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**THAILAND'S ECONOMIC BOOM AND
AGRICULTURAL BUST: Some Economic Questions and
Policy Puzzles**

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Thailand's economic boom and agricultural bust Some economic questions and policy puzzles¹

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with
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1 The absolute decline of Thai agriculture?

The *relative* decline of agriculture is a stylized fact of economic growth. As economies expand, they undergo structural change. Capital accumulation relative to labor and land endowments enables faster relative growth rates in industry and many countries, the pace of technical progress in non-agriculture exceeds that in the farm sector. Per-capita income growth skews the structure of incremental demand towards manufactures and services, and since many services are non-traded, this helps turn the domestic terms of trade against agriculture. All of these asymmetries contribute to the decline of agriculture's contribution to GDP and aggregate employment, even when—as in Thailand's recent past—the pace of agricultural output and productivity growth is quite respectable.

In Thailand, agriculture's relative decline has been pronounced for several decades. Since the late 1980s, however, the data suggest a dramatic acceleration in the rate of decline, accompanied by an *absolute* reduction in agricultural employment. About five years ago a group of leading Thai economists wrote that “the current prognosis is for the labor force in agriculture to decline absolutely sometime in the 1990s” (Ammar *et al.* 1993). By the time this statement was published, the absolute size of the Thai agricultural labor force was already shrinking, and had been so since 1989 (Figure 1). The fact of this decline in a rapidly growing economy should not be surprising, but the speed at which the labor force growth trend turned negative, and the magnitude of its subsequent decline (by about 15%, or three million workers between 1989-95), are remarkable. While some part of this trend may reflect improved data collection methods, the substantive economic causes are intuitively easy to grasp: tremendous aggregate investment growth (Figure 2), bidding up wages in all sectors (Figure 3) and stimulating accelerated mechanization as a substitute for labor in agriculture (Figures 4-6).

What is much more surprising than the decline in agricultural employment is that from 1989 until 1995 (the most recent year for which data are available) the total planted land area of Thai agriculture has also fallen (Figure 7). From 1989 to 1995 planted area in the Central and Northern regions declined by annual rates of about 2% and 1% respectively; in spite of small increases in the South and Northeast, total planted area fell by about 0.36% annually (Table A-1). Moreover real agricultural output growth underwent a sharp decline in the early 1990s, falling by about 18% between 1990 and 1992 (Figure 8) in spite of generally favorable trends in global commodity markets. Between 1980-90 and 1990-94, the growth rate of agricultural output slipped from over half that of GDP to 38% (Table 1); the sector experienced negative real growth in 1990 (-3.7%) and again in 1993 (-1.7%) (Asian Development Bank).

the following stylized facts. (1) While the total agricultural labor force is by no means fixed even in the short run, the agricultural wage is endogenous to agricultural labor demand. (2) Changing factor proportions, output diversification and technical progress in agriculture could all contribute substantially to changes in observed aggregate agricultural factor demand. The complication that then arises is that in order to model agricultural labor demand in a convincing manner, we must simultaneously explain agricultural wage formation. The dividend is that by doing so in terms of non-agricultural wages, prices, investment and productivity growth, we are able to see much more clearly how the determinants of Thai agricultural factor demand are to be found in the overall development of the economy and not merely within agriculture. In particular, since land and labor are complementary inputs, we expect to find that some part of the explanation for the observed land area decline is to be found in the labor market trends documented in section 1.

Our model explains agricultural land and labor demand in terms of product prices, prices of other variable inputs, quantities of fixed inputs, and measures of technological progress. We assume the return to agricultural land to be determined residually, so its price does not appear in these expressions. Wages, on the other hand, are explained by reference to the intersectoral labor market.

Labor demand

Agricultural labor demand is determined by the agricultural wage (WA)⁵ and the price of fertilizer (PF), both expressed in terms of agricultural prices (PA); the quantities of non-labor factors including land (NA), irrigation (IR) and agricultural machinery (KA); and a measure of technological progress (T), as in (1):

$$(1) \quad LA = LA(WA/PA, PF/PA, NA, IR, KA, T)$$

Land demand

While the total land endowment may be regarded as fixed in the short run, planted area may fluctuate from year to year. In our model the demand for land, measured as the area planted in each period, is determined by agricultural prices, a measure of labor availability or wages, the price of fertilizer, the quantities of other inputs (irrigation, labor, agricultural machinery), and technology. Whether the quantity of agricultural labor or the wage should

according to official figures, 15% of GNP is produced in agriculture using 60% of the labor force, while the remaining 40% of the labor force produces 85% of GNP. This implies a ratio of labor productivity in agriculture to non-agriculture of about 1/8, a very high figure and one that is not at all supported by relative wage data, which could not reasonably be interpreted to indicate a ratio of less than 1/4.

⁵ Unsubscripted variables refer to current values. Only lagged values are subscripted e.g. WA₋₁.

appear in this equation depends on our assumption about labor mobility. If labor were intersectorally immobile (or at least of very limited mobility) then it would be appropriate to use the quantity of agricultural labor as a measure of a fixed factor endowment.

Alternatively, if labor were mobile so that farmers, having made their land use and technology decisions, could readily hire the required labor, then the wage would be a more appropriate explanatory variable. Neither specification is likely to be strictly correct in a short-medium run analysis of Thai agriculture, and we lack sufficient information to test them empirically. Accordingly, we fit both models and compare their results. The alternative explanations for land demand are shown as (2a) and (2b):

$$(2a) \quad NA = NA(PA, WA/PA, PF/PA, IR, KA, T),$$

or:

$$(2b) \quad NA = NA(PA, PF/PA, LA, IR, KA, T),$$

Equations (1) and either (2a) or (2b) are interdependent since endogenous variables appear on their right hand sides. There are two additional complications. First, some or all equations may be underidentified, depending on the exact combination of exogenous variables included and excluded from each. Second, due to the large share of agriculture in total employment, the agricultural wage is also not invariant with respect to changes in agriculture and its presence as explanatory variable is another source of simultaneity bias. We resolve these problems, and in doing so capture the economic links between agricultural and non-agricultural development, by simultaneously explaining the agricultural wage by reference to the intersectoral labor market.

Agricultural wages

The Thai labor market exhibits a high degree of intersectoral mobility at the margin, and the agricultural wage has tracked the non-agricultural wage fairly closely over time (Figure 3). It is tempting to conclude that agricultural wages are determined by wages in non-agriculture, but of course reverse or bidirectional causality cannot be ruled out. We expect that agricultural wages (WA) and non-agricultural wages (WN) are related, but that the correspondence is not exact due to transactions costs and adjustment lags, i.e. $WA = WA(WA_{-1}, WN)$. We then explain WN by constructing an inverse non-agricultural labor demand function in terms of non-agricultural prices (PN), the aggregate capital stock (KN), labor supply (LF), and a time trend (T) capturing technical progress:

$$WN = WN(PN, KN, LF, T).$$

If a linear combination of these variables is correlated with the non-agricultural wage, then we can explain the agricultural wage by a partial adjustment expression such as (3):

$$(3) \quad WA = WA(WA_{-1}, WN) = WA[WA_{-1}, WN(PN, KN, T, LF)],$$

in which the current value of WA depends on contemporaneous and lagged values of exogenous variables determining the non-agricultural wage.⁶

The solution of equations (1), (2a) or (2b) and (3) as a simultaneous system resolves the identification problem (each equation in the system will now in fact be overidentified). Economically, the system captures the main linkages between sectors through the markets that matter most—product and labor markets—thus enabling us to measure agricultural factor demands in terms not only of agricultural prices and resource endowments, but also of key variables in the non-agricultural sectors that are likely to have influenced agriculture through relative price and factor productivity effects. By substitution from (3) into (1) and (2) it can readily be seen that the reduced form of the system is a pair of agricultural factor demand equations in which the explanatory variables are prices (PA, PN), fixed factor stocks (KA, KN, IR), and technological progress (T).

Data, estimation and results

We use a time series of provincial and regional data known as the TDRI Dynamic Project data set. Most data in these series are obtained from statistical series compiled by the relevant government agencies. The data set spans 35 years (1961-95) and four regions (Central, North, Northeast and South) as well as the Bangkok Metropolitan Region (BMR). Some of the data have been aggregated from province-level statistics. The agricultural price series is a Fisher index of the prices of 22 crops, and the non-agricultural price is a Fisher index of the prices of manufactures and prices of services. The non-agricultural capital stock series does not come from the TDRI data base, and is in fact a measure of the aggregate capital stock. However, since capital in agriculture is a tiny fraction of total capital in Thailand, this does not pose a serious problem. Other notable features of the data are summarized in an appendix to this paper.

For estimation we select some specific categorical variables for inclusion in each of the factor demand equations. These have the effect of compensating for unexplained

⁶ A more complete model of the labor market would include the possible effects of wages on the supply of labor through changes in the labor force participation rate.

variation introduced by the use of an aggregate agricultural price series. In the labor equation we use a measure of the area planted to field crops divided by that planted to tree crops (FT). In the land equation we use IN, the value of land-intensive crops divided by that of land-saving crops (land-intensive crops comprise most field crops plus rubber; land-saving crops are most vegetable and fruit crops plus oil palm). Each equation includes regional dummy variables. The labor equation also includes a dummy for 1974, a year in which agricultural labor demand was clearly far above its equilibrium value due to the previous year's boom in world rice prices and the impact of the first OPEC oil crisis on industrial production. Defining all continuous variables except the time trend in logarithms (denoted by a prime, e.g. $LA' = \ln(LA)$), the equation system to be estimated, excluding regional dummies, is:

$$(4) \quad LA' = a_1 + b_1(WA' - PA') + c_1(PF' - PA') + d_1NA' + e_1IR' + f_1KA' + g_1FT' + h_1T + \epsilon_1,$$

$$(5a) \quad NA' = a_2 + b_2PA' + c_2(PF' - PA') + d_2(WA' - PA') + e_2IR' + f_2KA' + g_2IN' + h_2T + \epsilon_2,$$

or

$$(5b) \quad NA' = a_2 + b_2PA' + c_2(PF' - PA') + i_2LA' + e_2IR' + f_2KA' + g_2IN' + h_2T + \epsilon_2,$$

$$(6) \quad WA' = a_3 + b_3PN' + c_3KN' + d_3LF' + e_3WA'_{-1} + h_3T + \epsilon_3,$$

where we expect b_1, f_1, d_2, e_2 and d_3 to take negative signs, and $d_1, e_1, g_1, b_2, c_2, f_2, g_2, i_2, b_3, c_3$ and e_3 to take positive signs. Simultaneity means that OLS estimators would be inconsistent. An instrumental-variables approach such as two-stage least squares (2SLS) would yield consistent estimators, but efficiency can be improved by fitting all equations as a system. Three-stage least squares (3SLS) is an algorithm for estimating systems of equations which yields consistent estimators that are asymptotically equivalent to full-information maximum likelihood. Accordingly, we use 3SLS to fit systems consisting first of (4), (5a) and (6), then of (4), (5b) and (6). We use the SHAZAM v.7.0 econometrics package (White 1993). Table A-2 reports estimates for the former system, while results for the latter system are shown in Table A-3.

Standard tests on the fitted equations reveal evidence of AR(1) processes, as may be expected in annual data. If uncorrected, these produce estimators that are consistent but inefficient. As a check, we fitted (4)-(6) using 2SLS with an AR(1) correction; the results (not reported) indicate improved efficiency but essentially unchanged parameter estimates.

Since most of our 3SLS estimates are highly significant, we take no action to correct for autocorrelation. It can readily be seen that the estimation results of the two models are very similar in terms both of signs and magnitudes of coefficient estimates and of overall fit. In the following discussion we concentrate on the longer-run model in (4), (5a) and (6).

Labor demand. As expected, labor demand is positively associated with land area, and negatively with the agricultural wage and the stock of agricultural machinery. Contrary to expectations, an increase in the fertilizer price contributes to increased labor demand. This result may be due to high correlation between fertilizer use and irrigation, since most fertilizer is used in irrigated rice production. Alternatively, an increase in the fertilizer price may result in reallocation of resources to more labor-intensive, less fertilizer-using crops, a shift masked by our use of an aggregate measure of output. It was also surprising that higher values of FT, the field crop-tree crop index, were associated with *lower* labor demand. However, the magnitude of this parameter estimate is extremely small. The coefficient of the time trend (T) suggests that over the entire period, technical progress in agriculture has been labor-using at a rate of approximately 3% per year.

Land demand. The estimated parameters of the land demand function conformed entirely with expectations, and all estimators are significant at conventional levels. Higher agricultural prices are associated with increased land demand, as are increases in the quantities of complementary inputs (agricultural capital) and the price of a substitute (fertilizer). Higher agricultural wages reduce land demand. An increase in irrigated area represents a positive land supply "shock" that causes planted area to expand, but by less than a proportional amount—indicating that as irrigated area expands, demand for non-irrigated land contracts. As expected, the land-use intensity index is positively associated with land demand. Technical progress in agriculture has been land-saving over the period covered by the data, at a rate of about 1% per year.

Agricultural wages. As in the land demand equation, the estimates of (6) were all of the predicted sign. Surprisingly, perhaps, the dynamic component of the model had no impact, with the estimated coefficient of WA_{-1} being just smaller than its standard error and very small in magnitude. By contrast, the contemporaneous determinants of non-agricultural wages, PN, KN and LF, were all found to exert strong effects on WA. The estimates suggest that over the period covered by the data, labor productivity growth in non-agricultural sectors has increased the agricultural wage at a rate of approximately 1.7% per year; however, the coefficient of T is not statistically significant.

We can use the agricultural wage estimates to draw some inferences about the impacts of intersectoral price trends and fixed factor endowment growth on agricultural factor demand. These and other results are summarized in elasticity form in Table 2.

Elasticities of agricultural labor and land demand are computed by making appropriate substitutions, for example from (5a) and (6) into (4), and from (4) and (6) into (5a) in the first model (since the estimators for lagged wages were all zero the elasticity calculations make no use of these).

Table 2: Estimated elasticities of agricultural labor and land demand

Elasticity of: With respect to:	Model 1: Longer-run (eq. (4), (5a), (6))		Model 2: Shorter run (eq. (4), (5b), (6))	
	Labor demand	Land demand	Labor demand	Land demand
Land use	0.82	—	0.82	—
Labor use	—	—	—	0.53
Agricultural wage	-0.62	-0.16	-0.39	—
Agricultural prices	0.44	0.17	0.29	0.01
Non-agricultural prices	-0.79	-0.20	-0.53	-0.28
Fertilizer price	0.28	0.12	0.11	0.11
Irrigated area	0.15	-0.04	0.18	-0.09
Agricultural machinery	0.01	0.21	-0.18	0.20
Non-agricultural investment	-0.26	-0.07	-0.14	-0.08
Labor supply	1.14	0.29	0.57	0.30
Time trend	0.01	-0.01	0.03	-0.02

Source: 3SLS estimates reported in Tables A-2 and A-3.

Values of the elasticity estimates confirm that agricultural factor demand is largely driven by non-agricultural phenomena, specifically by non-agricultural prices (PN) and investments (KN). These affect agricultural wages and thus drive agricultural resource allocation decisions. By contrast, the effects of agricultural investments such as mechanization and expansion of irrigated area, while significant, are relatively small.

The Model 1 estimates show the agricultural labor demand elasticity with respect to an increase in non-agricultural capital stock at -0.26. The labor series is measured in millions of workers and the capital stock in baht*10¹², so the elasticity can be interpreted as follows: other things equal, one agricultural worker migrates to non-agriculture for every 3,800,000 baht invested (US \$152,000 at an exchange rate of baht 25:\$1). The elasticity of planted land area with respect to non-agricultural investment is about -0.07; by an analogous calculation, every million baht invested outside agriculture reduces planted area

by about 1 rai. Comparing these numbers with the labor-land ratio (approximately 0.16, i.e., one worker per 6 rai) provides an immediate sense of the Rybczinski effect of non-agricultural growth in Thailand: at constant prices, non-agricultural investment growth causes factors to be withdrawn from agriculture at a rate of 3.8 workers per rai. Neither factor is fixed in agriculture, but in a relative sense labor enjoys high mobility. The result provides a strongly intuitive explanation for the reasons behind the rapid mechanization of Thai agriculture in the 1990s, as seen earlier in Figs. 4-6.

The difference between the two econometric models is that in Model 1 we presume land use decisions to be made with the assumption of mobile labor, while in the shorter-run Model 2, labor is assumed fixed. In Model 1, agricultural labor responds flexibly to external shocks, while in Model 2, the burden of adjustment to a price or technology shock falls more heavily on land. Thus the longer-run model shows an elasticity of land demand with respect to agricultural prices of about 0.17, while the corresponding elasticity in the shorter-run model is only 0.01. These values span the estimate of 0.08 obtained by Panayotou and Chartchai (1990). Their model of changes in land demand used agricultural wages as an exogenous explanatory variable, but did not attempt to explain wage formation. Moreover, their data do not cover the period of very rapid growth and structural change that began after 1987.

Finally, in light of the discussion to come in section 4, it is of particular interest to note that in the shorter-run model the elasticity of agricultural labor demand with respect to agricultural machinery is negative; labor and machinery are substitutes, and each percentage point increase in agricultural machinery stocks diminishes labor demand by 0.18%. In the short run, therefore, mechanization diminishes employment opportunities in agriculture, a point to which we return in considering the implications of the current economic crisis.

3 Policy issues⁷

Was Thai growth in the 1990s "too fast"?

The economic implications of the absolute declines in agricultural land and labor use and of dramatically slower sectoral output growth are potentially profound. Agriculture has long been regarded as one of the economy's leading sectors, and the country enjoys clear comparative advantage in several crops, most notably rice.⁸ Agriculture's sudden decline may also be a source of policy concern, if it has occurred at a rate greater than warranted by

⁷ Data in this section are largely drawn from commissioned background papers and data collection by Ms. Niramon Sutummakid, Faculty of Economics, Thammasat University.

long-term trends in factor endowment and productivity growth rates, and if the economy is characterized by significant market or technological irreversibilities.

Where does the problem arise? In the standard "Dutch disease" model of growth and structural change, the long-term relative decline of a tradable sector occurs in response to a permanent change in relative prices or rates of factor accumulation, technical progress, or changing consumer preferences (Corden and Neary 1982). In such cases the decline is socially optimal, since any intervention directed at slowing or reversing the sector's decline would reduce economic welfare. In the Thai case, however, some key assumptions of the standard theoretical result may be violated. Most notably, the accelerating rate of capital accumulation since the late 1980s appears to have been driven by an investment boom that was unsustainable in the long run and thus, as it turned out, was not permanent. The fact that much of this investment was financed by borrowing in short-term international money markets is of course relevant to the outcome, since it means that the end of the boom was marked by capital outflow and a consequent reduction in non-agricultural output and labor demand. It is also significant that much of the boom occurred in labor-intensive non-tradable sectors such as property development and construction, where asset prices were driven to unjustifiable heights by a combination of "irrational exuberance" and lax project appraisal and monitoring by lenders.⁹

Seen this way, the investment bubble of the 1990s was analogous to a temporary resource boom. As such, it may have had several undesirable consequences that would justify intervention. First, the decline in agriculture's domestic terms of trade with other sectors—caused by the investment boom and by spending on non-traded, non-agricultural goods and services—was probably exaggerated. Second, too-rapid growth in non-agricultural labor demand may have stimulated a faster rate of non-agricultural wage growth than long-term factor market trends would warrant. This in turn would have provided incentives for labor migration and for agricultural mechanization. Third, the presence of unaccounted externalities within agriculture, particularly those relating to water use, soil quality and erosion, may have stimulated a pattern of agricultural response to the non-agricultural boom which will be costly to correct. Mechanization and the depletion of environmental resources entail sunk costs, and their presence suggests that the investment boom may have induced some changes in Thai agriculture that are irreversible, at least in the short or medium run. In the presence of sunk costs and associated irreversibilities,

⁸ For a period in the early 1990s some Thais preferred to describe the country as a "NAIC"—Newly *Agro*-Industrializing Country—rather than the more generic NIC label applied to other East and Southeast Asian economies.

⁹ The phrase "irrational exuberance" was coined in 1997 in a reference to the US economy by US Federal Reserve chairman Alan Greenspan; nevertheless, it seems to fit the Thai case rather well.

protection is economically justified for sectors negatively affected by a temporary boom (van Wijnbergen 1984). A variant of this argument applies to rural-urban migration, where reversal of the labor flow involves transactions costs. Once again, the implied loss of welfare motivates policies to dampen the effect of the boom.¹⁰ In either case, excessive investment may have some unexpected long-term costs for the Thai economy.

In the presence of sunk costs or transactions costs, a temporary boom may reduce economic welfare in the long run, by causing some degree of irreversible decline in non-booming tradables sectors and by causing some resources to be wasted. In this sense growth may be "too fast", and corrective policies merited. In sections 4 and 5 below we examine more closely the impacts of the investment boom on migration and the use of fragile and marginal agricultural lands. Before doing so, however, we note some areas in which prior policy changes may have a bearing on the present agricultural problem.

The role of economic policy reforms

The extent to which policy changes, and especially trade policy reform, affected Thai agricultural growth in recent years is less well understood than is the overall role of relative price and profitability trends. Ammar and Suthad (1990) documented a trend to lower levels of agricultural taxation in data extending through 1986; since that time there have been further reductions in net agricultural taxation as well as in the trade protection of non-agricultural goods (figure 10). The trend shown in figure 10 has two main causes: the abandonment of rice export licensing, export duties and reserve requirements in the early 1980s, and non-agricultural trade liberalization, especially in the early 1990s. Together, these reform episodes have arguably made significant contributions to the defense of domestic agricultural prices relative to non-agricultural prices. They would have partially offset the deterioration of the agricultural terms of trade that is expected to occur in developing economies due to relatively rapid growth in domestic demand for non-agricultural and non-traded goods.

If the overall trend of microeconomic policy reform has been to reduce penalties on agriculture, how have reforms contributed to the observed changes in overall agricultural output and input demand, and in particular to observed changes in upland and highland areas? While a definitive answer is unlikely to emerge even after extensive research, several straws in the wind deserve mention. First, economic growth and the liberalization of Thai trade and financial systems has presumably promoted the expansion and

¹⁰ For an analysis of the macroeconomic implications of a temporary resource boom see the discussion of the Indonesian oil economy in the 1970s and 1980s by Woo, Glassburner and Nasution (1995).

commercialization of agriculture in formerly remote areas. These trends, along with infrastructural development, must have facilitated specialization in agricultural economies where subsistence concerns formerly dominated land use decision-making. Domestic transport costs, made artificially low by subsidies on diesel and gasoline, were further reduced by extensive tariff cuts affecting the automobile industry around 1990. Thus the trend away from upland rice and corn cultivation for domestic consumption must be attributed in part to the liberalization of Thai trade policy.

Second, some agricultural policies and trends that discriminate among crops have potentially powerful influences on land use. One of these is the well-documented program to promote agricultural diversification, which has used trade policy and subsidies to encourage farmers growing rice to switch some land into production of legumes such as soy bean and mung bean (TDRI 1995). Another less well known set of policies ensures continuing protection and/or subsidization of a subset of crops grown mainly in highland areas, for reasons of livelihood, promotion of production and domestic price support. Under Thai law, fresh potatoes and several other temperate climate vegetables grown in highlands are identified as restricted imports in the category of "imports generally not allowed". This policy has the stated objectives of "protecting local production" and "to enable farmers to sell their products at reasonable prices" (GATT data, cited in Coxhead 1997). In 1992, the average nominal protective rate (NPR) for fresh vegetables was 53%, far above the average tariff rate for all commodities (*ibid.*). In compliance with WTO conditions, quantitative restrictions such as the potato import ban, and similar bans on onion and garlic imports, will be converted to tariffs by 2003. A minimum access volume (MAV) will be permitted to enter at tariff rates generally around 20-30%. Imports over the MAV ("out-quota" imports) will be taxed at higher rates, ranging from 57% (garlic) to 125% (potato) and 142% (onion) (Ministry of Commerce). However, the net agricultural impact of changes in trade policies for these vegetables is likely to be slight. They account for a very small fraction of total agricultural land use, albeit one that is likely to be disproportionately influential in environmental outcomes due to high altitude and slope and prevailing vegetable cultivation practices, which are highly conducive to erosion (IBSRAM 1996). The greater impact of trade policy reforms on agricultural land use and production decisions is likely to be felt indirectly, as indicated above and in Figure 10.

4 Growth, land use changes and the environment: some evidence from provinces of Northern Thailand

In this section we make an initial attempt to address the second issue raised in the introduction to this paper, that of the impact of recent economic changes on the use of marginal agricultural lands in upland and highland areas. If overall growth of the economy, rising wages, and declining relative agricultural prices contribute to the overall decline of agricultural land demand, how is that decline distributed? Since land use is also changing, driven in part by the same set of economic forces, what impact is that having on land use in environmentally fragile, agriculturally marginal upland and highland areas?

The environmental issue arises because upland and highlands, the most recent to be brought into intensive cultivation, are also in many respects the most fragile from an environmental point of view. Highland agricultural lands are typically steeply sloping and often of poor inherent quality. As such they require substantial investments in physical infrastructure (e.g., terraces or hedgerows) if they are to be used for long-term intensive agriculture—that is, for production of annual crops. At the same time, the remoteness of most highland agricultural areas means that credit for such investments is typically hard to obtain. Moreover, land tenure institutions are frequently poorly defined and land use rights may be contested, and this insecurity may discourage soil-conserving investments. The combination of unfavorable geography and imperfect institutional and market conditions has generated severe land degradation and soil erosion in many upland and highland agricultural areas.¹¹ Have Thailand's recent rapid growth and policy reforms contributed to a lessening of pressure on marginal agricultural lands? Or has the decline in physical land area (which must exceed that of planted area, given that irrigation and multiple cropping have expanded) taken place elsewhere, with the cultivated margin continuing to expand? If so, has the expansion in highlands been of a form likely to accelerate or retard land degradation and soil erosion?

In very poor countries and in relatively land-abundant economies, it is hardly surprising to observe farmers mining the soil, either in pursuit of basic household food security or because the abundance of land makes soil-conserving investments unprofitable. About a generation ago, Northern Thai agricultural areas were indeed characterized by poverty and relative land-abundance. Both appear to be declining rapidly as rapid urbanization, infrastructural development and non-agricultural income growth have steadily

¹¹ 1981 data from the Department of Land Development indicated that 26 million rai (8% of total land area) suffers moderate erosion; 43 m. rai (13%) suffers severe erosion, and 39 m. rai (12%) suffers severe erosion. Upland crops are prime land uses in these three categories (cited in Tongroj 1990, p. 35).

reduced dependence on agriculture for subsistence, even in remote highland areas, at the same time as population growth has rendered good agricultural land relatively scarce.

Economic theory suggests that agricultural commercialization and increasing land scarcity would all tend to raise the value of agricultural land, and therefore to increase returns to investments in soil conservation. In spite of this, rapid land degradation continues. The paradox is that the rapid growth of non-agricultural income—wages and remittances—simultaneously reduces both incentives to degrade agricultural land and the real value of investments directed at conserving it. Similarly, changes in the prices of agricultural products may increase or reduce the incentive to invest in land quality (Clarke 1992), depending in part on tenurial and other institutions. It is not clear whether Thailand's agricultural transformation will ultimately increase or reduce incentives to preserve marginal agricultural land in highland and upland areas.

The transformation of highland agriculture in Northern Thailand provides a vivid illustration of this paradox. Just two decades ago, the agricultural census showed that upland/highland food cultivation consisted almost exclusively of rice, corn and minor vegetable crops, all grown primarily for subsistence. In a typical highland province like Chiang Rai, more than ninety per cent of the rural population derived their income exclusively or primarily from agriculture. For more than three-quarters of farm families, animal-drawn carts were the only means of transport over roads that became effectively impassable during the rainy season. Poverty was endemic, and average levels of educational attainment extremely low. Today, however, most agriculture is commercially oriented; remote households that once produced subsistence staples almost exclusively are now able to produce a much wider range of crops—notably fruit and vegetables—for distant urban markets, taking advantage of paved roads, pick-up trucks, and cellular phones. Farm households, and especially their children, derive an increasing fraction of their income from seasonal or even permanent participation in off-farm and urban labor markets, where rural industrialization and the growth of service sector industries including tourism have generated new non-farm job opportunities. These structural changes have been accompanied by a demographic transition in which the average number of children per rural family has fallen by approximately half in a single generation. For the typical farm family, all these changes have raised real income and reduced its variability across seasons and years.

As incomes have increased and become more diversified, and with diminishing concern about food security, one might expect to find widespread adoption of soil-conserving practices in a land-scarce economy. Yet there is no broad evidence of such a trend. Since the late 1980s, field crops such as corn have expanded in total area and as a

fraction of cultivated area of provinces with high proportions of upland and highland, while in generally lowland provinces, corn area has declined markedly. Corn area in Northern Thailand, having increased more than eightfold between 1961 to 1988, declined by 30% from 1989-95; at provincial level, the declines were highest by far in lowland provinces such as Sukhothai (-46%) and Uttaradit (-56%) while in Chiang Mai and Chiang Rai/Phayao, corn area increased by 70% and 12% respectively (TDRI 1997; also see Nipon *et al.* 1995).¹² Grown continuously, using conventional tillage and land management techniques on fragile upland soils, corn and other field crops rapidly deplete soil nutrient content and are major causes of erosion.

Corn area changes across provinces are clearly interrelated. As lowland provinces have diversified away from this relatively low-return crop (partly in response to incentives provided by agricultural diversification programs), the center of corn production has moved up-slope to upland and highland provinces in the upper north.

More intriguingly, in some highland areas agricultural land use seems to be following divergent paths, even within very small and geographically homogeneous areas. Individual farms and some small groups have indeed adopted physical conservation practices such as grass strips and hedgerows; others have switched from traditional staples like upland rice to tree crops or pasture; but others still have specialized in cabbage and other commercial vegetable crops. Under most conditions, perennial crops conserve soil quality and minimize erosion; physical structures such as grass strips and hedgerows with annual crops planted between are moderately effective, and intensively cultivated vegetable crops are highly damaging. Therefore, these practices in highlands all have very different implications for land quality and soil erosion.

Some of this heterogeneity in land use and land management may arise because households face different constraints and norms imposed by culture, geography, poverty and legal status (Townsend 1995). We hypothesize, however, that policy and market trends in the national economy also play a major role in influencing farmers' land use and

¹² Of the four broad categories of crop (paddy rice, field crops including 'second crop' (dry season) rice, tree crops and vegetables) there has been a sustained decline in the total area and share of the first and a corresponding rise in the second; treecrop and vegetable areas have changed a little but have only a small effect on total land use in Northern Thailand (Table A-1).

Within the field crop category, recent years have witnessed some dramatic changes in planted area. On average and in the provinces of the lower North, sugarcane and dry season rice have risen, while corn and some other grains and pulses have declined. In provinces where upland and highland agriculture dominates, however, corn typically shows the biggest increases in planted area, while sugarcane and dry season rice have contracted. During the seven-year period from 1989-95, the area planted to dry season rice and sugarcane rose by 45% and 72% respectively in the Northern region, while corn area declined by 21%. In Chiang Mai and Chiang Rai/Phayao, however, dry season rice declined by 50-70%; sugarcane declined by 35-45%, and corn rose by 13% (Chiang Rai) and 70% (Chiang Mai).

technology adoption decisions, and thus ultimately affect the quality of the land resource. Over more than two decades, agricultural policy shifts have benefited producers of field crops, including corn (Nipon *et al* 1995); meanwhile, urbanization and changing consumer preferences have caused sharp rises in the demand for temperate-climate vegetables such as cabbage and potato, which are grown in highlands. Over the same period, rising labor costs have reduced the profitability of labor-intensive activities, at least where labor is geographically or intersectorally mobile, as the analysis in section 2 of this paper confirms. A full understanding of how farmers' decisions are reached clearly requires an understanding not only of 'micro' institutional and economic conditions but also of how markets and policies in the broader economy contribute to the creation of conditions conducive to, or discouraging of, soil conserving crops and technologies. Only by examining micro and macro factors and their interactions together can the paradox of land-degrading practices in a rapidly growing economy be resolved.

Changing land use in the provincial data

Several phases of introduction, rise and decline of new crops in Thai agriculture have been documented. The commercialization of corn cultivation in the early 1970s was succeeded by 'booms' in cassava, soybean and sugarcane (Ammar *et al* (1993). In the 1990s, rapidly rising per capita incomes has stimulated the expansion of non-traded crops such as temperate-climate vegetables and orchard crops.¹³ These trends can all be discerned in provincial land use data, at least for those provinces where climate, soil and infrastructure make significant land use changes feasible.

The overall decline of agricultural land area can also be seen in the provincial data, and this yields some revealing insights. Regionally, as noted above, the decline in planted area has occurred in the Central and Northern regions. However, this change has not been uniformly distributed at the provincial level, and within the other regions some provinces have also experienced significant planted area declines. Not all of these provinces correspond to upland or highland areas. A brief analysis of provincial data from Northern Thailand highlights the empirical issues.

Inspection of the aggregate Northern Thailand planted area data (Figure 7) suggests that a structural break occurred in 1988 after which planted area, having increased steadily for nearly three decades, began to decline. We can test the hypothesis of a structural break

¹³ In non-traded crops, the upland/highland provinces tend to reinforce the regional trend rather than running counter to it (as for field crops). From 1989-95, longan and cabbage area and production both increased substantially in Chiang Mai and Chiang Rai (which account for most planted area of both crops), and also in the North as a whole.

in the series by fitting a spline function, in which dummy variables are used to permit a curve fitted to the data to take a new slope and intercept after 1988. Define a time trend t , a dummy variable ($D89$) taking the value 0 for 1961-88 and 1 thereafter, and their product, $tD89$. The spline function yields the following estimates:

$$\begin{aligned} \text{Planted area} = & 8.91 + 0.70*t + 33.35*D89 - 1.21*tD89 \\ & (0.348)^a \quad (0.021)^a \quad (5.436)^a \quad (0.1705)^a \\ & (\text{Adj. } R^2 = 0.98; \text{ figures in parentheses are standard errors; superscript } a \text{ indicates} \\ & \text{significance at 1\%; units = million rai}). \end{aligned}$$

The estimates strongly support the hypothesis of a structural break in the regional data, with planted area increasing by 700,000 rai/yr until 1988, but declining by 510,000 rai/yr from 1989—an average annual decline of about 2.5%.

If all provinces faced uniform conditions, we would expect similar results from the same spline function separately to the provincial data. However, the estimates for individual provinces display no such uniformity. Some provinces exhibit strong downturns after 1989; others show no change in the trend (for details of provincial estimates see Appendix table A-4). Among the provinces of the Upper North, there is considerable diversity in the planted area trend relative to the regional average.

What factors explain divergent land area responses across provinces after 1988? A priori, we expect to find that much of the variation is due to differences in agricultural land quality and productivity, labor mobility, and infrastructure-related costs such as marketing expenses. As the opportunity cost of resources that are complementary with land rises, less productive land will tend to be removed from production. Other things equal, higher labor mobility should be associated with more rapid reductions in planted area. Better infrastructure, such as roads, should be associated with lower transactions costs and thus with agricultural productivity since roads extend the reach of the market into agricultural areas and thus facilitate specialization. On the other hand, better infrastructure should also permit mobility, and may be a proxy for other development indicators, and may thus be associated with more rapid agricultural decline.

We test these propositions using provincial data from Northern Thailand. The percentage change in planted area between 1989-1995 is expressed as a function of variables that we hope capture the foregoing explanations. These are: irrigation expenditures per agricultural laborer (IRR, a proxy for land quality); forested area as a percentage of total area in 1988 (FOR, a proxy for highland/upland area); average education levels (ED, a proxy for labor mobility), and the intensity of roads per unit area (RD), a

measure of infrastructural development.¹⁴ We hypothesize that area growth is positively associated with land productivity and negatively with forested area and labor mobility; infrastructural development may have ambiguous results as just suggested. The results of a linear regression on the provincial data were as follows:

$$\Delta P8995 = 51.99 + 0.146*IRR - 0.272*FOR - 17.313*ED - 0.07*RD$$

$$(20.92)^b \quad (0.043)^a \quad (0.122)^b \quad (5.502)^a \quad (0.156)$$

(Adj. $R^2 = .4708$; $N=16$; figures in parentheses are standard errors; superscripts *a* and *b* indicate significance at 1% and 5% respectively.)

Although the sample is small and the variables imperfectly measured, these results support the first three hypotheses; as anticipated, the test of the fourth hypothesis is inconclusive.¹⁵ Land quality is positively associated with the change in planted area. Forested area, which we interpret to indicate the importance of upland and highland agriculture in the provincial land base, shows a negative association. Labor mobility also has a negative association, and the magnitude of this effect dominates the influence of all other variables. Road intensity has no measurable relationship with the change in planted area. In the provincial data, as in our earlier regional analysis, it appears that explanations of changing land area may be dominated by labor force trends and characteristics rather than by agronomic features. For highlands, the clear implication is that land retirement will be more likely to occur in areas where farmers and their children are more capable of moving to other jobs.

From the perspective of environmental management, the results suggest that the highland areas most "at risk" of degradation are those that are agronomically suited to high-valued crops but which have farm labor forces that are older or relatively poorly educated (the two are likely to be highly correlated). Within such areas, the environmental risks may be minimized, for example when the high-valued crops planted are fruit trees or other relatively soil-conserving perennials, or maximized, when the choice is instead made to plant vegetables or other short-season, highly land-degrading and erosive crops such as corn. As we noted in the introduction to this section, this is *exactly* the bifurcation of land use that appears to be taking place now in the highland agricultural areas of Northern Thailand. Consideration of these emerging land use patterns in the context of trends in the

¹⁴ Data were obtained from Ammar et al 1987, Table 3, and from Agricultural Statistics of Thailand, Crop Year 1990/91.

¹⁵ The equation was reestimated using an additional 15 observations from the provinces of Northeast Thailand. Parameter estimates and significance levels were essentially unchanged.

Thai labor market will help sharpen the focus of environmental policy debates on upland and highland land use.

A further implication of the analysis is that the more rapid withdrawal of relatively well-educated workers from agriculture may reduce the rate of agricultural productivity growth by removing those most capable of assimilating and applying new ideas. The labor outflow will reduce the average educational level of those who remain behind (this is likely also to be inversely correlated with age, at least among adults). If so, growth of non-agricultural labor demand will dynamically (and possibly irreversibly) increase the productivity differential between agriculture and the rest of the Thai economy.

Of course, the provincial data are too highly aggregated to reveal details of what kind of land is being added to or removed from the planted area base in any year. To understand the relationship between aggregate economic growth and changes in upland or highland land use, it is necessary to go to the farm or village level where not merely land use, but a range of other data pertaining to local agronomic, cultural and economic conditions can be brought into the analysis.¹⁶

5 The 1997-8 economic crisis and Thai agriculture

Part of the source of the economic crisis of 1997 was a real exchange rate appreciation that reduced the competitiveness of Thai tradables sectors. Rapid wage growth associated with the real appreciation reduced profitability in many of Thailand's traditional, labor-intensive export manufacturing industries. The loss of international competitiveness, exacerbated by increasingly tight liquidity through 1996-97, caused a contraction in garments, textiles, footwear and similar sectors that threw tens of thousands of unskilled or semi-skilled workers out of work. In late 1997, the Thai press reported huge increases in open unemployment and predicted widespread movement of labor 'back to the farm'. One question that immediately arises is whether such a movement would actually take place, and if so, with what consequences.

The rapid transfer of labor out of agriculture in the past decade appears to indicate a high degree of intersectoral labor mobility in Thailand. The recession, however, may well reveal that this mobility is much greater in one direction (away from the farm) than the other. There are two possible reasons for this asymmetry. First, even with high and rising open unemployment, the expected wage in non-agriculture may still exceed the reservation price of migrant labor. This idea was reflected in a recent press report:

¹⁶ The implied field-level research is the subject of a separate study presently being conducted.

According to a government report, 600,000 industrial workers have lost their jobs this year. The Agriculture Ministry believes that many would go back to farming and related activities *if the incentives were right* ["Ministry Seeks Funds to Lure Unemployed Back to Farms", *Bangkok Post*, October 28 1997, italics added].

If the basis of this report is accurate then a sizable part of the presently unemployed industrial labor force prefers urban unemployment to returning to the farm.

A second reason may have to do with the nature and rate of agricultural and non-agricultural investment in recent years. As seen in Figures 4 and 5, agricultural investment in labor-replacing equipment—large and small tractors in particular—grew exponentially during the period of very rapid intersectoral labor transfer. At the same time, national stocks of buffalo, a very labor-intensive source of draft power, fell sharply (TDRI 1997). The raw data suggest that even if labor were to return to the farm, fixed investments in labor-replacing machinery may mean that the creation of new farm jobs occurs only with a long lag (perhaps too long to motivate any transfer in the short run). A more capital-intensive agriculture sector may mean that even with open unemployment of unskilled labor in urban areas, there is little reverse migration, at least to commercialized agriculture.

Although the mechanization data suggest limited possibilities for reverse migration, there is of course variation within agriculture. In highlands, mechanization has not proceeded at the same pace as in agriculture generally. Moreover, property rights in land remain poorly defined in highlands, imbuing land in such regions with characteristics of an open-access resource. Thus while our analysis indicates that the *total* agricultural land area response to the economic crisis is likely to be limited, the potential for expansion is greatest in areas of agriculturally marginal land. This response to unemployment and declining real wages would match that of other Southeast Asian countries in periods of recession and economic crisis (Coxhead 1992; Repetto and Cruz 1992).

We have argued that whether a recession in non-agricultural sectors will lead to large-scale migration and a boom in agricultural employment will depend on the labor market process and on the elasticity of agricultural labor demand. Both aspects can be captured in stylized form with a simple labor market analysis (Diagram 1). The width of the diagram measures total labor supply at any point in time. If agricultural labor demand is measured from the right and non-agricultural labor demand from the left, and if non-agricultural wages are fixed by some criterion other than equality of marginal product with the wage, the diagram shows how labor will move between sectors in response to fluctuations in non-agricultural demand. Workers face a choice between accepting rural (farm) work with an assured wage (w_A) and migrating in search of urban (non-agricultural) work at a higher wage (w_N), but with a probability $p < 1$ of actually finding employment, the

classic migration model of Harris and Todaro (1970). In this model there is always positive unemployment in the urban labor market as workers seek higher-paying jobs. In this model labor market equilibrium is given by the condition $w_A = \rho w_N$, where ρ is non-agricultural employment as a fraction of the supply of labor to non-agricultural sectors. In Diagram 1, for given values of w_N and L_N , this condition is satisfied only by points along the rectangular hyperbola hh , the so-called "Harris-Todaro curve", and in this way the agricultural wage is seen to depend on non-agricultural wages and employment (Corden and Findlay 1975).

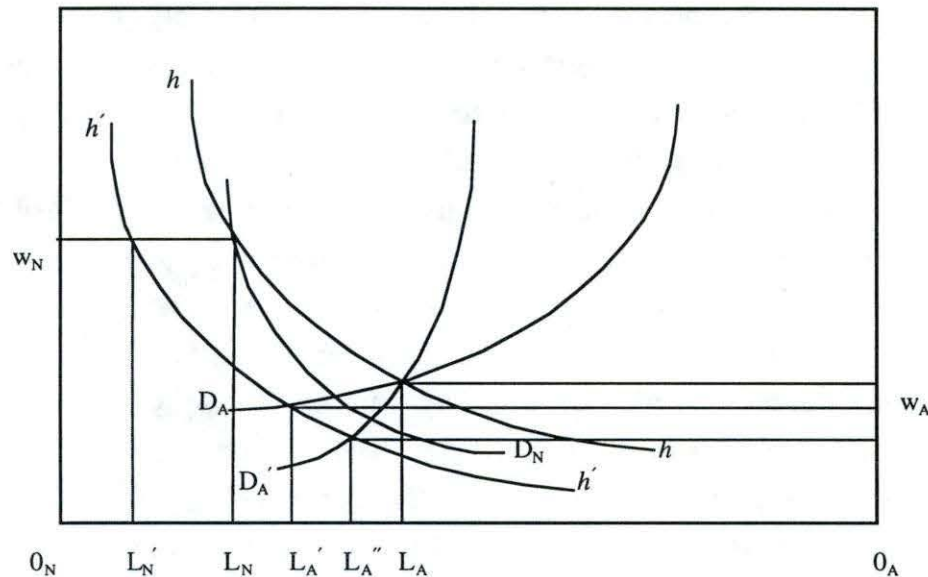


Diagram 1: Migration and wage effects of a recession in the Harris-Todaro model

At the initial non-agricultural wage w_N and employment level L_N , the curve hh describes all points satisfying the Harris-Todaro condition. Agricultural employment is L_A with wage w_A , and there is urban unemployment of $L_N - L_A$. A reduction in urban labor demand (to L'_N) with fixed urban wage reduces w_A by an amount determined by the intersection of the agricultural labor demand curve and the new Harris-Todaro curve $h'h'$. A less elastic agricultural labor demand curve implies a greater decline in the agricultural wage and reduced urban-rural migration, as can be seen by comparing the changes in unemployment associated with L'_A and L''_A , associated with demand curves D_A and D'_A respectively.

Diagram 1 captures the essential features of our argument about adjustment and migration in the wake of Thailand's investment boom and collapse. First, since $\rho < 1$ it is always preferable to some workers to be unemployed in the urban labor force than to return to the land. Second, if mechanization means that agricultural labor demand becomes less responsive to wages, then it is easy to see that a recession resulting in a fall in non-

agricultural employment will cause fewer workers to return to the land when agriculture is mechanized than when it is not. This can be seen in the diagram by comparing the employment shift associated with two agricultural labor demand curves. Curve D_A represents the pre-mechanization labor demand curve; D_A' is less elastic and represents labor demand in a mechanized agricultural sector. Initial agricultural labor demand is $O_A L_A$. Suppose non-agricultural labor demand contracts (from L_N to L_N'). In non-mechanized agriculture there is a substantial back-flow to rural areas, accompanied by a slight fall in agricultural wages. In mechanized agriculture, by contrast, there is little migration and a larger wage decline, reflecting the relative inelasticity of agricultural labor demand with respect to wages after mechanization.

Why should the Harris-Todaro model be accepted as a representation of the Thai labor market? On the positive side, it captures some basic stylized facts about the Thai labor market, notably that nominal wages in non-agriculture are “sticky downwards” whilst returns to agricultural labor probably depend much more on agricultural profitability; that migration is possible although at a cost; and that there is a pool of urban unemployed or underemployed workers. On the negative side, the original Harris-Todaro model postulated a labor market in which every worker faced the same probability of employment each day. However, a modern re-interpretation might simply recognize that the move from rural to urban labor markets involves a sunk cost which can be thought of as the cost of being “in line” for an urban job—finding accommodation, learning where jobs may be found and under what conditions, and so on. Workers may then be reluctant to move back to rural areas even if the probability of urban employment falls, so long as the difference between w_A and pw_N is less than some margin.¹⁷ The proposed policy, cited above, of subsidizing workers’ return to farming presumes some such fixed cost.

Adjustment and poverty

The foregoing is speculative in that at present we lack suitable data to test the hypothesis of irreversibility in agricultural investments and intersectoral labor flows. In spite of this is worth considering some welfare implications should irreversibility turn out to have increased. One way to do this is to compare indicators of human welfare from previous periods of economic stress in the Thai economy.

In recent years, Thailand’s record of poverty alleviation has been exemplary (Medhi 1994; World Bank 1990). Since poverty and labor productivity are intimately linked in

¹⁷ This is just an application of the “hurdle price” concept developed to explain investment under uncertainty (Dixit and Pindyck 1994).

developing economies, it is clear that the investment boom of the past decade has made a major contribution to poverty decline through its effects on wages. However, Thailand's recent past contains some warning signs that appear to be relevant in the present period of crisis and adjustment. From 1960-80, the headcount measure of poverty in Thailand declined from 59% to 20%, and the number of the poor from 16.7 to 9.5 million (World Bank 1990: Tables 3.2, 3.3). However, during the economic slowdown of the early 1980s, poverty incidence actually increased, and in marked fashion—not only in relative terms but also in absolute numbers. Between 1981-86, the headcount measure increased from 20% to 26%, and the number of the poor from 9.5 million to 13.6 million.

Unlike the current crisis, the slowdown of the early 1980s did not produce a recession: GDP growth averaged 7.2% annually from 1965-80, and about 5% from 1981-86. As at present, however, the slowdown was accompanied by a reduction in net rural-urban migration, indicating that when times are hard, Thais fall back on agriculture as an income source. If the rapid agricultural mechanization that has accompanied the non-agricultural investment boom has diminished the capacity of agriculture to absorb labor—as implied by the elasticities in Table 1—then an important component of the Thai economy's informal safety net for poor, unskilled labor may have disappeared. In retrospect, there was a case for subsidizing agricultural employment during the 'boom' years of the past decade, as a means of inhibiting the effects of the investment boom on agricultural production, land use and the rate of mechanization. Coincidentally, similar arguments have surfaced in the course of the current economic crisis (Bangkok Post, October 1997).

6 Conclusions and directions for further research

In this paper we examine recent trends of land use and employment in Thai agriculture. We find not only that land use trends are apparently dictated by agricultural wage growth, but further, that wage growth itself has been driven almost exclusively by investment in the non-agricultural sectors of the economy. The boom of the late 1980s and early 1990s, or at least some part of it, was temporary, with overinvestment driven by a combination of factors including "irrational exuberance" about the future of Southeast Asian economic growth, moral hazard on the part of borrowers, a lack of accountability and transparency on the part of financial intermediaries, and inadequate monitoring and regulatory capacity on the part of government. The boom in turn accelerated a pattern of change in economic structure that turned the terms of trade against agriculture, particularly through wage growth. The boom thus generated incentives for agricultural mechanization and land use

shifts that may in turn have created irreversible changes in agricultural technology and the resource base.

While agricultural land use has declined overall in major regions of the country, marginal lands in upland and highland areas have not been not the first, nor the only, lands to be taken out of production. Indeed, there is evidence that cultivation of erosive and nutrient-depleting crops such as corn has actually expanded in upland and highland provinces—both in terms of total area, and as a share of area planted. This expansion of a relatively low value-added crop in more remote and less productive upland and highland areas is almost certainly because generally lower labor mobility diminished the effects of the economy-wide boom on such areas.

As long as agriculture and the economy were growing rapidly as for most of the previous decade, the negative effects of higher agricultural wages (and perhaps of agricultural land degradation) could conceivably be overlooked in the context of a rapidly expanding economy. However, a serious economic downturn of the kind experienced in late 1997 may reveal hidden costs of the agricultural 'bust' that accompanied Thailand's non-agricultural 'boom'.

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Table A-1: Trends in land use and the value of agricultural output, by region, 1961-1995

	Planted area – millions of rai (average)				Change in area (% per year)			
	1961-68	1969-78	1979-88	1989-95	1961-68	1969-78	1979-88	1989-95
Whole Kingdom								
Upland	9.192	19.077	31.399	32.181	9.65	8.97	2.42	-2.88
Paddy	42.199	52.309	61.281	60.886	2.49	3.37	0.48	-0.43
Tree	8.028	10.945	13.302	16.231	10.49	2.52	1.96	3.31
Vegetable	0.590	0.865	0.796	0.584	7.13	3.77	-3.75	0.09
Central								
Upland	3.054	6.414	10.186	9.372	8.25	8.41	2.63	-3.46
Paddy	13.534	14.901	15.092	12.890	1.47	1.70	-0.09	-2.04
Tree	1.158	1.560	1.918	2.713	8.70	2.23	3.55	3.04
Vegetable	0.112	0.132	0.062	0.030	6.39	-1.49	-4.10	10.39
North								
Upland	3.113	6.483	10.950	11.490	19.81	7.71	2.70	-3.22
Paddy	8.590	10.905	13.571	13.396	3.87	3.71	1.56	-0.30
Tree	0.185	0.257	0.321	0.402	5.07	2.87	1.71	5.67
Vegetable	0.326	0.517	0.555	0.430	10.12	5.19	-1.86	-0.23
Northeast								
Upland	2.757	5.790	10.149	11.114	5.92	12.98	2.33	-1.81
Paddy	16.754	22.804	28.684	31.526	3.34	5.02	0.70	0.70
Tree	0.146	0.212	0.244	0.398	6.52	2.98	1.29	9.11
Vegetable	0.137	0.188	0.170	0.121	3.84	6.81	-7.04	-1.14
South								
Upland	0.269	0.389	0.114	0.205	11.78	-5.21	0.44	1.26
Paddy	3.322	3.700	3.934	3.073	2.20	2.26	-0.64	-2.81
Tree	6.538	8.916	10.819	12.718	11.18	2.57	1.78	3.13
Vegetable	0.014	0.027	0.010	0.003	24.86	8.42	-12.15	30.99

continued next page --

Table A-1: Trends in land use and the value of agricultural output, by region, 1961-1995
(cont'd)

	Output value – billions of baht (average)				Change in output (% per year)			
	1961-68	1969-78	1979-88	1989-95	1961-68	1969-78	1979-88	1989-95
Whole Kingdom								
Upland	2.572	17.014	52.495	92.378	11.58	25.89	10.14	7.27
Paddy	2.824	5.860	13.706	19.315	7.89	13.92	9.48	7.63
Tree	0.399	0.536	2.042	6.229	-5.32	10.07	22.17	14.92
Vegetable	0.104	0.399	0.835	0.846	13.03	25.18	1.53	14.01
Central								
Upland	1.640	11.382	28.190	39.484	14.60	25.09	10.61	3.39
Paddy	0.918	1.982	4.390	5.493	5.61	15.57	10.03	10.97
Tree	0.129	0.154	0.462	1.792	-5.99	8.14	22.21	22.67
Vegetable	0.023	0.067	0.045	0.029	6.17	20.41	-4.90	9.52
North								
Upland	0.352	2.049	7.355	19.309	15.26	26.54	16.00	10.65
Paddy	0.821	1.601	3.874	5.010	7.36	16.07	9.82	6.05
Tree	0.024	0.039	0.110	0.355	-4.83	16.69	13.98	21.24
Vegetable	0.056	0.253	0.602	0.647	22.77	31.68	2.27	16.83
Northeast								
Upland	0.467	3.385	16.871	33.397	6.00	35.98	12.61	10.75
Paddy	0.880	1.863	4.652	7.897	12.63	13.42	10.26	8.45
Tree	0.023	0.028	0.070	0.163	-6.01	8.12	12.78	8.03
Vegetable	0.022	0.069	0.182	0.167	5.37	25.55	8.15	5.34
South								
Upland	0.113	0.198	0.080	0.188	12.81	1.67	13.62	22.69
Paddy	0.205	0.414	0.790	0.915	9.74	13.09	7.66	7.39
Tree	0.223	0.315	1.400	3.921	-4.84	11.34	23.75	12.24
Vegetable	0.003	0.010	0.005	0.002	30.68	40.35	-4.40	41.87

Note: Output calculated at 1988 prices.

Source: Office of Agricultural Economics: Agricultural Statistics of Thailand

Table A-2: 3SLS estimates of labor demand, land demand and agricultural wage equations (4), (5a), and (6).

Variable	Abbreviation	Labor demand (LA)	Land demand (NA)	Agricultural wage (WA)
Agr. land	NA	0.8179 (0.0745) ^a	—	—
Agr. wage/agr. price	WA	-0.4874 (0.0876) ^a	-0.1580 (0.0684) ^b	—
— lagged	WA _{t-1}	—	—	0.00007 (0.00008)
Agr. price	PA	—	0.1288 (0.0644) ^b	—
Non-agr. price	PN	—	—	1.2781 (0.1046) ^a
Fert. price/agr. price	PF	0.1825 (0.0462) ^a	0.1198 (0.0481) ^b	—
Irrigation	IR	0.1854 (0.0232) ^a	-0.0399 (0.0174) ^b	—
Agr. machinery	KA	-0.1620 (0.0221) ^a	0.2112 (0.0150) ^a	—
Non-agr. capital	KN	—	—	0.4181 (0.0859) ^a
Field crops/tree crops	FT	-0.0015 (0.0006) ^b	—	—
Land-intensity	IN	—	0.4166 (0.0265) ^a	—
Labor force	LF	—	—	-1.8428 (0.2115) ^a
Time	T	0.0314 (0.0042) ^a	-0.0104 (0.0046) ^b	0.0170 (0.0108)
Central dummy	DC	-0.2939 (0.0713) ^a	0.1127 (0.0459) ^b	1.6145 (0.2029) ^a
North dummy	DN	0.1473 (0.0712) ^a	-0.0873 (0.0518) ^c	0.6408 (0.1405) ^a
N' east dummy	DE	0.6141 (0.0945) ^a	-0.2447 (0.0814) ^a	1.4478 (0.2437) ^a
N / d.f.		140 / 127	140 / 129	140 / 131
Adj. R2		0.9624	0.9697	0.9511

Notes:

1. Std errors in parentheses. Superscripts *a*, *b*, and *c* denote significance at 1%, 5% and 10% respectively.

2. All variables except time trend and regional dummies are measured in logs. For units and other descriptors see text and Table A-3.

3. R² is indicative only (not bounded in [0,1]).

Source of basic data : TDRI. [File: tuang:dataset.xls]

Table A-3: 3SLS estimates of labor demand, land demand and agricultural wage equations (4), (5b), and (6).

Variable	Abbreviation	Labor demand (LA)	Land demand (NA)	Agricultural wage (WA)
Agr. land	NA	0.8201 (0.0757) ^a	—	—
Agr. wage/agr. price	WA	-0.3923 (0.0740) ^a	—	—
— lagged	WA _{t-1}	—	—	0.00001 (0.00007)
Agr. labor demand	LA	—	0.5285 (0.0549) ^a	—
Agr. price	PA	—	0.1128 (0.0439) ^b	—
Non-agr. price	PN	—	—	1.3580 (0.1067) ^a
Fert. price/agr. price	PF	0.1060 (0.0451) ^b	0.1061 (0.0416) ^b	—
Irrigation	IR	0.1810 (0.0230) ^a	-0.0931 (0.0172) ^a	—
Agr. machinery	KA	-0.1768 (0.0211) ^a	0.2014 (0.01260) ^a	—
Non-agr. capital	KN	—	—	0.3685 (0.0801) ^a
Field crops/tree crops	FT	-0.0006 (0.0004)	—	—
Land-intensity	IN	—	0.2467 (0.0266) ^a	—
Labor force	LF	—	—	-1.4420 (0.2088) ^a
Time	T	0.0304 (0.0039) ^a	-0.0188 (0.0022) ^a	0.0042 (0.0097)
Central dummy	DC	-0.2948 (0.0688) ^a	0.1671 (0.0410) ^a	1.2349 (0.2004) ^a
North dummy	DN	0.0567 (0.0625)	-0.1905 (0.0373) ^a	0.3844 (0.1388) ^a
N'east dummy	DE	0.3909 (0.0802) ^a	-0.4828 (0.0704) ^a	0.9916 (0.2406) ^a
Constant		-6.523 (1.3088)	11.872 (0.5374) ^a	10.172 (1.6907) ^a
N/d.f.		140 / 127	140 / 129	140 / 131
Adj. R2		0.9678	0.9801	0.9512

Notes:

1. Std errors in parentheses. Superscripts *a*, *b*, and *c* denote significance at 1%, 5% and 10% respectively.

2. All variables except time trend and regional dummies are measured in logs. For units and other descriptors see text and Table A-3.

3. R² is indicative only (not bounded in [0,1]).

Source of basic data : TDRI. [File: tuang:dataset.xls]

Table A-4: Spline function estimates by province, Northern Thailand

Province	t	D89	t*D89	Constant
Nakhon Sawan	0.08 ^a 0.0066	2.99 ^c 1.7065	-0.12 ^b 0.0535	2.47 ^a 0.1091
Phetchabun	0.17 ^a 0.0094	7.07 ^a 2.4332	-0.28 ^a 0.0763	-0.10 0.1556
Uthai Thani	0.05 ^a 0.0035	3.08 ^a 0.905	-0.11 ^a 0.0284	0.20 ^a 0.0579
Kamphaeng Phet	0.09 ^a 0.0065	4.71 ^a 1.6947	-0.15 ^a 0.0532	0.17 0.1084
Tak	0.02 ^a 0.002	0.74 0.5139	-0.02 0.0161	0.06 ^c 0.0329
Phichit	0.03 ^a 0.0043	0.96 1.1228	-0.04 0.0352	1.33 ^a 0.0718
Phitsanulok	0.07 ^a 0.0046	1.86 1.2002	-0.07 ^c 0.0376	0.67 ^a 0.0768
Nan	0.02 ^a 0.0014	1.54 ^a 0.3569	-0.05 ^a 0.0112	0.12 ^a 0.0228
Phrae	0.01 ^a 0.0013	0.58 ^c 0.3266	-0.02 ^c 0.0102	0.31 ^a 0.0209
Lampang	0.01 ^a 0.0016	0.45 0.4149	-0.02 0.013	0.46 ^a 0.0265
Sukhothai	0.04 ^a 0.004	1.37 1.0497	-0.05 0.0329	0.92 ^a 0.0671
Uttaradit	0.03 ^a 0.0018	2.02 ^a 0.455	-0.07 ^a 0.0143	0.21 ^a 0.0291
Chiang Mai	0.01 ^a 0.0027	1.39 ^c 0.7004	-0.05 ^b 0.022	0.84 ^a 0.0448
Chiang Rai & Phayao	0.07 ^a 0.0055	2.81 ^c 1.4275	-0.11 ^b 0.0448	0.9 ^a 0.0913
Mae Hong Son	0.00 ^a 0.0005	-0.10 0.1405	0.00 0.0044	0.05 ^a 0.009
Lamphun	0.00 ^a 0.0012	0.38 0.3124	-0.01 0.0098	0.28 ^a 0.0200
All provinces	0.7 ^a 0.0213	31.83 ^a 5.5278	-1.16 ^a 0.1734	8.91 ^a 0.3535

Notes: See text for description. Superscripts a,b and c denote significance at 1, 5 and 10% respectively.

Figure 1 Thailand: Agriculture labor by region, 1961-1995
(in thousands)

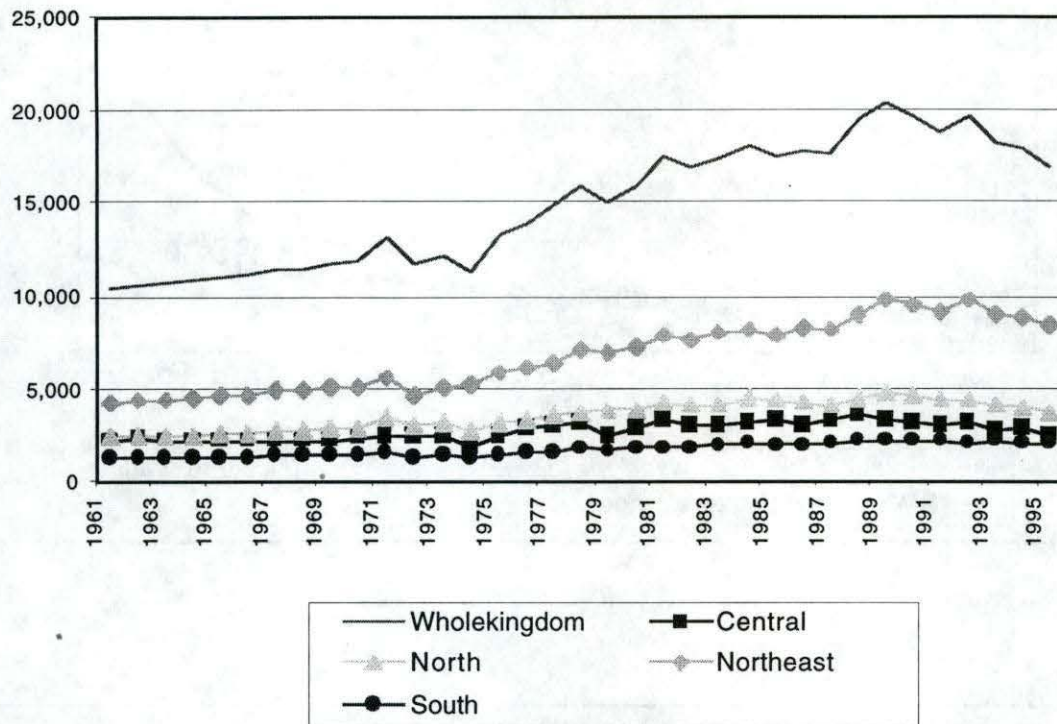


Figure 2 Thailand: Net capital stock and growth rate, 1961-1995

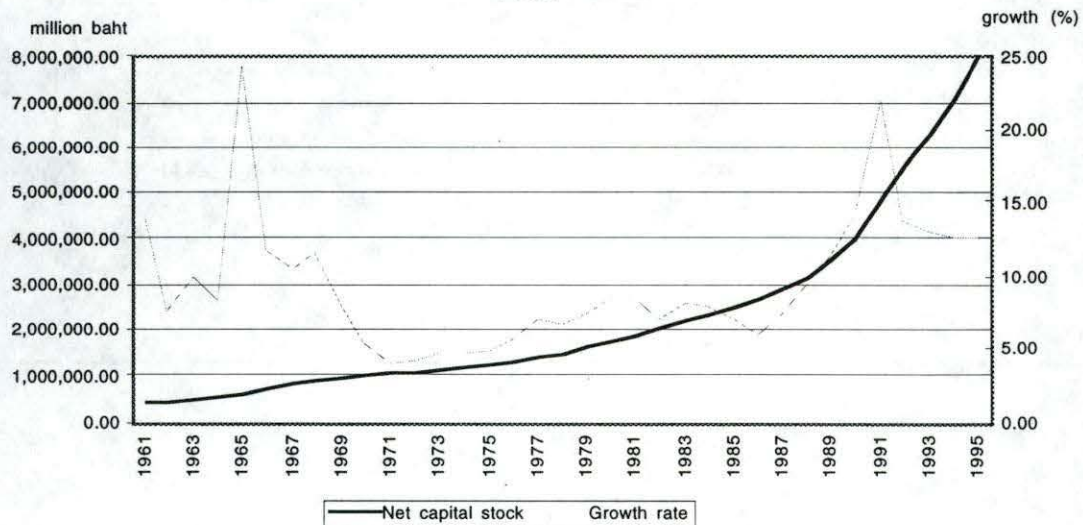


Figure 3 Thailand: Agriculture and non-agriculture wage, 1961-1995 (baht/day)

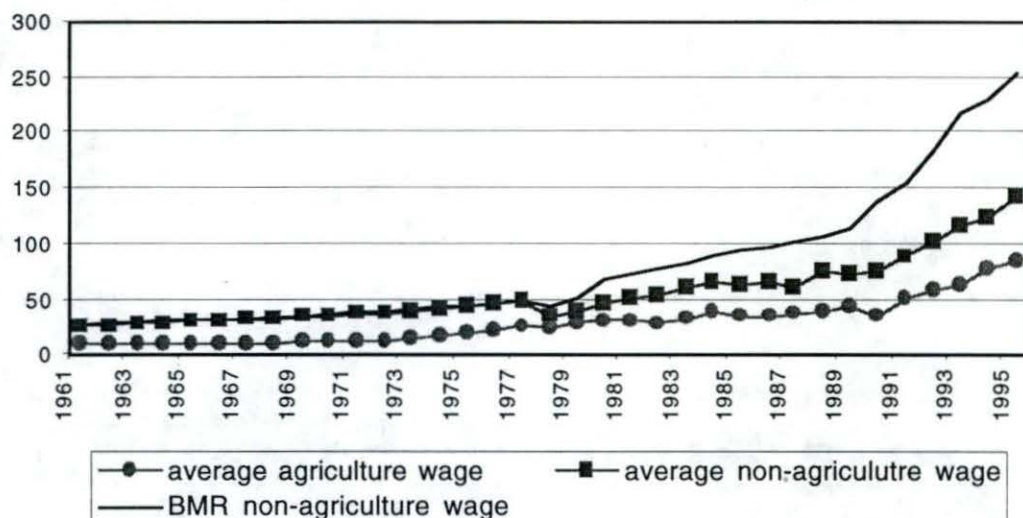


Figure 4 Thailand: Number of big tractors by region, 1961-1995 (unit)

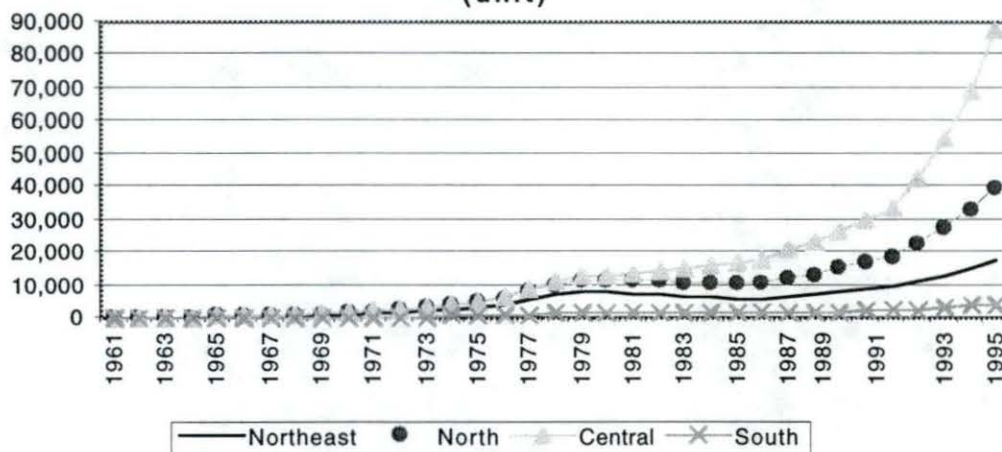


Figure 5 Thailand: Number of 2 wheel walking tractors by region, 1961-1995 (unit)

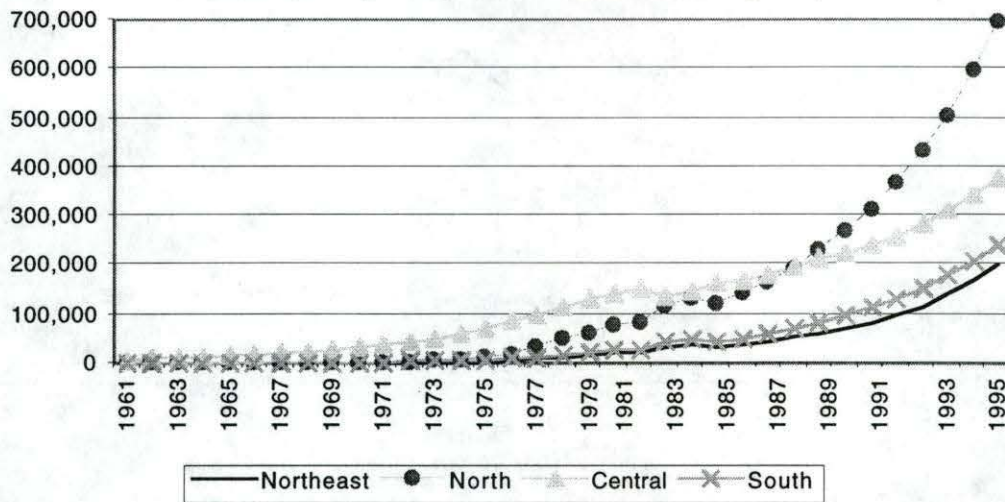


Figure 6 Thailand: Number of water pumps by region, 1961-1995 (unit)

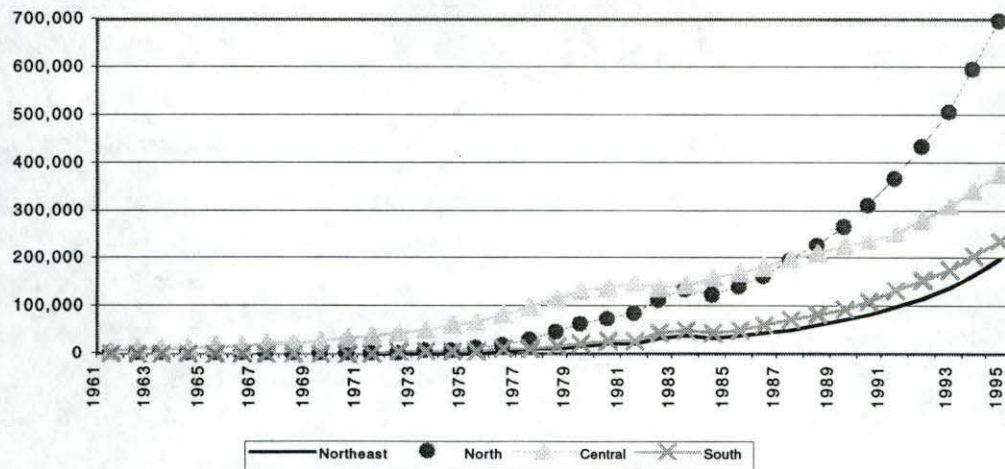


Figure 7 Thailand: Agriculture area (planted area) by region, 1961-1995 (rais)

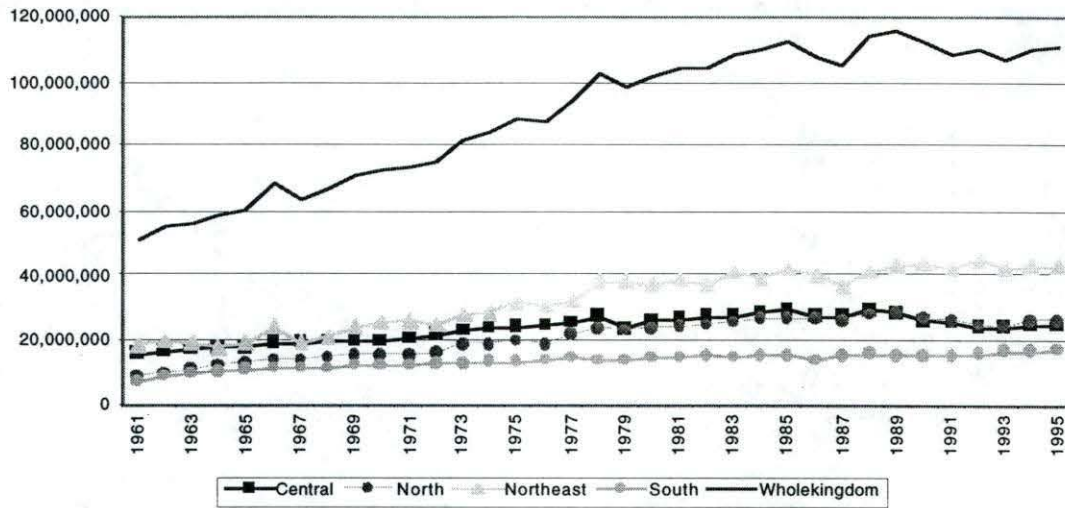
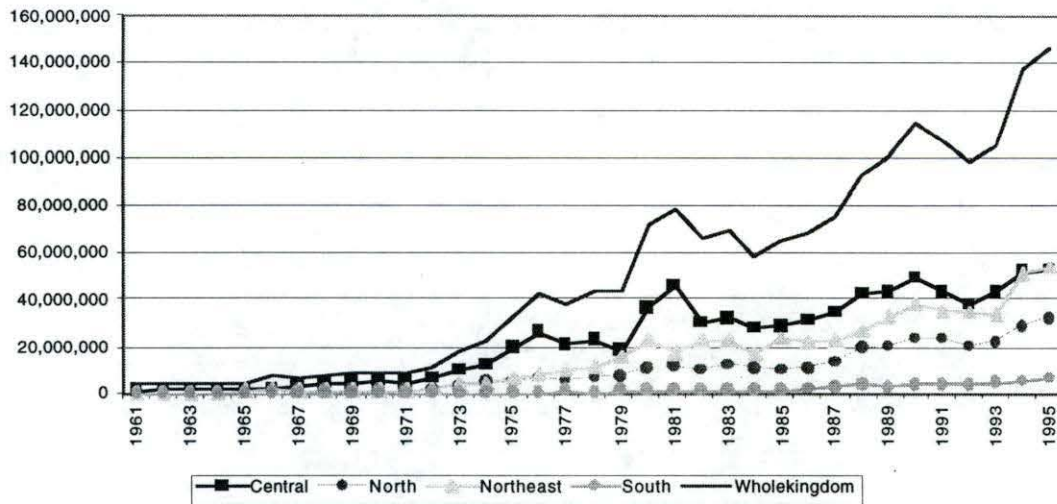
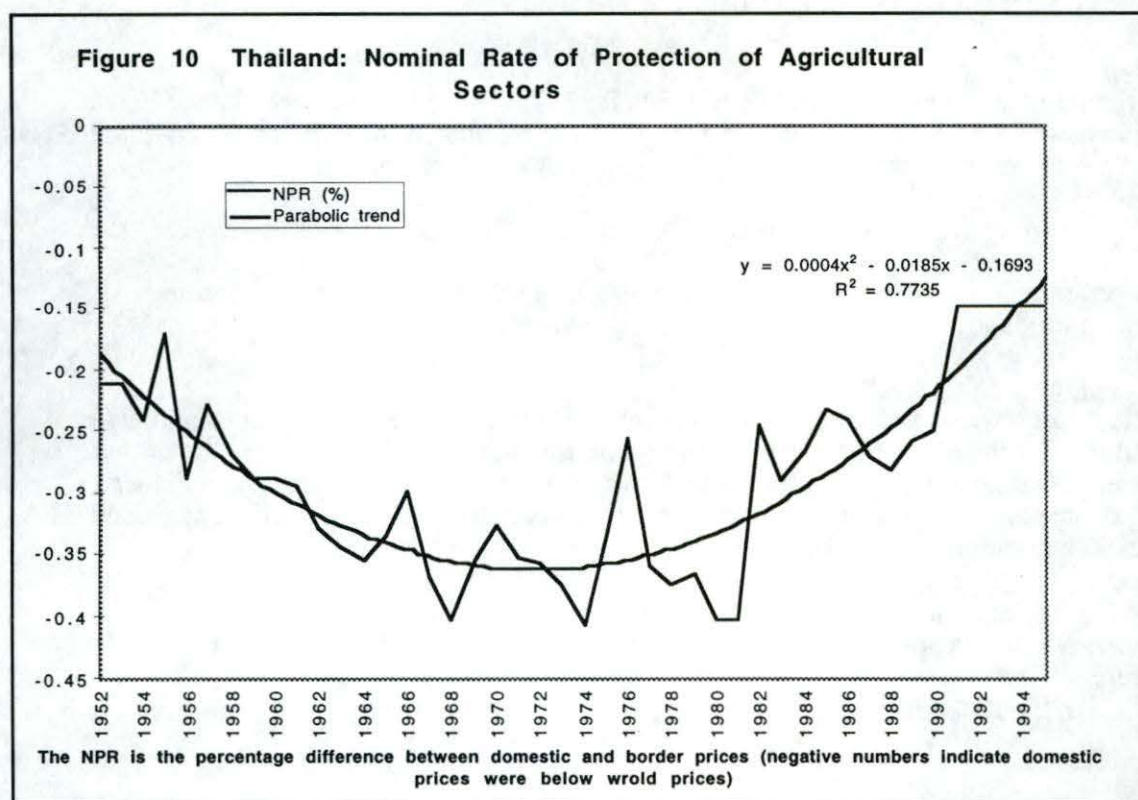
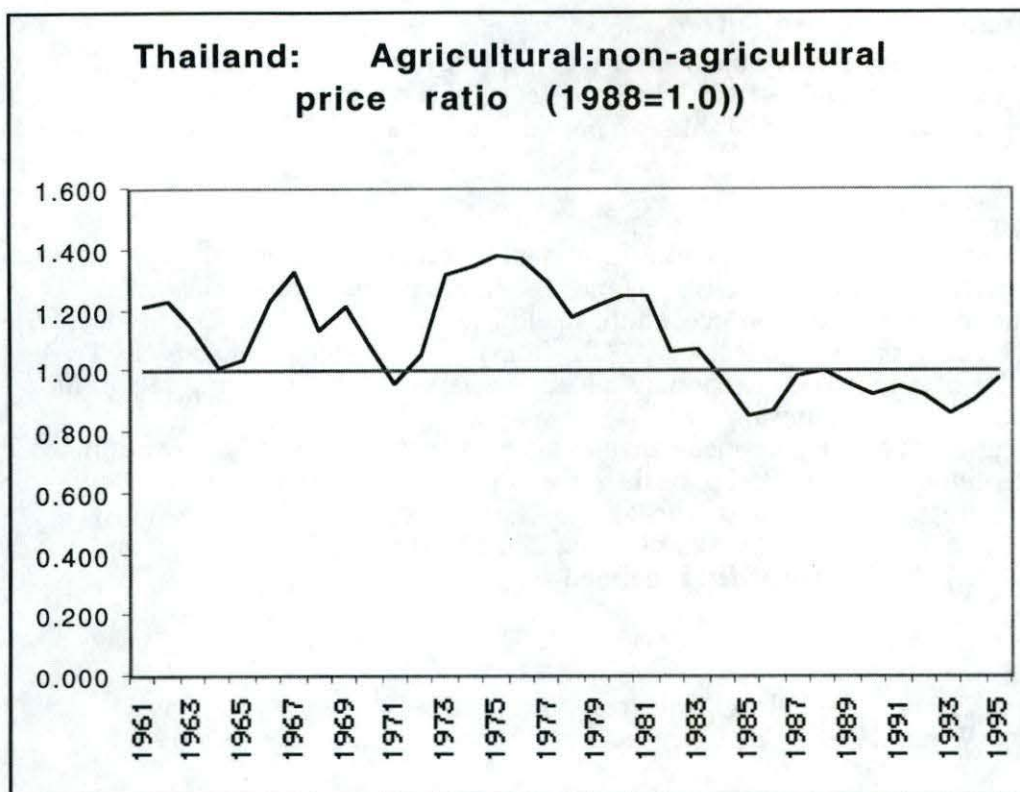


Figure 8 Thailand: Real value of agriculture output by region, 1961-1995 (,000 baht of 1988 price)





Appendix: data and estimation

As mentioned in the text, most of the data used in this study are drawn from the TDRI Dynamic Project data base (TDRI 1997), which is constructed primarily from official sources. The following notes and Table A-5 provide a summary and descriptions of individual variables.

Aggregate output

This study cover 22 crops: cassava, cotton, groundnuts, kenaf, mungbean, maize, soybeans, sugarcane, sorghum, rice (major and second crops), pineapple, rubber, oil palm, coconut, longan, coffee, tobacco, chilli, shallot, garlic and cabbage. The production and planted area by crop were collected by TDRI from the Agricultural Statistics of Thailand, Office of Agricultural Economics, plus some vegetable and tree crop data from the Agricultural Extension Division.

The aggregate output and price variables are constructed as Fisher indexes from the data on the 22 individual crops. Let p_{it} be the price of i in period t and q_{it} be the quantity of i in period t , for crops $i = 1, \dots, K$ and years $t = 1, \dots, T$. The period t price and quantity vectors that are to be aggregated into scalars are given by $q_t' = (q_{1t}, q_{2t}, \dots, q_{Kt})$ and $p_t' = (p_{1t}, p_{2t}, \dots, p_{Kt})$. The Fisher index is defined as

$$F_t = (L_t \cdot P_t)^{1/2},$$

where $L_t = (p_t' q_{t-1}) / (p_{t-1}' q_{t-1})$ is a Laspeyres index, and $P_t = (p_t' q_t) / (p_{t-1}' q_t)$ is a Paasche index (White, 1993). The base year for price and quantity indexes is 1988.

Land

The measure of agricultural land area is planted land, which is the sum of area planted to 22 crops. Data from Agricultural Statistics of Thailand, OAE

Labor

Agricultural and non-agricultural labor data for 1971-1995 collected from Labor Force Survey (round 3), NSO. The data before 1971 are calculated from the ratio of cultivated land per agricultural worker by region by Ammar *et al.* 1987, which is:

$$\text{Agricultural labor} = \text{cultivated land} / \text{cultivated land per agricultural worker}$$

Accordingly, non-agricultural labor is the difference between total labor force and agricultural labor.

Agricultural capital stock

In this study, we use data on stocks of large and small tractors, water pumps and water buffalo. For the econometric exercises reported in Section 2 we used an index of two wheel walking tractors, large tractors and water pumps. The value index is a Fisher aggregate (as for aggregate output). Quantity data are from OAE, price data are based on Bangkok retail price (TDRI).

Non-agricultural capital stock

Non-agricultural capital stock refer to net capital stock from NESDB 1970-1990, the data before 1970 and after 1990 calculated from

$$K_t = K_{t-1} + \text{INV}_t$$

where,

$$K_t = \text{net capital stock in year } t \text{ (1988 price)}$$

INV_t = gross fixed capital formation in year t (1988 price).

Source: Chaiyuth Punyasavtsut Ph.D. dissertation (U of Wisconsin-Madison, in progress)

Irrigated area

Irrigated area is accumulated water resources development completed by region, from Royal Irrigation Department and collected by OAE.

Fertilizer

Fertilizer refers to agricultural usage of chemical fertilizer. The total usage data were collected from OAE and decomposed to regional level using regional fertilizer use shares from the 1978 and 1993 agricultural censuses, NSO.

Wages

Wage data for agricultural and non-agricultural labor were computed from NSO labor force survey data for 1977 to 1995. The rest of agricultural wage data collected from the study of Polpon Upyanon and Nikom Chantarawitun, non-agricultural data from Year Book of Labor Statistics, International Labor Office.

Table A-5: A summary of the data by type, source and coverage

Variable	Years and coverage	Source	Note
Planted area	1961-1995 22 crops, provincial (22 x 70 x 35)	Agricultural Statistics of Thailand, Office of Agricultural Economics Statistics of Vegetable in Thailand, Department of Agricultural Extension Statistics of Fruit Tree in Thailand, Department of Agricultural Extension	Aggregate land by sum of 22 planted area by region
Production of crops	1961-1995 22 crops, provincial (22 x 70 x 35)	Agricultural Statistics of Thailand, Office of Agricultural Economics Statistics of Vegetable in Thailand, Department of Agricultural Extension Statistics of Fruit Tree in Thailand, Department of Agricultural Extension	Aggregate output formula (region level)
Fertilizer used	1961-1995, national (1 x 35) 1978, 1993, regional	Agricultural Statistics of Thailand, Office of Agricultural Economics Agricultural Census Survey 1978 and 1993, National Statistical Office	Disaggregate by share of regional used in 1978 and 1993
Agricultural labor	1961-1995 regional (4 x 35)	Labor Force Survey, National Statistical Office (1971-1995)	Agricultural labor for 1961-1970 computed from land per labor ratio
Agricultural capital	1961-1995 provincial (70 x 35)	Agricultural Statistics of Thailand, Office of Agricultural Economics	Agricultural capital means tractors, 2 wheel walking tractors, water pumps and buffaloes
Non-agricultural capital	1961-1995 national (1 x 35)	National Income of Thailand, Office of the National Economic and Social Development Board	Net capital stock
Farm price	1961-1995 22 crops, national price (22 x 1 x 35)	Agricultural Statistics of Thailand, Office of Agricultural Economics Statistics of Vegetable in Thailand, Department of Agricultural Extension Statistics of Fruit Tree in Thailand, Department of Agricultural Extension	
Wholesale price	1961-1995 22 crops, Bangkok price (22 x 1 x 35)	Price Division, Department of Economic Commercial	
Fertilizer price	1961-1995 Bangkok price (1 x 35)	Price Division, Department of Economic Commercial	Fertilizer price is a average of 21-0-0, 16-20- 0 and 15-15-15 price

Variable	Years and coverage	Source	Note
Agricultural wage	1961-1995 regional (4 x 35)	Labor Force Survey, National Statistics Office (1977-1995) Polpon Upanyanon, Thammasat Economic Journal, Vol.14 No.3, 1996 (in Thai) (1954, 1965, 1967, 1970, 1972 and 1975, some region) Nikom Chantarawitun, Rangngan Thai Kub Shewit Thi De Kaw. 1989 (in Thai)	The rest of data from 1961-1976 was estimated
Non-agricultural wage	1961-1995 regional (4 x 35)	Labor Force Survey, National Statistics Office (1977-1995) Year Book of Labor Statistics, International Labor Offices. (1966-1972, 1974, 1976) Polpon Upanyanon, Thammasat Economic Journal, Vol.14 No.3, 1996 (in Thai) (1954) Nikom Chantarawitun, Rangngan Thai Kub Shewit Thi De Kaw. 1989 (in Thai)	The rest of data from 1961-1976 was estimated
Agricultural capital price	1961-1995 FOB price (1 x 35)	Agricultural Statistics of Thailand, Office of Agricultural Economics Department of Custom	Price of big tractor, 2 wheel walking tractor and water pump calculated from value of import/quantity
Agricultural price index	1961-1995 national (1 x 35)	National Income of Thailand, Office of the National Economic and Social Development Board	GDP deflator of agricultural value added (1988 price)
Non-agricultural price index	1961-1995 national (1 x 35)	National Income of Thailand, Office of the National Economic and Social Development Board	GDP deflator of non-agricultural value added (1988 price)

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