44) is derived from the equation:

\[
D = n_d = S + L,
\]

where \(d\) is the total time available per working member. In deriving the elasticity of labor supply with respect to family labor force \((n)\), equation (44) is rewritten as:

\[
\frac{\partial S }{ \partial n } \frac{n}{S} = \frac{D}{S} - \frac{\partial L }{ \partial n } \frac{n}{L} \frac{L}{S}.
\]
A MODEL OF AN AGRICULTURAL HOUSEHOLD

considered first. For LLES, the expenditure elasticities of LES are used to test the validity of the restriction that the expenditure elasticities of C and M for LLES be identically one. For both expenditure functions, the expenditure elasticities for LES are significantly different from unity indicating that the main restriction of LLES is not confirmed by LES. The LES estimates themselves are highly plausible: the expenditure elasticity for own consumption of padi (0.52) is positive but less than one, whereas that for nonfarm goods (2.74) is highly elastic; the implied elasticity of leisure (0.28) indicates a mild trade-off between income and leisure.

Similarly, regarding LES, the claim is tested that LES imposes the restriction that own-price elasticities bear an approximately proportional relationship to expenditure elasticities. For the three estimated functions C, M, and S, for LES the ratios of the own-price to the expenditure elasticity are -0.08, -0.28, and -0.63, respectively, indicating that the own-price and expenditure elasticities are not related by a constant proportion. It is concluded that the alleged proportionality restriction is not a significant factor, probably because the budget share of each commodity is quite large and the level of disaggregation is correspondingly low. Moreover, the own-price elasticities of LES are quite plausible: the elasticity of the staple food item, padi, is low (-0.04), whereas that for nonfarm goods is considerably higher (-0.77); the own-price elasticity of labor supply (0.51) indicates that labor supply does respond positively but inelastically to changes in the wage rate.

An alternative test of the LES own-price elasticities involves a direct comparison of the LES estimates with the unrestricted LLES estimates; for LLES, however, the only own-price elasticity estimated is that for labor supply, for which the LLES estimate differs significantly from the LES estimate (1.79 and 0.51, respectively). The significance of this point, however, is undermined by the observation that the labor supply elasticities are derived by means of equation (44) and hence are sensitive to the specification of total available time (D). Thus,

20. The alleged factor of proportionality is the inverse of Frisch's flexibility of the marginal utility of money. See Deaton, "A Reconsideration of the Empirical Implications of Additive Preferences."

21. According to Deaton: "Clearly, the approximation (i.e., the proportionality relationship) will only be close for a good which occupies a very small fraction of the budget and it will only be close for all goods if the level of disaggregation adopted is high." Ibid., p. 340.
\( p S/Jp \) varies from 1.79 on the assumption of an eight-hour day to 1.05 on the assumption of a six-hour day. Because the corresponding elasticities of demand for leisure are \(-0.63\) and \(-0.56\), the source of variation must be the arbitrary specification of \( D \). On this basis, it can be argued that the directly estimated elasticities of labor supply for \( \text{LES} \) are to be preferred to the derived elasticities for \( \text{LLES} \).

The analysis thus far indicates a preference for the \( \text{LES} \) expenditure elasticities for \( C \) and \( M \) and all of the labor supply elasticities of \( \text{LES} \) rather than those of \( \text{LLES} \). Of the ten remaining elasticities, for which a comparison between \( \text{LES} \) and \( \text{LLES} \) is possible, only three show a sign change; of the remaining seven, only two show an absolute variation of \( \pm 0.50 \). Because there is no a priori expectation concerning the sign or magnitude of these five elasticities, it is not possible to choose among them. For example, as the size of the family labor force increases, it is quite plausible for the family to restructure its consumption pattern away from padi and nonfarm goods and toward leisure (as predicted by \( \text{LLES} \)), or away from nonfarm goods and toward padi and leisure (as predicted by \( \text{LES} \)). On the other hand, five of the pairs of estimated elasticities for \( \text{LES} \) and \( \text{LLES} \) are both consistent and plausible. For example, both \( \text{LES} \) and \( \text{LLES} \) indicate that the household consumption pattern is largely independent of the age of the household head. Similarly, both systems predict a mild, negative response in the consumption of padi as the wage rate increases; that is, the cross-price elasticity of padi consumption with respect to the price of leisure is negative and inelastic.

Because arguments have been advanced to the effect that the \( \text{LES} \) estimates may be superior to those of \( \text{LLES} \), in the subsequent analysis in chapters 6 and 7, the main emphasis is on the \( \text{LES} \) estimates; the \( \text{LLES} \) estimates, however, are retained for purposes of comparison. Thus, the main discussion in chapters 6 and 7 is in terms of the \( \text{LES} \) estimates, although reference is made to the \( \text{LLES} \) estimates wherever those estimates indicate different interpretations and assessments of policy interventions.

22. The elasticities of \( C \) with respect to \( n_1 \) and of \( M \) with respect to \( n_2 \) and \( \epsilon \) differ in terms of sign, and the elasticities of \( M \) with respect to \( w \) and \( n_1 \) differ in terms of magnitude. The elasticities of \( M \) with respect to \( n_2 \) and \( \epsilon \), however, although differing in sign, are consistent in indicating that \( M \) is not highly responsive to either variable.

23. The elasticities are those of \( C \) with respect to \( w, n_2, \epsilon \), and \( a \), and that of \( M \) with respect to \( a \).
Table 14. Elasticities of Household Response with Respect to Selected Variables, Malaysia and Taiwan

<table>
<thead>
<tr>
<th>Variables</th>
<th>Malaysia</th>
<th>Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of agricultural output (p)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Price of nonfarm goods (q)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Wage rate (w)</td>
<td>—0.51</td>
<td>—0.46</td>
</tr>
<tr>
<td>Family labor force (n₁)</td>
<td>—0.25</td>
<td>—0.46</td>
</tr>
<tr>
<td>Number of dependents (n₂)</td>
<td>0.12</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Note: Elasticities for Malaysia are given first and are taken directly from table 12. The elasticities for Taiwan are given second and are taken from table IV in Lawrence J. Lau, Wuu-Long Lin, and Pan A. Yotopoulos, “The Linear Logarithmic Expenditure System: An Application to Consumption- Leisure Choice,” *Econometrica*, vol. 46, no. 4 (July 1978), p. 865.

A Comparison of Malaysian and Taiwanese Results

Although the arguments presented above favor using LES rather than LLES estimates for a number of reasons, it is still of considerable interest to compare the LLES estimates obtained here with the LES estimates obtained by Lau, Lin, and Yotopoulos for Taiwan. Table 14 compares selected household response elasticities for Malaysia and Taiwan.²⁴

The comparison reveals a remarkable similarity between the two sets of elasticities. Of the eleven elasticities for which a comparison

²⁴ Elasticities of leisure, rather than of labor supply, are presented in order to minimize the effect of the arbitrary specification of total time available.
is possible, eight are within ±0.20 and all eleven have the same sign. The implication is that the structure of preferences of Malaysian padi farmers is not greatly different from that of their Taiwanese counterparts. The three exceptions to this conclusion are the elasticities computed for the size of the family labor force. The Taiwanese results show that consumption of all three commodities is independent of the size of the family labor force. The Malaysian results, on the other hand, indicate that, as the size of the family labor force increases, expenditure is reallocated from consumption of commodities to the consumption of leisure. In other words, the structure of preferences is independent of the size of the family labor force in Taiwan but is a function of family labor force in Malaysia. Apart from this difference, the results reveal an astonishing degree of comparability between the two countries in the preference structures underlying the behavior of rural households.

25. At this point in the analysis, total expenditure (E) on the two commodities and leisure is held constant by assumption.
The Interaction of Production and Consumption Decisions

The household reaction to changes in labor market conditions or padi prices consists of both a restructuring of consumption patterns, attributed to expenditure and consumption substitution effects, and a production response. It follows that exogenous changes in variables underlying the profit function will influence total household expenditure ($E$), which will in turn initiate a further change in household consumption patterns. For example, consider the impact on household consumption of nonfarm goods ($M$) resulting from a change in the wage rate ($w$). The demand curve for nonfarm goods can be written as:

\[ M = M(q, p, w, E; a), \]

where \( a \) represents household characteristics. Total expenditure, \( E \), is defined as:

\[
E = \pi(p, w; \alpha, X_1) + wn_d + A,
\]

where \( \alpha \) indicates the technological parameters of the production function and \( X_1 \) is area operated. Given the definition of \( E \), the effect of a change in \( w \) on \( M \) is given by:

\[
dM = M_{aM} + M_{aw} + M_{aw} \frac{\partial \pi}{\partial E} + \frac{\partial \pi}{\partial E} + n_{id}.
\]

The production impact of the change in the wage rate enters equation (47) through the term \( \frac{\partial \pi}{\partial w} \). To isolate this term, equation (47) can be rewritten in elasticity terms as:

\[
\eta = \epsilon + \frac{\partial M}{\partial E} \frac{\partial \pi}{\partial w} \frac{w}{E}.
\]

where \( \eta = \frac{\partial M}{\partial M} \frac{\partial w}{\partial w} \) and \( \epsilon = \frac{\partial M}{\partial M} \frac{\partial w}{\partial w} + \frac{\partial M}{\partial M} \frac{\partial w}{\partial w} \)

The elasticities \( \epsilon \) and \( \eta \) can be interpreted as follows: \( \epsilon \) can be regarded as the elasticity of \( M \) with respect to \( w \) on the assumption that the level of farm profits is held constant, whereas \( \eta \) can be interpreted as the elasticity of \( M \) with respect to \( w \) on the assumption that farm profits are allowed to vary according to the dictates of profit maximization. It follows that a simple measure of the significance of integrating production and consumption decisions can be obtained by comparing \( \epsilon \) and \( \eta \) elasticities computed for a variety of dependent and independent variables.

The Quantitative Significance of the Theory of the Farm Household

Table 15 presents the \( \epsilon \) and \( \eta \) values for the elasticities of own consumption of padi (\( C \)), consumption of nonfarm goods (\( M \)), and supply of labor (\( S \)) with respect to all the exogenous variables that enter

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2. A more precise definition of all variables is given in the appendix.
3. The elasticities computed in chapter 5 are of the type \( \frac{\partial M}{\partial M} \frac{\partial w}{\partial w} \), which shows the response of \( M \) to changes in \( w \) with \( E \) held constant.
both the consumption and the profit functions (that is, the price of padi, \( p \), and the wage rate, \( w \)), and with respect to the neutral technical efficiency parameter of the production function (\( \alpha_0 \)). Table 15 therefore compares all the elasticities for which the integration of household production and consumption decisions is potentially significant, because the other decision variables of policy interest, such as the level of farm output and household demand for labor, are determined independently of consumption decisions, as discussed in Chapter 3. The other exogenous variables considered here (size of family labor force, \( n_1 \); number of dependents, \( n_2 \); age of household head, \( a \); and educational attainment of household head, \( e \)) only influence consumption decisions.

The elasticities shown in table 15 are computed from the production function estimates of chapter 4 and the LES estimates of chapter 5.4 Those elasticities in the rows marked \( \epsilon \) are computed on the assumption that farm profits (\( \pi \)) are exogenously determined, and they therefore do not allow for the impact of changes in production behavior on consumption decision variables; those elasticities in the rows marked \( \eta \) are computed on the assumption that farm profits (\( \pi \)) are endogenously determined, and they therefore allow fully for the impact of changes in production behavior on household consumption behavior.

Of the nine pairs of elasticities shown in table 15, six differ with respect to sign; of the remaining three elasticities, two differ with respect to absolute magnitude by \( \pm 0.50 \), and all three differ by \( \pm 0.40 \). Thus, policy conclusions based on a model of household behavior that fails to integrate production and consumption decisions will in general be inaccurate with respect to either the direction of the induced change or its magnitude. These results establish the quantitative significance of integrating production and consumption decisions in a single model of household behavior. It can be concluded that the theory of the farm household is of considerable importance when assessing the microeconomic impact of changes in the price of the main agricultural output, the wage rate for agricultural labor, and the nature of technology.

It is obvious that a change in technology will only affect consumption decisions if total expenditure is allowed to vary with the induced

---
4. The emphasis on LES estimates rather than LLES estimates follows from the comparison of the two systems in chapter 5.
Table 15. A Comparison of Selected LES Elasticities with Respect to Selected Variables to Test the Significance of Integrating Household Production and Consumption Decisions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Own consumption of padi (C)</th>
<th>Consumption of nonfarm goods (M)</th>
<th>Labor supply (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of padi (p)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>-0.04</td>
<td>-0.27</td>
<td>0.08</td>
</tr>
<tr>
<td>$\eta$</td>
<td>0.38</td>
<td>1.94</td>
<td>-0.57</td>
</tr>
<tr>
<td>Wage rate (w)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>0.06</td>
<td>0.29</td>
<td>-0.07</td>
</tr>
<tr>
<td>$\eta$</td>
<td>-0.08</td>
<td>-0.35</td>
<td>0.12</td>
</tr>
<tr>
<td>Neutral technical efficiency parameter ($a_0$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>0.42</td>
<td>2.21</td>
<td>-0.65</td>
</tr>
<tr>
<td>$\eta$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The elasticities in the rows marked $\varepsilon$ are computed on the assumption that farm profits ($r$) are constant. The elasticities in the rows marked $\eta$ are computed on the assumption that farm profits ($r$) are variable. Elasticities are computed from the production function estimates of chapter 4 and the LES estimates of chapter 5.

Changes in farm profits. Nevertheless, the magnitude of the consumption response elasticities is surprising although households significantly reduce their labor supply and expand their consumption of staple food items, the main impact is their increased consumption of nonfarm goods, for which the response elasticity is 2.21. The change in the elasticities with respect to output price and the wage rate are equally dramatic. For example, with farm profits held constant, a rise in the price of padi induces the household to reduce its consumption of padi and nonfarm goods and to supply more labor. If, however, allowance is made for the impact of the price rise on farm profits, household behavior is reversed: the household can now afford to consume more padi and nonfarm goods and to reduce its supply of labor. Similarly (but conversely), the response elasticities with respect to the wage rate show an entirely different picture depending on whether farm profits are assumed exogenous or endogenous. If they are assumed to be exogenous, the increase in the wage rate increases the value of the household’s stock of labor; the household responds by increasing its consumption of padi and nonfarm goods and reducing
its supply of labor. With farm profits endogenous, however, the reduction in the level of farm profits induced by the rise in the wage rate more than offsets the rise in value of the household's stock of labor, and hence the household is forced to reduce its consumption of padi and nonfarm goods and to increase its supply of labor.

Specific Elements Determining the Importance of the Theory

Once it is established that the theory is of quantitative significance, it is also of interest to examine the specific elements in the analysis that determine the importance of the theory. In this respect, an examination of equation (48) shows that the significance of integrating production and consumption decisions depends on the product of the following three terms: the sign and magnitude of the expenditure elasticity \( (E\partial M/M\partial E) \); the sign and magnitude of the elasticity of profits \( (\partial \pi/\partial \omega) \); and the importance of farm profits in total expenditure \( (\pi/E) \). It follows that, if any of the three terms tends to zero, there is little to be gained by integrating farm production and household consumption decisions. Each of the three terms is examined below.

Regarding the expenditure elasticity, it can be observed from table 15 that the difference between \( \epsilon \) (computed on the assumption that farm profits are exogenous) and \( \eta \) (computed on the assumption that farm profits are endogenous) tends to be greatest for elasticities of nonfarm goods and smallest for elasticities of own consumption of padi. This is a direct reflection of the relative magnitude of the expenditure elasticities. Thus, the expenditure elasticity for \( M \) is 2.74 and that for \( C \) is 0.52. From the point of view of the dependent variables, therefore, the significance of the theory of the farm household increases with increases in the size of the expenditure elasticity. Regarding the sign of the expenditure elasticity, for commodities with positive expenditure elasticities \( (C \text{ and } M) \), the term \( (\eta - \epsilon) \) for any given independent variable carries the opposite sign to the corre-

5. The income effect thus outweighs the substitution effect. This result can be compared with that in chapter 5, in which total expenditure, rather than farm profits, was held constant. In that analysis, the substitution effect dominated the income effect, and labor supply response was positive.
responding term for any commodity with a negative expenditure elasticity (labor supply).

The importance of the expenditure elasticity reinforces the arguments in favor of using LES estimates rather than LLES estimates, because the latter, but not the former, are restricted to be unity. For example, the effects of a change in technology can be considered. For this case, the elasticities (computed on the assumption that farm profits are exogenous) are zero because, with farm profits given, the consumption decisions are independent of technology. It follows that differences in the \( \eta \) elasticities (computed on the assumption that farm profits are endogenous) between the LES estimates and the LLES estimates arise solely because of differences in the expenditure elasticities.\(^6\) Thus, the LES elasticity of own consumption of padi with respect to the neutral technical efficiency parameter is smaller than that of LLES, because the relevant expenditure elasticity for LES is only 0.52, whereas that for LLES is restricted to be 1.00. The reverse holds for the elasticity of nonfarm goods, because the expenditure elasticity for LES in this case is 2.74, whereas the LLES elasticity is still restricted to unity. Because the restriction on the LLES elasticities amounts to holding the budget shares constant, the elasticities of demand with respect to a change in technology will be identical for all commodities.\(^7\) An important methodological conclusion flows from this discussion: specifications of the utility function that restrict the estimated values of the expenditure elasticity will be inappropriate vehicles of analysis for the theory of the farm household.

Turning to the profit elasticities, table 15 reveals that, for any given commodity, the larger the difference between \( \varepsilon \) (computed on the assumption that farm profits are exogenous) and \( \eta \) (computed on the assumption that farm profits are endogenous) is, the larger is the response of profits. For example, the elasticity of profits with respect to the wage rate \( (w) \) is -0.47, whereas that of profits with respect to the neutral technical efficiency parameter \( (\alpha_0) \) is 1.61, and the corresponding absolute values of the term \( (\varepsilon - \eta) \) for the consumption of nonfarm goods are 0.64 and 2.21, respectively. It is thus much more

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6. See, for example, equation (48) where \( w\partial \pi/\pi \partial w \) and \( \pi/E \) are common to both LES and LLES estimates.

7. The LLES elasticities of \( C \) and \( M \) with respect to the neutral technical efficiency parameter \( (\alpha_0) \) are both 0.81. Apart from this difference, the conclusions of LES and LLES concerning the importance of the theory of the farm household are similar.
important to work within the framework of the farm-household model when the focus is on examining changes in the neutral technical efficiency parameter than when the focus is on a change in the wage rate. From the point of view of the independent variables, therefore, the significance of the theory of the farm household increases with increases in the size of the elasticity of profits. With respect to the sign of the profit elasticity, the comment on the sign of the expenditure elasticity applies with equal force.

Finally, the third term—the ratio of farm profits to total household expenditure—appears in every estimate of \( \eta \) and may, therefore, be regarded as an intercountry, interregional, or intergroup measure of the importance of the theory of the farm household. That is, in situations where the ratio is relatively high, the integration of production and consumption decisions is more important than in situations where the ratio is low. The arithmetic mean of this ratio for the sample studied here is 0.50. As discussed in Chapter 4, however, the production function analysis revealed that the neutral technical efficiency parameter \( (\alpha_0) \) of farms that have been double-cropped for less than two years is approximately 22 percent higher than that of farms that have been double-cropped for two or more years. It follows that, with other things equal, the farm profits of the former will be almost 40 percent higher than those of the latter. It may be of importance, therefore, to group Muda farmers according to experience with double-cropping when examining the significance of the theory of the farm household.

Accordingly, \( \pi/E \) has been recalculated for the two groups of farms with full allowance being made for the shift in the neutral technical efficiency parameter. For farms double-cropped once, \( \pi/E = 0.54 \), for farms double-cropped more than once, the ratio falls to 0.39. Changes in \( \pi/E \) of this magnitude certainly affect the magnitude of the \( \eta \) response elasticities, but they do not alter the qualitative nature of the results given in table 15. For example, the elasticity of own consumption of padi with respect to the neutral technical efficiency parameter now varies from 0.45 on newly double-cropped farms to 0.33 on farms double-cropped for a longer period, as compared with a value of 0.42 given in table 15 for the entire sample. Similarly, the

8. The downward shift in \( \alpha_0 \) with duration of double-cropping was attributed to declining fertility.
9. See equations (24) and (26).
elasticity of nonfarm goods with respect to the wage rate varies from -0.41 on newly double-cropped farms to -0.21 on farms double-cropped for two or more years, as compared with a value of -0.35 given in table 15. Thus, intergroup variations in the ratio of farm profits to total expenditure can lead to significant changes in the various response elasticities.\textsuperscript{10}

Interregional or intercountry differences in \( \pi/E \) may, of course, be considerably more important than the intergroup difference examined above, because it can be demonstrated that \( \pi/E \) decreases with increases in the level of wage rates. Thus, as wage rates increase, the numerator of the ratio falls (that is, \( \delta \pi/\delta w < 0 \)) but the denominator \( (E = \pi + wD + A) \) either increases (if \( D > \delta \pi/\delta w \)) or falls less than the numerator (because \( D > 0 \)). It follows that the theory of the farm household will have greater significance in economies characterized by low wage rates than in high-wage economies.\textsuperscript{11}

Given the mean value of the ratio of farm profits to total expenditure obtained in this study, the main points of the analysis can be summarized as follows: First, the theory of the farm household is quantitatively important if either the expenditure elasticity is absolutely large (as is the case for nonfarm goods and labor supply) or the impact of a change in an exogenous variable on farm profits is large (as in the case of a change in technology). The theory is especially important in the event that both occur simultaneously (as in the case of the elasticity of demand for nonfarm goods with respect to changes in technology). Second, the theory is quantitatively less important if either the expenditure elasticity is absolutely low (as is the case of own consumption of padi) or the impact of a change in an exogenous variable on farm profits is small (as in the case of a change in the wage rate). The theory is quantitatively unimportant in the event that both occur simultaneously, although even in this case the possibility of a sign change cannot be ruled out (as in the case of the elasticity of own consumption of padi with respect to the wage rate).

\textsuperscript{10} In the discussion of policy intervention in chapter 7, however, the distinction based on duration of double-cropping is not explicitly considered, although the implications for each group can be ascertained fairly easily from the information that has been presented thus far.

\textsuperscript{11} This is an obvious implication of the increasing value of time.
Policy Implications

The estimated household model is used in this chapter to examine the economic efficiency and social equity of a variety of policy measures of importance for rural development. The policy areas examined are: rural-urban migration costs; output price intervention; microeconomic effect of family planning; and technological innovations.¹

Response Elasticities

The main response elasticities for this analysis are shown in table 16. The elasticities reported in the table are for the linear expenditure system but, where the corresponding estimates of the linear logarithmic expenditure system differ significantly, both estimates are presented, with the LLES estimates given in parentheses.

Before policy conclusions are derived from the results, the micro and partial nature of all the elasticities given in table 16 needs to be considered. In each application, the response of an individual house-

¹. In Chapter 2 the wage rate was included as an important area for study. As will be seen, the wage rate becomes an endogenous variable in the remainder of the analysis and is not, therefore, treated as a separate issue.
hold should be distinguished from the aggregate market response. The elasticities computed from the household model show the effect of a change in an exogenous variable on household behavior when all other exogenous variables are held constant. Any attempt to draw macro, general equilibrium conclusions must face the problems of aggregation and of the macro interdependency among variables that at the micro level can be treated as exogenous. To achieve the transition from a micro and partial analysis at the household level to a macro and general analysis at the market level, two simple assumptions are made. The first is that the relevant macroeconomic relationships can be obtained by multiplying the corresponding microeconomic relationships by the total number of households in the padi sector. The second is that the only interdependency at the macro level between variables that are exogenous at the micro level is between the wage rate and all other variables.

With regard to the first assumption, all the information required for exact aggregation is contained in the estimated micro relationships and the observed distributions of household characteristics. Because the intention here is simply to give a crude and approximate indication of the macro implications of the model, however, it seems sufficiently accurate to adopt the concept of the "representative household" rather than to attempt a numerical aggregation of the micro relationships.2

The second assumption implies that the wage rate is the only variable that needs to be considered endogenous at the macro level. The justification for this assumption is that the prices of the main inputs and outputs, including padi, and the prices of many consumer items are determined in world markets, subject to government tariff policy.3 Other variables that are exogenous at the micro level (such as family labor force, number of dependents, and area operated) are also exogenous at the macro level, because the focus is on the short run, during which these variables can be considered fixed.4

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2. This approach is also adopted in Pan A. Yotopoulos and Lawrence J. Lau, "On Modelling the Agricultural Sector in Developing Countries," Journal of Development Economics, vol. 1, no. 2 (September 1974).
3. Prices of nontraded consumer goods and services, however, are determined in the local market. To the extent that the supply curve of such items is less than perfectly elastic, the analysis presented here can only be considered approximate.
4. It can also be argued that some of the variables are not determined by strictly economic considerations.
Table 16. Household Response Elasticities with Respect to Selected Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Elasticiies (T)</th>
<th>Own consumption of padi (C)(^a)</th>
<th>Consump-</th>
<th>Household</th>
<th>Farm</th>
<th>Total</th>
<th>Marketed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>tion of</td>
<td>labor supply</td>
<td>labor demand</td>
<td>padi output</td>
<td>padi output</td>
<td>expenditure</td>
</tr>
<tr>
<td>Price of padi (p)</td>
<td>0.38</td>
<td>1.94</td>
<td>-0.57</td>
<td>1.61</td>
<td>0.61</td>
<td>0.66</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-1.94)</td>
<td>(0.09)</td>
<td>(-1.47)</td>
<td>(-0.47)</td>
<td>(-0.55)</td>
<td>0.49</td>
</tr>
<tr>
<td>Wage rate (w)</td>
<td>-0.08</td>
<td>-0.35</td>
<td>0.11</td>
<td>-1.47</td>
<td>-0.47</td>
<td>-0.55</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.09)</td>
<td>(0.09)</td>
<td>(0.09)</td>
<td>(0.09)</td>
<td>(0.09)</td>
<td>(0.09)</td>
</tr>
<tr>
<td>Family labor force (n(_i))</td>
<td>0.44</td>
<td>0.06</td>
<td>0.62</td>
<td>-</td>
<td>-</td>
<td>-0.09</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>Number of dependents (n(_d))</td>
<td>0.23</td>
<td>-0.05</td>
<td>0.12</td>
<td>-</td>
<td>-</td>
<td>-0.50</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>Neutral technical efficiency</td>
<td>0.42</td>
<td>2.21</td>
<td>-0.65</td>
<td>1.61</td>
<td>1.61</td>
<td>1.85</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>parameter (a(_e))</td>
<td>(0.81)</td>
<td>(0.81)</td>
<td>(-2.31)</td>
<td>(0.81)</td>
<td>(0.81)</td>
<td>(0.81)</td>
<td>(0.81)</td>
<td>(0.81)</td>
</tr>
</tbody>
</table>

Note: The response elasticities reported here are for LLE. Where the corresponding LLES estimates differ with respect to sign or with respect to magnitude by ±0.50, the LLES are also reported in parentheses.

a. Elasticities with respect to p, w, and a\(_e\) are taken from table 15. Elasticities with respect to n\(_i\) and e are taken from table 14. Elasticities with respect to n\(_d\) are derived from equation (47).

b. Elasticities are taken from table 9.

c. Elasticities are derived from the equation R = Q - C, with C/R set at its mean value of 0.198.

d. Elasticities are derived from equation (46).
Accordingly, only the market for labor needs to be considered. It was established in chapter 2 that the market for agricultural labor in the Muda River Valley can be considered competitive and that the wage rate is determined by the interaction of supply and demand. The equilibrium wage rate for agricultural labor can, therefore, be determined by equating labor demand and labor supply for the representative household, that is:

\[ H = S + G, \]

where \( H \) and \( S \) are labor demand and supply of the representative padi household, and \( G \) is the use made per household of labor supplied by nonpadi households (for example, households that are landless and households outside the Muda River Valley).

Following a change in an exogenous variable (such as the technology parameters), \( H \) and \( S \) will change in line with the partial response elasticities given in table 16. In general, this will necessitate a change in the wage rate to restore equilibrium in the labor market—a change that will affect not only \( H \) and \( S \) but also \( G \). The impact of these interrelated changes can be described by differentiating the equation for labor equilibrium—equation (49)—with respect to wages and a given exogenous variable, \( X \). The resulting labor market condition for equilibrated proportional changes in wages and \( X \) can be written in terms of elasticities as:

\[ E_{\omega X} = \frac{\% \Delta \omega}{\% \Delta X} = \frac{\eta_{\omega X} (\Delta H) - \eta_{\omega X}}{\eta_{\omega X} - \eta_{\omega X} (\Delta S/H) - \eta_{\omega X} (\Delta S/H)} , \]

where \( \eta_{\omega w} \) is the elasticity of hired labor, \( G \), with respect to the wage. The total response, mutatis mutandis, of a chosen endogenous variable, \( Y \), to a change in a given exogenous variable, \( X \), can now be written:

\[ E_{YX} = \eta_{YX} + \eta_{\omega X} \cdot E_{\omega X} , \]

where the first term on the right-hand side gives the response, ceteris paribus, and the second term gives the part of the total response attributable to the induced change in wages.

In the calculation of the macro response elasticities in table 17,
Table 17. Selected Market Response Elasticities with Respect to Selected Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Own consumption of padi goods (C)</th>
<th>Consumption of nonfarm goods (M)</th>
<th>House supply (S)</th>
<th>Labor demand (H)</th>
<th>Total padi output (F)</th>
<th>Marketed padi output (E)</th>
<th>Non-Muda labor supply (G)</th>
<th>Wage rate (w)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of padi (p)</td>
<td>0.27</td>
<td>1.47</td>
<td>-0.14</td>
<td>-0.36</td>
<td>-0.02</td>
<td>-0.06</td>
<td>-0.09</td>
<td>1.34</td>
</tr>
<tr>
<td>Family labor force (n1)</td>
<td>0.46</td>
<td>0.05</td>
<td>0.38</td>
<td>0.47</td>
<td>0.15</td>
<td>0.09</td>
<td>-0.02</td>
<td>-0.33</td>
</tr>
<tr>
<td>Number of dependents (n2)</td>
<td>0.24</td>
<td>-0.03</td>
<td>0.11</td>
<td>0.09</td>
<td>0.03</td>
<td>-0.47</td>
<td>0.00</td>
<td>-0.06</td>
</tr>
<tr>
<td>Neutral technical efficiency parameter (α)</td>
<td>0.31</td>
<td>1.72</td>
<td>-0.48</td>
<td>-0.42</td>
<td>0.95</td>
<td>1.02</td>
<td>-0.10</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Note: Calculated from equations (50) and (51) using the household elasticities in table 16
which are used in the policy analysis below, equations (50) and (51) are applied using the values of the elasticities in table 16 and setting $S/H = 0.81$. It is also assumed that the elasticity of nonpadi hired labor with respect to a wage change is $-0.07$, as it is for padi households in the Muda region with the production side of the model omitted (see table 15). This assumption is valid if the utility function and the mean values of the exogenous variables delineating the characteristics of a representative household are the same for both padi and nonpadi households. Other possible values for the elasticity of off-farm labor response were tried and the results compared with those obtained under the assumption that $\eta_{ow} = -0.07$. It was found that the policy results were not highly sensitive to a range of values for $\eta_{ow}$ from $-0.1$ to $2$. That is, $\eta_{ow}$ can be negative, or positive and inelastic, or positive and moderately elastic without substantially affecting the policy implications. It is only for highly elastic values of off-farm labor response that the results change markedly. For example, if labor from outside the Muda area is in perfectly elastic supply to farms in Muda (that is, $\eta_{ow} \to \infty$), then $E_{x\omega} \to 0$ and the market elasticities calculated from equation (51) would approach the household values given in table 16. A strong indication that the outside labor supply is highly inelastic is given, however, by observing that wages increased greatly after the Muda Irrigation Project was completed. Money wage rates more than doubled between 1970 (pre-project) and 1973 (post-project), whereas the consumer price index (exclusive of rice) increased by only 15 percent and rice prices by less than 50 percent during the same period. The theoretical possibility of a negatively sloped labor supply curve is also demonstrated by Barzel and McDonald, using the linear expenditure specification.

Adjustments in the labor market may not, however, fully work themselves out during the course of a single agricultural cycle. An extension of the model to more than one cycle would require allowance for changes in the land market. As argued earlier, the land market is

6. S includes some nonpadi labor. At the mean, however, over 80 percent of all household labor is allocated to padi either directly (self-employment) or indirectly (wage-employment).
subject to nonmarket forces. It is therefore argued that, although it is reasonable to take the household's operational holding as being fixed, some allowance should be made for the possibility that rents are sensitive to changes in prices and technology. If, indeed, rents change, then nonwage, noncrop net other income \((A)\) will change, and this will initiate other repercussions on household behavior. How important is this likely to be? From the raw data, net rents (that is, rental payments less rental receipts) amount to almost 7 percent of net profits \((r)\) and approximately 3 percent of total expenditure \((E)\). Therefore, if the rental changed by 10 percent, total expenditure would change by only 0.3 percent and would have only minor impact on household consumption decisions. Accordingly, the analysis proceeds on the assumption that land rental remains constant

Rural-Urban Migration Costs

The question of surplus labor and the effect of rural-urban migration on agricultural output has received considerable theoretical attention in the absence of microeconomic empirical data. Based on the model introduced by Sen in 1966, the discussion has focused on the labor supply response following the departure of a family member from a household that does not participate in the labor market. In Sen's framework, labor market participation is considered a sufficient condition for the constancy of per capita labor supply, because the equation of the marginal utility of leisure to an exogenously determined wage rate remains unaffected. By way of contrast, the results establish that the per capita labor supply may be a function of the size of the family labor force, in which case an exogenously determined wage rate is no longer a sufficient condition for a constant per capita labor supply. In the Muda model, the removal of a working member from an agricultural household influences per capita consumption patterns through a change in the value of discretionary time available to the household and through changes in the extent of the household participation in the labor market.

Because the household has access to the labor market, the profit-maximizing level of agricultural production is determined independently of the number of working family members. Following the depar-

ture of one family worker, the profit-maximizing level of output can be maintained by either reducing household consumption of leisure, or increasing the quantity of hired labor, or both. The economic cost of migration is determined, at least in part, by the value of $\eta_{s_{1}}$, the elasticity of family labor supply with respect to changes in $n_{1}$. If $\eta_{s_{1}} = 1$ (that is, the per capita labor supply of the remaining household members remains constant), then the entire impact of migration is transmitted to the labor market. Alternatively, if $\eta_{s_{1}} = 0$ (that is, the per capita labor supply increases proportionately with decreases in the number of working family members), then there is no effect on the labor market. In the event of the latter, the economic cost of migration, in the sense of foregone output, is zero, because the loss of one working family member is restored entirely by a reduction in the consumption of leisure by the remaining family members. On the other hand, if $\eta_{s_{1}} = 1$, migration will lead to a loss of output, the extent of which will be determined by the change in the agricultural wage rate induced by the increased demand for hired labor.

In the study area in northwest Malaysia, $\eta_{s_{1}}$ is estimated to be 0.62 (see table 16)—that is, 38 percent of the reduction in household labor supply following the departure of one working family member is replaced by extra effort on the part of the remaining family members, ceteris paribus. The ultimate effect on output, however, and thus the economic cost of migration depends on the response of hired labor and the household to changes in the market wage. If the supply of hired labor from landless households is perfectly elastic, the economic cost of migration is zero, because additional labor can be hired without increasing the wage rate and hence without reducing output. Alternatively, the elasticity $ED_{n_{1}}$ of total labor hours used in padi production with respect to the number of working family members is 0.47, mutatis mutandis, as can be seen in table 17, which was computed under the assumption that the nonpadi hired labor supply has an elasticity of $-0.07$ as obtained from the consumption side of the household model. It can be concluded that migration from padi-producing households in rural Malaysia is socially beneficial, provided the migrant's marginal productivity at his point of destination exceeds 0.47 of his marginal productivity at the point of origin.

In determining shadow prices, the cost of rural labor is frequently

10. If, instead, $\eta_{s_{1}} = 2.0$, this conclusion holds, even if the migrant's marginal productivity at the point of destination exceeds 0.38 of the marginal productivity at the point of origin.
equated with labor's marginal product in agriculture. In contrast, the results of the present analysis indicate that, when allowance is made for the supply response of household members to changes in family composition and to indirect changes in the wage rate, and when allowance is also made for labor market response to the removal of rural labor, the true shadow price of a rural-urban migrant will be less than 50 percent of his marginal product. It is concluded that estimates of the opportunity cost of rural-urban migrant labor that are based only on a direct estimate of the marginal product of labor in the rural sector will overstate labor's true opportunity cost.

Output Price Intervention

An analysis of output price intervention carries important implications for Malaysia's current efforts to achieve self-sufficiency in padi. Much of the success of Malaysia's efforts in this direction must be attributed to technological change, especially the rapid expansion of irrigation facilities that allow double-cropping. In addition, however, Malaysia has also kept the domestic price of rice above the c.i.f. (cost, insurance, and freight) price, thereby subsidizing producers. The estimates of the household response elasticities of total and marketed output shown in table 16 and the general equilibrium market response elasticities shown in table 17 can be used to examine the extent to which price policy has contributed to this objective. The elasticities also give some indication of the impact of price policies on rural income distribution.

The elasticities in table 16 establish that, at the microeconomic level, Malaysian farm households respond positively to an increase in the price of padi output: the elasticity of total output is 0.61 and that of marketed output is 0.66. These elasticities, however, give the response, ceteris paribus, of an individual household. If all households respond to the price increase as indicated, the supply of labor from padi households will decrease, the demand for labor will increase,

and the resulting potential increase in market wages may bring about a reduction in output and marketed surplus, which in turn will bring about lower elasticities, mutatis mutandis. As in the previous application, the impact on the market wage will depend on the response of hired labor. Using $\eta_{ow} = -0.07$, it is calculated that the elasticities of output and marketed surplus with respect to price are $-0.02$ and $-0.08$, respectively (see table 17). Short of an infinitely elastic labor supply, this finding of a negligible output response to price changes remains essentially unaltered over a broad range of values of the elasticity of hired labor with respect to the wage. As $\eta_{ow}$ ranges from $-0.1$ to $2.0$, the elasticity of output with respect to price ranges from $-0.02$ to $0.11$. It is concluded that, if the response of hired nonpadi labor is inelastic, as it is assumed to be, the effects of government price intervention on output and marketed surplus have been essentially nil.

In discussing the income distributional effects of changes in output price, the impact on incomes in padi households is examined first and then the repercussions on other sectors of the economy are considered. In padi households, the microeconomic effect of an increase in output price can be derived immediately from the definition of total expenditure, as is seen in equation (46). Thus, the elasticity of farm profit with respect to price is 1.61. Padi households, therefore, receive a major income benefit from price increases, and this has substantial expenditure effects on the pattern of household consumption.

The associated changes in production and consumption in padi households can be expected to have a major effect on other household groups. For example, much of the increased expenditure made possible by price increases is allocated to nonfarm commodities ($M$). The household elasticity of $M$ with respect to $p$ is 1.94 and the market response elasticity is 1.47 (or 1.57 if $\eta_{ow} = 2.0$); thus, the indirect effects through changes in consumption can be expected to lead to significant increases in income for those in both rural and urban areas who produce or supply nonfarm commodities.

12. In contrast, the mutatis mutandis elasticities of output and marketed surplus with respect to neutral technological change are 0.96 and 1.09, respectively.

13. Most models of marketed surplus do not allow for the impact of an induced change in the equilibrium wage rate. See, for example, Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region," *Economic Journal*, vol. 73 (September 1963), pp. 477–87.
Of more importance, however, is the effect of a price increase on those members of the rural sector who depend primarily on wage-employment as a source of income, because it is this group who are usually among the poorest in most developing countries. Increases in the price of a major consumption item such as padi can be expected to impose severe hardships on this group. Fortunately, however, the evidence from northwest Malaysia indicates that this group can expect a compensating benefit in the form of increased wage income. Table 16 indicates that the household response, ceteris paribus, to a price change will involve an increase in demand for padi labor (both family and hired) and a reduction in household labor supply. The combination of an increased demand and a reduced supply of labor from padi households will bring about secondary changes in either the wage rate, or the use of hired labor, or both. It is calculated that $E_{wp}$, the elasticity of the market wage with respect to a change in price, mutatis mutandis, is 1.34 and that $E_{hp}$, the elasticity of hired labor use with respect to price, is $-0.09$. Therefore, the large increase in wages more than offsets the slight decline in employment, and households that depend on wage-employment as a source of income can expect their income to increase as a result of the increase in the price of padi.\textsuperscript{14}

**Microeconomic Effect of Family Planning**

Much of the economic literature surrounding the policy issue of family planning has focused on the determinants of fertility.\textsuperscript{15} Little attention has been given to the impact of a successful family-planning policy on short-run household behavior. The model presented here allows an analysis of the potential benefits of delaying an expansion of the family for one period. That is, the short-run effect of a marginal increase in the number of dependents on household consumption and labor supply can be examined and the results interpreted as the potential savings if, in fact, family size remains constant.

On this basis, the results of table 17 reveal that an increase in the

\textsuperscript{14} For a value of $\pi_{wp} = 2.0$, the elasticity of the market wage with respect to a change in the price of padi falls to 1.07, but the elasticity of hired labor use increases to 2.14. Thus, both wage rate and the quantity of hired labor increase.

The number of dependents is associated with an increase in household labor supply and farm labor demand. It follows that one result of a successful family-planning program is to reduce family and market labor supply as well as labor demand. The reduction is, however, very small ($E_{SN_1} = 0.11$ and $E_{HN_1} = 0.09$) and the impact on the wage rate ($E_{wN_2} = -0.06$) and hence on the output of padi is likely to be negligible.\footnote{The results are virtually the same for $\eta_{wN} = 2.0$.}

The impact of family planning on own consumption of padi and on marketed surplus is apt to be more substantial—the elasticity of own consumption with respect to the number of dependents is 0.24 and the elasticity of marketed surplus is $-0.47$. A rural family-planning program might be an important concomitant to policies that result in the transfer of labor from the rural sector. A 10 percent reduction in the labor force of the representative household results in a 0.9 percent reduction in marketed surplus, which can be compensated for by a 1.9 percent ($= 0.9/0.47$) reduction in the number of dependents in the representative household.\footnote{The corresponding adjustment if $\eta_{wN} = 2.0$ is 1.1 percent ($0.5/0.47$).}

Technological Innovation

Changes in agricultural technology are fundamental components of rural development strategies and have generated considerable discussion in the literature.\footnote{See Yujiro Hayami and Vernon W. Ruttan, Agricultural Development: An International Perspective (Baltimore: Johns Hopkins Press, 1971).} Of interest has been the extent to which the benefits of technological innovation are transmitted through the labor market to those who depend primarily on wage-employment as a major source of income. This concern, however, has been interpreted rather narrowly, with the result that most of the research in this area focuses on shifts in the demand curve for labor—that is, on the production side of the model—without considering the concomitant shifts in the labor supply curve and the induced changes in the wage rate stemming from the impact of technology on the allocation of household time between leisure and labor.\footnote{See Surjit S. Sidhu, “Economics of Technical Change in Wheat Production in the Indian Punjab,” American Journal of Agricultural Economics (May 1974), pp. 217–26.} As with the other policies
discussed, the model presented here goes beyond this narrow focus and explores the interactions of labor demand, labor supply, and the wage rate.

An outward shift in the production function is considered here—that is, an upward shift in the neutral technical efficiency parameter \((\alpha_0)\). Regarding the effect of technological change on farm households, it is calculated that the elasticity of farm profits with respect to technological change is 1.61. It is clear, therefore, that padi households receive a significant income increase from an upward shift in the production function.

Given the high elasticity of expenditure with respect to technological change, it can also be predicted that other households will receive indirect distributional benefits from increased expenditure by padi households. Thus, the elasticity of demand for nonfarm goods is quite high (1.72 if \(\eta_{Gw} = -0.07\), and 1.82 if \(\eta_{Gw} = 2.0\)), indicating that those households or enterprises that supply nonfarm goods and services will also enjoy increased levels of income as a result of improved technology.

Turning to the general equilibrium effects of technological change on the income of households providing off-farm padi labor, it is found that there will be a substantial effect on both the demand and supply side of the labor market. Because the elasticity of demand for labor (both family and hired) with respect to \(\alpha_0\) is 1.61 and the elasticity of family labor supply with respect to \(\alpha_0\) is \(-0.65\), it can be expected that neutral technological change will increase the wage bill. As indicated in table 17, the calculation of the mutatis mutandis elasticity of the wage with respect to \(\alpha_0\) is 1.38. Similarly, the mutatis mutandis elasticity of hired labor use with respect to \(\alpha_0\) is calculated to be \(-0.26\), which implies that, although there will be some reduction in employment, neutral technological change will have a sizable positive impact on the wage bill. This result is of considerable significance because it indicates that the trickle-down approach to economic growth is at least partially valid in that the benefits of improvements in farm technology are being transmitted through the

20. The model presented here can be used in a similar manner to analyze the impact of specific nonneutral changes in technology.

21. If, however, \(\eta_{Gw} = 2.0\), the elasticity of the wage with respect to \(\alpha_0\) falls to 1.10, but that of hired labor increases to 2.2. This result parallels that of a rise in the price of padi.
labor market to those who are not themselves primarily padi farmers. Agricultural projects, which benefit directly those members of rural society who control the main productive assets, can also be expected to benefit those who own little or no land through changes in wage rates and the wage bill.

Conclusions and Future Research

The discussion in this chapter has illustrated the potential usefulness of farm-household models in the policy context. In the particular instance of the Muda River Valley it has been demonstrated that the model can be applied to a number of policy issues ranging from output price intervention to technological innovation. In specific applications, the results of the estimated model indicate that the economic cost of rural-urban migration in northwest Malaysia is small when compared with the marginal productivity of the migrant before his departure, that output price intervention is not effective in increasing marketed surplus, and that substantial benefits arising from increases in agricultural output prices and improvements in technology are distributed through the labor market to those who rely heavily on wage-employment as a major source of income.

Further explorations would enhance the policy payoff obtained from applying the household model. Three directions for future research seem particularly important. First, the sensitivity of the results to econometric specification, especially regarding the choice of utility and production functions, needs to be explored more fully. Some indication of the need for such an effort is given in chapters 5 and 6, by the comparison of results from the linear expenditure system and the linear logarithmic expenditure system. Second, the models should be applied to firm households, especially those in small towns and the urban informal sector, which supply nonfarm goods. And third, the models should be expanded so that some of the variables which are currently exogenous (especially, risk, area operated, and savings) become endogenous.
Appendix

Data Base and Definition of Variables

In this appendix, the data base used in the study is briefly described, and then the variables—production function variables, expenditure function variables, and other variables—are defined.

Data Base

The data for this study were collected during the course of one calendar year, beginning in November 1972 and ending in November 1973, as part of a cooperative program by the Food and Agricultural Organization (FAO) and the International Bank for Reconstruction and Development (IBRD). The households for this survey were sampled in two stages. First, a simple random sample was taken of all rural population census enumeration blocks within the command area of the Muda Irrigation Project (642 blocks in total) using a 25 percent sampling fraction. Of the resulting 14,788 households, 10,196 were identified as being engaged primarily in padi work, either as padi farmers or as padi farm workers. The sample was then stratified
by (a) the number of years the household had been double-cropping, and (b) whether the land operated was acid or nonacid. Within each stratum thus identified, the sample size was chosen to be proportional to the standard deviation of mean annual cash income. The final sample size was 839 households, or slightly more than 8 percent of the population.

Each household in the sample was interviewed fifty-four times during the course of the year. These interviews comprised an opening and closing inventory (which collected information on a variety of stock variables such as asset ownership and family size) and fifty-two weekly interviews (which collected information on a variety of flow variables such as expenditure, income, output, and labor usage). The data from the fifty-two weekly interviews were aggregated into thirteen periods of four weeks each. Because of the comparatively short period of recall for the respondents (one week), the data base constitutes a relatively high quality source of information on the main flow variables.

For the purposes of this study, attention was concentrated on those households that have been double-cropping for one or more years and that operate nonacid land. This concentration ensures a relatively homogenous sample: it omits those households that were operating on the qualitatively inferior acid soils (8 percent of the original sample), those that were in the process of switching from single- to double-cropping during the period of observation (20 percent of the original sample), and those that were not operating any land at all (5 percent of the original sample). The study also focuses on the single agricultural cycle for which a complete record of inputs and outputs is available. That is, the study is confined to the second agricultural crop cycle in the 1972–73 season. Of the two padi crops grown in the Muda River Valley, the second relies on irrigation water and runs from April/May to August/September. For the household model, therefore, the decision horizon is taken to be the duration of the second crop cycle.

For the production function analysis, the sample obtained above was then further adjusted to exclude (a) all households that failed to report labor usage for land preparation, planting, harvesting, or threshing; (b) all households that failed to report padi output; and

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(c) all households that did not hire labor. The last adjustment involved removing only seventeen farms, because most households participated extensively in the labor market. The final sample size for the production function analysis was 386 households.

For the expenditure function analysis, the main limiting factor was the wage variable. Wages were calculated from original data by dividing the total value of wages in kind and cash by the number of hours of wage employment. The construction of this variable entailed using the weakest data obtained from the survey because of the inconsistent reporting of wage income, especially in kind, by some households. The obvious discrepancies in the reporting process were omitted and the resulting sample contained 207 observations.

Definition of Variables

All the variables used in the monograph are defined below. Where necessary, the definitions presented encompass both the theoretical concept and the corresponding empirical manifestation employed in the econometric exercises.

**Production Function Variables**

- \( F = \) output of the agricultural crop. Padi output is measured in gantang (1 gantang = 5.32 pounds).
- \( X_1 = \) area operated. Area operated is measured in relong (1 relong = 0.71 acres) and is controlled for soil quality differences by omitting all households operating acid land.
- \( X_2 = H = \) labor input. Male and female labor are weighted equally. The labor of household members under fifteen years of age is not included because information obtained from the survey indicated that the use of child labor is essentially nil. Labor is measured in man-hours.
- \( X_3 = \) flow of capital services. The capital variable measures the flow of capital services to padi production in physical terms. That is, the flows of buffalo and two- and four-wheel tractors are aggregated to form a single measure of the flow of capital services. The weights used in the aggregation represent the relative time needed for each power source to bring a constant area to the same state of readiness for planting. To arrive at buffalo-equivalents, the
flow of four-wheel tractor hours is weighted by 14 and that of two-wheel tractor hours by 3.5.

$X_4 =$ other variable inputs. Other variable inputs include various fertilizers and pesticides in value terms (Malaysian dollars per relong)

$a_0 =$ neutral technical efficiency parameter. It is the constant in a Cobb-Douglas specification of the production function.

$\pi =$ restricted farm profits That is, gross revenue $(pF)$ less the cost of the three variable factors, labor $(X_2)$, capital services $(X_3)$, and other variable inputs $(X_4)$.

### Expenditure Function Variables

$C =$ own consumption of the agricultural crop. Own consumption of padi is measured in gantang (1 gantang = 5.32 pounds).

$M =$ consumption of nonfarm goods.

$S =$ household labor supply. Household labor supply is measured in man-days. Male and female labor are weighted equally and child labor is ignored.

$L =$ consumption of leisure. Leisure is measured in man-days and is obtained as a residual by subtracting total time worked from total time available for the working family members.

$c, m =$ per capita consumption of padi $(C/n)$ and nonfarm goods $(M/n)$ respectively.

$s =$ per capital labor supply $(S/n_1)$.

$p =$ price of agricultural output (Malaysian dollars per gantang of padi).

$q =$ price of nonfarm goods. Given the heterogeneity of nonfarm goods, the econometric model is set up in terms of the value of nonfarm goods (that is, $qM$).

$w =$ wage rate (Malaysian dollars per man-day).

$n =$ family size.

$n_1 =$ family labor force. Number of family members over fifteen years of age.

$n_2 =$ number of dependents. Number of family members under fifteen years of age.

$k =$ proportion of working family members in family $(n_1/n)$.

$D =$ total time available to working family members. Total time available is obtained from the weekly survey after
A MODEL OF AN AGRICULTURAL HOUSEHOLD

adjusting for sickness, holidays, and fluctuations in the number of working household members over the survey period. It is recorded in man-days.

\( d = \text{per capita total time available (D/ni)}. \)

\( e = \text{educational attainment of the household head. The educational variable is expressed in terms of consecutive integer codes based on the number of years of formal education received by the household head.} \)

\( a = \text{age of household head. The age variable is expressed in terms of consecutive integer codes based on the age of the household head.} \)

\( A = \text{nonlabor, nonpadi net other income.} \) A is a residual that captures all other sources and uses of income. It includes receipt and payment of taxes, gifts, and rent, as well as the household's net credit position including net saving.

\( E = \text{total household expenditure.} \) E is obtained as the sum of farm profits (\( \pi \)), value of the family labor stock (\( wD \)), and nonlabor, nonpadi net other income (\( A \)). It is an augmented version of Becker's concept of full income.

\( b = \text{per capita total expenditure (E/n) minus the per capita value of the family labor stock (wD/n).} \)

Other Variables

\( U = \text{household utility.} \)

\( V = \text{maximized value of household utility.} \)

\( Z = \text{production and consumption of nonfarm, nonmarketed goods.} \)

\( T = \text{time allocated to Z goods production.} \)

\( N = \text{quantity of labor sold if N > 0, and quantity of labor purchased if N < 0.} \)

\( E_{rx} = \text{mutatis mutandis elasticity of Y with respect to X.} \)

\( \eta_{x} = \text{ceteris paribus elasticity of Y with respect to X.} \)

\( H = \text{labor demand of the representative household.} \)

\( G = \text{labor supplied by nonpadi households.} \)


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In this innovative study in economic analysis, a model of short-run behavior that combines production and consumption decisions in a theoretically consistent fashion is developed for an agricultural household. Using a sample of households from the Muda River Valley in Malaysia, the authors show that the integration of production and consumption decisions yields substantially different policy conclusions from those obtained by the traditional approach: analysis of production or consumption alone, in isolation from each other.

Among the policy issues analyzed are output response to price changes and technological innovation, costs of migration, and the short-run benefits of family planning programs. All policy analysis is conducted in a framework that allows for changes in labor supply and demand—as predicted by the household model. Changes in the wage rate as a result of policy intervention are also taken into account in determining market response.

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