Center for Studies in Demography and Ecology

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Draft: September 19, 2000

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• This work is supported by a grant to the authors from NICHD (grant number 1F32HD07687). The paper has been improved by comments of participants in the population seminar at the Center for Studies in Demography and Ecology, University of Washington. The assistance of Yih-Jiin Young, Thang Minh Nguyen, Nancy Morrow, and Sekar Thiagarajan with the maps, and the comments of Avery Guest, Sidney Goldstein, Nancy Grandjean, Ronald Rindfuss, Lea Trujillo, and Sara Curran on an earlier draft, are gratefully acknowledged.

POPULATION PRESSURE AND FERTILITY IN TRANSITION THAILAND

ABSTRACT

Prior the demographic transition in Thailand, fertility was high, but not uniformly so. As in other pre-transition settings, Thai fertility responded to pressures and opportunities created by socioeconomic structure and land availability. Drawing upon provincial data from the 1947 and 1960 censuses of Thailand, we find a strong "frontier effect" on Thai fertility in the 1950s. Fertility was higher in sparsely settled frontier provinces and lower in provinces with higher population density relative to cultivatable land. This finding is robust and holds up with controls for agricultural employment, land quality, and the sex ratio (an indicator of sex-selective migration). The effect of population pressure lowers the likelihood of marriage and of marital fertility. The findings from Thailand are consistent with the research of Easterlin on the nineteenth century United States and with other pre-transition societies. We suggest how demographic transition theory might be broadened to include fertility dynamics in pre-transition societies.

INTRODUCTION

The rapid and sustained declines in fertility from about 1870 to 1930 in many Western countries and from about 1960 to the present in many developing counties have given rise to the theory of the demographic transition. Although there are several variants of transition theory (Coale 1973, Davis 1963), there is broad agreement on the basic empirical features. In response to declines in mortality and the stirrings of socioeconomic development, fertility declines from levels with four to eight children per couple to small families with about two children. Although

there are variations in the timing, the conditions required for the onset of fertility change, and in the tempo of the decline, the process is one that is well recognized as one of the major correlates of modernization over the last century (Hirschman 1994b, Kirk 1996, Mason 1997, Watkins 1987).

There is, however, much less theoretical attention given to significant fertility dynamics during the pre-transition era. In 18th century Europe, for example, fertility is thought to have ranged from about 4.5 births per woman in some countries to about 7.5 births in others (Coale 1974). These very large variations in pre-transitional fertility differentials are often attributed to differences in "natural fertility"—which are unrelated to conscious motivations to control childbearing. Societies are thought to differ in cultural orientations that influence the proximate determinants of fertility, e.g., marriage, breastfeeding, or abstinence practices. Although a key assumption behind natural fertility may be true — conscious efforts to control fertility are necessary to produce the sustained and irreversible fertility transitions to the replacement levels found in the modern era — this does not necessarily imply that the wide swings in pre-transition fertility were not a response to social and economic factors. Indeed, the recent research provides much more evidence of continuity in fertility patterns and determination across pre-transition and post-transition societies than usually stated in demographic transition theory.

In this article, we examine regional variations in fertility during the 1950s in Thailand, about 10 to 20 years before the rapid reduction in Thai fertility began (Knodel, Chamratrithirong, and Debavalya 1987; Hirschman, Tan, Chamratrithirong, and Guest 1994) to test the "frontier hypothesis." The frontier hypothesis is an interpretation of how economic constraints—the availability of agricultural land—affects fertility levels in preindustrial settings. Although the

original development of the frontier hypothesis was based on studies of nineteenth century America (Easterlin 1976), it has found support from empirical studies of contemporary societies (Merrick 1978). Extending this work to Southeast Asia provides important insights into the roots of the rapid and sustained fertility declines that began there in the 1970s.

Theoretical Perspectives

The long-term viability of human communities requires that there be a rough balance between the needs of populations for sustenance and the resources available from the environment. Since the industrial revolution, and especially over the last century, this elementary postulate has been obscured with revolutionary changes in technology and transportation that expanded the availability of food and other resources at an unprecedented scale. But for much of human history, technological change moved at a snail's pace, if at all, over the centuries. The corollary of imperceptible technological change was that the rate of population growth oscillated, but with a central tendency close to zero.

Demographic theory has developed in response with the recent past—the dramatic changes in mortality and fertility that are known as the demographic transition. These transitions occurred in much of Europe from 1870 to 1930 and have begun in much of the developing countries in the world over the last few decades. In contrast, there is relatively little literature on the demographic dynamics in pre-transition societies. Kingsley Davis' (1963) version of demographic transition theory, which he labeled the theory of the multiphasic response, broadened the demographic transition theory's framework to consider a wide variety of responses to increased household size in both traditional and modernizing societies. These ideas have been

elaborated in articles by Friedlander (1969, 1983) and broadened to a general theoretical perspective of population homeostasis by Lee (1987) and Wilson and Airey (1999).

The central causal variable in Davis' essay is household strain, which is pressure created by a growth in household size under limited resources and/or rising expectations for economic improvement. In recent times, the increase in the probability of offspring survival is the basis for demographic disequilibrium or household strain. Although declining fertility is one response to household stain, this decline is generally thought to occur not through individual conscious control of childbearing (since modern contraceptives had not yet been invented) but rather more indirectly via macro level cultural and socioeconomic response, such as changing levels of out-migration and/or changing norms regarding the timing of marriage and terminal abstinence.

But other less dominant theories give more emphasis to an individual's or a couple's assessment of a changing opportunity structure. Richard Easterlin (1976) has pioneered an empirical literature with his work on the effects of population density in settled agricultural areas and frontier regions in nineteenth century United States. In his work Easterlin (1976) posits that the price and availability of land will affect decisions about family size when parents anticipate being able to endow their children with resources (land). He finds strong support for this premise in his analysis of the relationships among land availability, land prices, and fertility for six frontier states in the U.S. during the 19th century (Easterlin 1976). Bean et al. (1990) also find higher fertility in frontier areas.

Firebaugh (1982) finds a negative relationship between population density and fertility in India, as does Merrick (1978) in Brazil, but neither study systematically explores the key causal mechanism underlying Easterlin's hypothesis about density effects, to wit, parents' anticipated

capacity to endow their offspring when they come of age. It is this conception of endowment or "bequest" that motivates our study of population density and fertility. Our work also advances this literature by using census data to study a national rural population, and by exploring the source of fertility differentials, i.e., the extent to which the differentials are due to marriage patterns versus levels of fertility within marriage.

Thailand provides an ideal setting for an application of some of these propositions about frontier areas, resource constraints, and fertility. Historians have characterized Southeast Asia as having densely settled "pockets of intensive rice cultivation" with an open frontier available for exploitation (Reid 1988; see also Hirschman 1994a and Xenos 1994). Migration to and cultivation of frontier areas in the region to exploit opportunities for crop exports have been noted at least since the 1600s (Reid 1993); the past century has brought especially favorable economic conditions for rice cultivation and a rapid expansion of agriculture into previously unsettled or sparsely settled areas.

Interactions between rural Southeast Asian populations and their environments were clearly quite dynamic in historical times (Wyatt 1984, Reid 1993), and a number of studies have focused on the demography of the region during the premodern era (e.g., Owen 1987, Reid 1987, Flieger and Smith 1975). While these earlier works have provided valuable insights and stimulating hypotheses, population-based data on fertility, migration, and density are either lacking or are highly suspect for most of Southeast Asian history. Like Xenos (1994), we see great potential in early modern census data for the systematic analysis of the peopling of the Southeast Asian frontier, and we exploit this resource in our analysis of pre-transitional demographic differentials.

As we detail in the next section, forces impacting upon the population/environment equation during the late 19th and early 20th centuries included gradual population increase, a change in the profitability of cultivating previously unsettled territory, and the linking of these peripheral territories to the core. The region experienced an explosive increase in international trade, resulting in an expanded market for rice exports. Settlement of the surrounding jungle became profitable, albeit constrained by a lack of sufficient labor. It is our contention that these demographic and economic changes encouraged migration to underpopulated regions and led to relatively high fertility among the inhabitants of these newly settled areas.

The Country Setting

Thailand lies in the heart of mainland Southeast Asia (Figure 1), and possesses a fertile central plain and riverine delta, a mountainous north and south, and an arid northeastern plateau. Since the establishment of the first unifying kingdom at Sukhothai during the 13th century, and perhaps even before, the Thai population has been concentrated in the valleys of the Chao Phraya River and its tributaries, extending from the upper central plain, through the area surrounding present-day Bangkok, to the Gulf of Thailand. Except for these central river valleys and a few other important settlements, most of the country was either unpopulated or only very sparsely so until fairly late in this century (Wyatt 1984; Keyes 1989; Arbhabhirama et al. 1988).

But even if the early Thai population was small by modern standards, Thai demographic history is a dynamic one. The Thais themselves are thought to have arrived in present day Thailand during the period between the 7th and 13th centuries A.D. Non-Thai groups who had arrived earlier were displaced or assimilated, and, although adequate data are lacking, the

population presumably waxed and waned with the fortunes of the various Thai kingdoms. Numerous wars with Burma must have had dramatic impacts upon population size and its distribution. The taking of large numbers of prisoners was common. Warfare must have been extremely disruptive to agricultural life when populations were so concentrated into densely settled core areas. Eventually, these wars resulted in a move of the capital from Ayutthaya to Thonburi/Bangkok during the latter half of the 18th century (Hirschman 1994a; Keyes 1989; Reid 1988; Wyatt 1984).

The expansion of Thai agriculture

But throughout this turbulent history, the establishment of densely settled cores with an unpopulated or very sparsely populated frontier remained the basic Thai settlement pattern until the latter half of the 19th century. The beginnings of more extensive frontier settlement at that time had several causes. In 1855, Sir John Bowring negotiated a major treaty between the British and Siamese which did much to open Thailand's market to British goods and helped to make it profitable for investors to ship highly regarded Thai rice abroad (Wyatt 1984, Fuller et al. 1983); the growing numbers of wage laborers in Bangkok also increased the demand for rice (Hirschman 1994a). These changes led to a remarkable expansion of the transportation system linking agricultural regions in the surrounding countryside to the core Bangkok area, mostly through canals, at the turn of the century (Johnston 1976). The majority of land in the Thai central plain came under cultivation by 1925 (Piker 1976).

The aftermath of World War I brought about higher rates of population growth in Thailand (Piker 1976) and greater demands for Thai rice abroad (Hanks 1972). The expansion of

land under cultivation continued into the north, south, and northeast, until the disruption caused by World War II. After the second world war, population growth rates peaked at over 3% per year (Knodel et al. 1987; Piker 1976), the expansion of the transportation system further facilitated the linking of agricultural areas with the ports, and the area under cultivation again began to increase. The railway to Korat completed in 1900, to Chiang Mai in 1921, to Khon Kaen in 1930, and to Nong Khai in 1953 did much to expand production (Fuller et al. 1983, Ingram 1971), even if the primary motivations for railroad construction had more to do with issues of national security than with desires to increase agricultural output (Keyes 1989).

Prior to 1950, there was no national road system, so large-scale transport was limited to areas connected either by waterways or by the railroad. But the expansion of paved roads during the 1950s, and especially during the 1960s, further facilitated the linking of previously isolated outlying areas to population centers (Ingram 1971).

With little technological change occurring, most of the increased production resulted from an expansion of the amount of land under cultivation, and much of this expansion during the 1950s and 1960s occurred through the cutting of forest lands in the North and Northeast (Ingram 1971; Feeny 1988). Keyes (1982), for example, reports a decline in northeastern forest cover from 62% of all land in 1956 to 27% by 1973.[1]

This expansion of land under cultivation was further expedited by longstanding Thai traditions regarding land tenure. In Thailand, uncultivated land has generally been considered to be available to whomever would clear and maintain it (Piker 1976). According to the Land Acts

[1] Total land under rice cultivation increased from about 9 million rai (1 rai = 1600 m^2) around 1905 to 25 million rai in 1946 to 39 million rai in 1961 to 48 million rai in 1970 (Ingram 1971; Thailand National Statistical Office 1982).

of 1936 and 1980, Thais were allowed to clear and cultivate unused land (usually up to 25 rai), but the King could reclaim the land if it was left fallow for three years (Ingram 1971).

Eventually, homesteading becomes more difficult (or "expensive") as land becomes more scarce, marginal, and legally regulated. The 1901 Land Law was an early step in conceptualizing land as a "legal commodity" (Keyes 1976), but the idea of land being freely available to those who would cultivate it still exists in modern times. Marzouk (1972) reports that the land code current at the time made provisions for squatters by issuing a "reserve license," but over half of the land under cultivation in Thailand at that time did not even have this modicum of legal status. Arbhabhirama et al. (1988) report that in 1986 only 63% of all cultivated land was covered by either land title or certificate of utilization.

Homesteading of unoccupied land in Thailand has often been undertaken by newly formed families. In the ideal, a newly married rural Thai couple will reside first with the bride's parents (Fukui 1993). If the bride's parents' farm is large enough, it will be subdivided among her and her siblings. If it is not large enough to subdivide, the youngest daughter and her husband will inherit the house and farm while her siblings must accumulate enough capital to set up a house and farm of their own.

Migration during the 1950s and 1960s

In Thailand, the 1950s and 1960s were characterized by moderate levels of interprovincial migration. In 1960, 11% of the Thai population were not living in their province of birth, and this proportion increased to 13% by 1970. In 1960, recent interprovincial migration

(during the past 5 years) was reported by 3.6% of the Thai population over age 5; this figure rose to 5.9% by 1970 (Goldstein and Goldstein 1986).

Migration from rural areas to Bangkok during these two decades was substantial, and this feature of Thai migration has received the most attention in the literature. But the majority of interprovincial moves in Thailand during the late 1960s (and presumably during the 1950s as well) were rural-to-rural moves, 63% according to calculations by Goldstein and Goldstein (1986);[2] rural-to-urban moves comprised just 11% of the total.

A study conducted by Chulalongkorn University's Institute for Population Studies (1981) found that migration rates during the late 1960s were highest among young adults and were higher for males than for females.[3] The rates peak at ages 20-39 for men and ages 10-29 for women. These ages coincide with the beginning of family formation in Thailand,[4] and this conception is consistent with the reasons migrants give for leaving home. Among the reasons cited for rural-to-rural moves during the period 1975-80, family reasons were predominant for both male and female migrants, i.e., the move took place because of a change in marital status or to accompany another person in the household (Goldstein and Goldstein 1986). Goldstein and Goldstein (1986) do not present comparable data for earlier periods, but Visid and Penporn (1974) report on a study conducted during the late 1960s, in which marriage was by far the most common reason cited by male migrants for moving to their present rural location. Also, a study of a rural Thai village in Khon Kaen province (Fukui 1993) found that during the period between

[2] This proportion declined to 52% by the late 1970s.

[3] The Institute of Population Studies (1981) cites work (UNESCAP 1976) indicating that the sex ratio of migrants was over 130 for every age group from age 20 - 49, for both the late 1950s and late 1960s.

[4] We speculate that five-year age groups would probably indicate that women tend to migrate between the ages of 15 - 24, but these data are not available.

1935 and 1964, the primary reasons for migrating into the village were marriage and *ook-hien,* or the setting up of a new household by a newly married couple; no one migrated in for new land since all land was already occupied. The primary reason for out-migration during the same period was for new land, followed by marriage and *ook-hien*. Out-migrants who left the province moved west and northwest, the vast majority to Udon Thani in the upper Northeast.

Interprovincial migration during the late 1950s and late 1960s was primarily intraregional, with migrants relocating within the Northeast comprising the largest single migrant stream during both periods. But after intraregional migration, individuals from the densely settled Central region (excluding Bangkok) made up the majority of migrants to all three outlying regions during both periods (Goldstein and Goldstein 1986).

To summarize, during the 1950s substantial numbers of young Thai men and women, many of them recently married, were migrating between rural areas. Many of these migrants were moving from the densely settled Central region of Thailand, and some moved with the intention of setting up new households. An absence of strict regulation of land tenure allowed for the homesteading of unoccupied land where it was available. We are now prepared to investigate whether these migration patterns are associated with higher fertility in the receiving areas, as would be predicted by a frontier effect framework.

METHODS

Data

We focus on the 1950s for several reasons. First, as noted in the previous section, this was a period characterized by considerable migration to relatively underpopulated areas. Second,

the 1950s predate the introduction of contraceptives and the fertility decline that swept through Thailand during the late 1960s and 1970s (Knodel, Chamratrithirong, and Debavalya 1987). This serves our objective of investigating fertility differentials existing prior to the introduction of modern means of fertility regulation. Third, data collected for the 1960 census are the earliest available that allow us to estimate fertility levels and a number of predictor variables at the provincial level. We also draw extensively on published statistics regarding the amount of land under cultivation in each province during this and later periods.

An analysis of provincial-level data for a study such as this has a number of disadvantages. First, it restricts the number of data points in our analysis. Second, aggregation to the provincial level obscures variations within provinces (e.g., among *amphurs*, or districts). For example, provincial-level data make it impossible to distinguish urban from rural areas within provinces. Goldstein and Goldstein (1986) estimate that limiting migration estimates to interprovincial moves captures only about half of those who would be identified by using a definition of change in residence. Unfortunately, the required data are not available for geographical units smaller than provinces.

Reliable longitudinal data would be superior to the cross-sectional measures we employ, since our hypotheses address processes occurring over time. We attempt to capture some features of the historical nature of these phenomena in our measure of population density, but we believe that a truly longitudinal study of the filling of the Thai frontier would face serious problems of data quality; as noted above, we believe that the 1960 Thai census data are the earliest reliable data for the requisite outcome and predictor variables.

We utilize data from 59 of the 71 provinces existing in Thailand during the period of study. Since our hypothesis concerns the effects of resources on fertility in agricultural areas, we omit four provinces near Bangkok. Highly urbanized areas will provide opportunities and constraints that are distinct from those found in rural areas. For example, the Bangkok area will provide wage employment opportunities that are unlikely to encourage higher fertility in ways that agricultural opportunities on the frontier can. Omitted provinces include Bangkok and Thonburi, which comprise Bangkok proper;[5] Samut Sakhorn, which is very near Bangkok and is relatively highly urbanized; and Samut Prakan, which is adjacent to Bangkok and is very densely populated. Omission of these greater Bangkok provinces removes 9.7% of the total 1960 population. We also omit Mae Hong Song, located in the northwest corner of the country, because of its implausibly low level of fertility for the early 1950s (TFR = 4.8);[6] the southern island of Phuket because of the high proportion of municipal residents (37%);[7] Samut Songkram, just south of Bangkok, because it is extremely densely populated (826 persons/square kilometer of potentially arable land) and because marine fisheries, which should not be affected by population densities in the same manner as land-based agriculture, constitutes a central industry;[8]

[5] Bangkok and Thonburi together had a population of 1.7 million in 1960 (Thailand National Statistical Office 1963). The next largest city was Chiang Mai, with a population of only 34,000.

[6] Mae Hong Song was extremely remote, and travel within the province must have been exceptionally difficult during this period. We speculate that census enumerators may have focused their attention on the accessible urban population in the provincial capital (who presumably would have had relatively low fertility) and neglected the hill tribes in the countryside (who would presumably have had relatively high fertility). However, we note that Mae Hong Song is not an outlier in the overall fertility/density relationship; indeed, it falls
rather close to the estimated regression line.

[7] As in the provinces making up the greater Bangkok area, the widespread availability of opportunities for nonagricultural employment in Phuket violates the assumptions of our explanatory model.

[8] In 1961 and in 1962, Samut Songkram, one of the smallest provinces in land area, led the country in the annual catch of marine fish (Thailand National Statistical Office 1963).

Kalasin, in the Northeast, because we cannot estimate its population in 1947 (it did not yet exist as a separate province); and the four southernmost provinces of Yala, Pattani, Narathiwat, and Satun because they are culturally distinct.[9] The remaining 59 predominantly rural provinces include 85% of the total 1960 Thai population and 92% of the total land area.

Measures

Our estimates of provincial levels of fertility are based upon the Rele method (Rele 1967, 1989). The Rele method estimates the total fertility rate (TFR) from child-woman ratios (CWR) and a measure of mortality (life expectancy at birth).[10] The method produces fertility estimates for the period 0-4 years prior to the census with a CWR utilizing children 0-4 years of age and married women aged 15-49; fertility estimates for the period 5-9 years prior to the census employ a CWR utilizing children 5-9 years of age and married women aged 20-54.[11]

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[9] These provinces are predominantly Malay-speaking rather than Thai-speaking (Keyes 1989). The first three are outliers for fertility (they have very low fertility); all four are outliers for marriage rates among young females (all have very high rates).

The strength of the relationship between fertility and density among these four provinces is similar to that found among the other provinces in the analysis ($r = -0.60$ and $r = -0.56$, respectively), but the correlation is insignificant for the four data points. The slopes of the lines are also very similar ($b = -0.0026$ and $b = -0.0022$, respectively), but the line for the four provinces has a lower intercept.

Fertility levels at each given density level may be depressed among the Malay speaking provinces (in spite of early marriage) because of high divorce rates among some Malay groups during the period of study; Jones (1981) finds very high divorce/marriage ratios (30-70%) in the Malay provinces adjoining the southern Thai border during the 1950s. We speculate that an analysis of Malay geographical units would reveal a density/fertility relationship similar to that found among these 4 provinces. Mounts (1989), in fact, has found that high rural population density depresses nuptiality, as our paradigm would predict.

[10] The CWRs we employ are provincial measures. Since we do not have mortality data for each province, we use the same national measure of life expectancy for all provinces. If mortality was in fact higher in the frontier provinces, then our measures of fertility in these provinces will be too low, and our estimates of fertility differences between densely settled and sparsely settled provinces will be conservative.

[11] We also completed the analysis using the Coale indices of overall fertility, marital fertility, and

For the period 1955-59, the Rele method produces a lower estimate of the TFR than that derived from a stable population estimation procedure.[12] We conclude that the Rele method results in an underestimate of fertility because of an undercount of children aged 0-4 in the 1960 Thai census. Rele (1989) acknowledges this shortcoming of the method.

Children aged 5-9 are less subject to underenumeration in censuses. The Rele estimate of TFR for the period 1950-54 using children age 5-9 and women 20-54 is 6.2, which is much more consistent with the stable life table procedure described above. Thus, we will focus our analysis on the earlier period (1950-54), since we have more confidence in these estimates of provincial fertility.

Our density measure is designed to assess the perceived carrying capacity of the land as viewed by individuals living during the period covered by the study. As our index of population pressure, we compute provincial levels of population density using the 1947 census enumerated population in the province (Thailand National Statistical Office 1976) divided by the amount of land in the province under cultivation in 1978 (Thailand National Statistical Office 1982). The

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marriage (I_f, I_g, and I_m), but found that these measures did not work well. When births are used to compute I_f, it does not correlate well with the Rele measures of fertility 0-4 and 5-9 years before the survey ($r = 0.38$ and $r = 0.28$). In fact, I_f gives implausible results, e.g., I_f has a negative association with the proportion working in agriculture; Bangkok and Thonburi have the highest value of I_f. This may result in part from rural women choosing to have children in hospitals located within large cities.

I_f can also be computed using the number of children below age one. When it is calculated this way, there is still a poor correspondence between I_f and the Rele estimates of fertility 0-4 and 5-9 years before the survey ($r = 0.48$ and $r = 0.22$). While differential mortality or changing fertility may play a role, we believe that this lack of correspondence is primarily due to differential undercounting of small children, probably at its worst at age less than one, and at its best for children age 5-9.

[12] The Rele measure of TFR for this period is 5.6 children. Using an estimated female life expectancy at birth of 53 (UN 1993), a mean age of childbearing of 31 (based on data from the Thailand National Statistical Office, 1963), a proportion of women aged 35 and under of .762 (Thailand National Statistical Office 1965; data from the 1960 Thai Census), and the Coale-Demeny Model Life Table West Schedules (UN 1967), we derive an estimated TFR of approximately 6.3, or about .7 child higher than the Rele estimate.

1947 population is used because this provides the most current estimate of the population in each province during the early 1950s. The land under cultivation in 1978 is used as an estimate of the amount of land that could be brought under cultivation during the subsequent generation. 1978 represents approximately one generation (23-28 years) after the birth of children during the period of interest (the early 1950s).

1978 was used for two other reasons. First, it appears to be a typical year, and second, the total area under cultivation is available. The early 1970s seem very atypical since there was a drop in the number of rai planted in rice. We recalculated the associations between fertility and our density measure using the area planted in rice for other typical base years (e.g., 1968 and 1976) and obtained similar results.

There are several alternatives for measuring population pressure and we chose the one described above principally on theoretical grounds: given the data available to us, we feel it best captures the future potential for agricultural expansion. Our conceptualization of population pressure is consistent with measures used by Easterlin (1976) in his study of the American frontier. For example, Easterlin presents the actual improved-acreage as a percentage of ever-improved acreage to approximate the degree to which a frontier area has become saturated. We present the actual population size per unit of land that is cultivated one generation hence.[13]

[13] A plot of our density measure with fertility during the early 1950s reveals a strong negative association ($r = -0.56$, $p < 0.0001$) through the entire range of both variables (see Figure 3). An alternative density measure would divide the 1947 population by all land, a measure we believe to be inadequate since many of the provinces contain much land that almost certainly was not seen as potentially cultivable in the early 1950s. Though the correlation between this second measure of density and fertility is also negative and statistically significant ($r = -0.27$, $p = 0.04$), a plot of the values reveals that the relationship is driven by only four points; with these removed there is no discernable relationship. Substituting the 1960 population in the density measure yields nearly identical results.

We employ four additional independent variables in the multivariate analysis. First, the proportion of the population living in agricultural households (from the 1960 Thai Census) is included as a proxy measure for the availability of nonagricultural employment opportunities in the province. This variable controls for some of the effects of modernization on fertility differentials. Second, we include a measure of the quality of agricultural land to account for the fact that not all agricultural land is equally productive. Land in some areas will be capable of supporting more individuals per unit than others, so the inclusion of this control variable is necessary to better specify the relationship between available land and fertility net of variations in land quality. We approximate land quality in each province by a measure of the average number of kilos of rice produced per rai of land under rice cultivation in 1960 (Thailand National Statistical Office 1963). Third, we include a measure of the sex ratio of young adults (males 20-29/females 15-24) from the 1960 Thai Census to control for differences in the degree of competition for wives.[14] We anticipate that in areas where there is a shortage of marriageable women, overall fertility should be higher since each woman will have greater opportunities or pressure to marry early; Guest (1990) takes a similar approach.[15] The proportion of women aged

[14] A shortcoming of this measure is that if patterns of migration (and thus the sex ratio of young adults) changed over the course of the 1950s, the measure we employ will not be a good proxy for sex ratios earlier in the decade. We repeated the analysis using an alternative sex ratio (males 30-39/females 25-34) since the men and women enumerated in the 1960 census are 5-10 years older than they were during the period of interest (1950-54). This latter measure will be problematic if there is much outmigration after young adulthood. For example, men who did not marry may move elsewhere (in fact, it appears that this may have been the case for some provinces).

The substantive conclusions do not change no matter which sex ratio measure we employ. We retain our original measure because it correlates more highly with fertility during the early 1950s.

[15] Alternatively, the sex ratio of young adults can be thought of as a proxy measure for out-migration as an outlet for population pressure. Since the majority of migrants during the late 1950s were male (Goldstein 1971), areas with a low sex ratio (i.e., relatively more females than males) might reflect the process of out-migration, rather than lowered fertility, as an outlet for population pressure.

20-54 who were currently married in 1960 (according to the 1960 Thai Census) is included as an intervening variable to capture the effects of local marriage patterns (entry into and dissolution of marriage) on total fertility.[16]

Procedures

We begin with an illustration of the bivariate relationship between population density and fertility for the 59 Thai provinces using a scatterplot and a series of Thai provincial maps shaded for these variables. The second step is to estimate the effect of density on fertility net of the effects of nonagricultural opportunities, the quality of the agricultural land, and differences in the pressures/opportunities available for young women to marry. We pursue this second step by using probit and least-squares multivariate regression to simultaneously control for these potentially confounding factors. In the final step, we decompose the total effect of density on fertility into marriage and marital fertility components.

Hypotheses

Figure 2 outlines our proposed model of how population density affects fertility, and includes two control and two mediating variables. Our control variables are the proportion of

[16] We explored two alternative measures of marriage patterns: the singulate mean age at marriage for women and the proportion of women aged 15-24 who were currently married at the time of the 1960 census. The multivariate models including these measures of marriage lead to the same substantive conclusions as the models we present, except the importance of marriage is lessened, indicating that these alternative measures do not capture the influence of marriage as well as the measure we employ.

Our measure of marriage (proportion of women aged 20-54 currently married at the time of the census) may better capture the effects of marital dissolution and widowhood than the other two measures. It is also more elegant, being the denominator of our fertility measure, and our final models employing it explain a higher proportion of the variance than models employing the alternative measures.

agricultural households (a proxy for modernization) and land quality. We anticipate a strong negative relationship between population density and fertility once the potential masking effects of these two variables are controlled. This central hypothesis is interlinked with two other expected results. First, we anticipate that sparsely settled frontier areas will attract migrants who wish to profit from the growing demand for Thai agricultural products. Second, we expect that individuals living at the frontier will face lower costs for childbearing than parents living in more densely settled areas, since there will be a shortage of labor that can be alleviated to some degree by childbearing; and since parents at the frontier will anticipate better prospects for endowing their children with land than will farmers in more densely settled areas.

The two intervening variables in the model are the sex ratio of young adults and marriage patterns. We anticipate that some of the effects of density will be mediated through high male/female sex ratios. Where migration results in more marriageable males than females, there will be increased demand for women to marry early and/or begin childbearing early in the marriage. And where there is early marriage and childbearing (either as a consequence of these high sex ratios or because of more ample resources in low-density areas), period fertility measures will be higher than in areas where family formation is late. Finally, we anticipate that density may affect fertility via marital fertility (a "direct" effect in this diagram). In frontier areas, families will desire more children than in densely settled areas, thus increasing fertility within marriage. However, since modern methods of fertility control are not available in this population, we anticipate that the main effects of density should work through marriage patterns (especially age at marriage) rather than through within-marriage fertility control.

RESULTS

Description of the data

The measures used in the analysis are described in Table 1. The first column provides the mean value of each variable for all 71 Thai provinces at the time of the 1960 census. The remaining columns provide the means and range of the variables for the subset of 59 provinces used in the multivariate analysis. The range of provincial-level total fertility for the latter group is about a child and a half. Bangkok and Thonburi, which are not included in the multivariate analysis, have total fertility rates of approximately 5.8 births, but the lowest levels occur among the excluded southernmost provinces: Narathiwat and Pattani have TFRs around 5.1 during this period.[17]

Population density varies widely, from a low of 22 persons per square kilometer of potential farmland in sparsely settled Kamphaengphet province in the lower North (just south of Tak in Figure 1), to a high of 1,438 in Bangkok proper. The most densely settled province in the multivariate analysis is Lamphun (just south of Chiang Mai) in the upper North, with 386 persons per square kilometer of potential farmland. All of the provinces included in the analysis have at least 54% of their populations living in agricultural households, but agricultural productivity covers a broad range. The most productive areas are in the North and Central regions, while the least productive provinces are located in the more arid Northeast.

The average sex ratio of young adults is about even for men and women (0.93) but ranges fairly widely among the provinces. Sex ratios tend to be high (more men) at the extreme levels of

[17] As described earlier, Mae Hong Song reports a TFR of 4.8 for this period, but this figure is not considered plausible.

population density. There is also a fair range of proportions married (69% - 86%) among these rural provinces.

Bivariate analysis

If our depiction of frontier effects on fertility is correct, we would expect a plot of fertility by density in rural areas to reveal a negative relationship, i.e., fertility levels should decrease with increasing density. Empirically, this is what we find in the results displayed in Figure 3. Sparsely settled areas with high levels of fertility are in the upper left of the plot, and densely settled areas with low fertility are in the bottom middle and lower right of the plot ($r = -.56$; $p = 0.0000$). This association between population density and fertility is even more compelling when the positions of individual provinces within the plot are considered. As expected, the long-established densely settled provinces of the lower Chao Phraya river valley are in the bottom middle-right of the plot, while the sparsely settled provinces of the North, Northeast, and South, are in the upper left.

The cluster of four northern provinces in the bottom right of the plot can also be interpreted using our paradigm of frontier effects. While the North as a region was a major destination of migrants during this period, these four provinces had among the lowest proportions of recent migrants in 1960 (0.8% to 1.5%). Two of the provinces are long-established areas (Chiang Mai and Lampang) with probably little room for additional agricultural expansion. The other two (Phrae and Nan) are mountainous provinces with likewise little room for expansion. Indeed, all four provinces had very high densities of population per area of potentially arable land (between 312 and 381 persons per square kilometer).

These interrelationships among fertility, density, and expansion of the frontier are further illustrated in Figures 4 - 6[18]. Figure 4 is a map highlighting provinces with relatively low population density during the late 1940s and early 1950s (lightly shaded); i.e., these provinces had small populations in 1947 given the amount of land that would be under cultivation by 1978. These sparsely settled provinces occupy a swath across the middle of the country. The most densely settled areas (shaded dark) included the cluster of long settled provinces of the lower Chao Phraya and Suphan Buri river basins, just north and west of Bangkok, and much of the mountainous upper North. The other provinces of the lower Central plain, most of the southern peninsula, and the easternmost provinces of the Northeast had moderately high density during this period; the latter group in the late 1950s had among the lowest rice yields per rai in the country (Thailand National Statistical Office 1963). These densely settled areas probably did not afford much hope for further agricultural expansion.

But there were opportunities for agricultural expansion in the sparsely settled provinces across Thailand's as-yet-undeveloped heartland. Figure 5 shows that these frontier provinces were the preferred destinations of many migrants during the late 1950s.[19] Metropolitan Bangkok is also clearly an important destination, but it is omitted from consideration in our statistical analysis since individuals migrating to Bangkok almost certainly went seeking opportunities in the modern urban-based economy rather than for any perceived opportunities in agriculture. As discussed in the introductory section, most of the migration in Thailand during this period was

[18] The number of provinces in these provincial maps is 74 rather than 71 because the mapping program uses provincial boundaries current in 1990, when there were 74 provinces. For the additional provinces that did not yet exist during the 1950s, data from the larger provinces from which they were created are used for shading.

[19] The correlation between in-migration rates and population density for the 59 provinces included in the multivariate analysis is -0.33 ($p = 0.011$).

rural-to-rural, and this fact is reinforced by the large number of rural destinations for interprovincial migrants during the late 1950s. Figure 6 demonstrates that many of these sparsely settled provinces receiving large numbers of migrants were among the provinces with the highest fertility during the early 1950s.[20] While the correspondence is not perfect, this series of maps illustrates the great degree of overlap among the provinces having high potential for agricultural expansion, high in-migration, and high fertility.

The maps graphically present some of the broad patterns of migration and fertility during this period, but they are limited to the display of bivariate relationships among categorical variables. That is, the maps do not incorporate the potentially confounding influences of other processes that were occurring simultaneously, e.g., differential migration by sex, employment opportunities arising in the modern urban-based economy, and variations in land quality. We assess the influence of these factors, and explore the sources of the fertility differentials in rural areas, in the next section.

Multivariate analysis

Multivariate analysis of the effects of density on fertility, including the control and intervening variables described above, is shown in Table 2. The correlation matrix of all variables is included as an appendix.

Table 2a displays the effects of the predictor variables on the proportion of women aged 20 - 54 who were currently married in 1960. The outcome variable in these models is a proxy measure for marriage patterns (and exposure to pregnancy) during the early 1950s. These results

[20] The correlation between fertility and density for the 59 provinces in the multivariate analysis is -0.56 ($p < 0.001$); the correlation between fertility and in-migration is 0.32 ($p = 0.15$).

reveal a significant bivariate relationship between density and marriage patterns (Model 1), and demonstrate that the relationship becomes stronger and more significant as controls are added for agricultural households and land quality (Model 2), and the intervening effects of sex ratio (Model 3) are included. The controls and intervening factor all have effects in the expected directions, and their predictive power indicates the importance of including these variables to determine the full effects of density on marriage.

The models in Table 2b present the effects of the predictor variables, including the effects of marriage patterns, on the Rele measure of TFR during the early 1950s. Model 4 in this table displays the gross effects of density on fertility, Model 5 presents the effect of density net of the two control factors (proportion in agriculture and land quality), and Model 6 includes the additional effect of the intervening variable sex ratio. Measures of the proportion in agriculture, land quality, and the sex ratio of young adults are all important predictors of marriage, but not of fertility.[21] Also, the effect of density on fertility remains quite consistent with the inclusion of the control and intervening factors. It is only in the final model (Model 7), with the inclusion of marriage, that the direct effect of density is attenuated. About 55% of the effect of density on fertility is direct on marital fertility and most of the remainder (43%) is indirect through marriage patterns (Table 3).

DISCUSSION

Models including measures for the potential confounding influences of land quality, modernization, and sex ratio imbalances indicate that variations in population density affected

[21] The substantive conclusions do not change when the probit model is estimated without the log transformations.

fertility in rural Thailand during the early 1950s. Our central finding is consistent with empirical results from studies of population density and fertility in Brazil and India, and it verifies a central hypothesis regarding frontier effects that we derived from studies of the peopling of the American frontier.

Our multivariate model is also supported by a series of maps we present to illustrate the areal relationships among population density, migration, and fertility, by a bivariate plot of fertility and density levels among the provinces in our analysis, and by other research focusing on Thai migratory patterns during this period. Earlier work on Thai migration supports our contention that many young Thai couples migrated to areas where there appeared to be opportunity for agricultural expansion, and setting up new households seemed to be a primary motive. The long-established densely settled central region provided a large proportion of the young migrants, and the major streams went to rural areas.

We anticipated that density would affect fertility primarily through marriage patterns. We were surprised, however, to find that most of the effect of density (about 55%) is <u>not</u> accounted for by the path through marriage patterns, but rather appears to influence fertility directly. We consider four possible explanations for the surprisingly important role of fertility within marriage.

First, there may have been more control of fertility within Thai marriage during this period than we anticipated. Even though modern means of fertility control were not available at this time, couples may have been able to control their level of childbearing within marriage through abstinence or withdrawal.

A second consideration is that these within-marriage effects could be due in part to differential impacts of spousal separation due to seasonal migration, if seasonal migration was more common in core than in frontier areas. Since enumeration is *de jure*, it is unlikely that our sex ratio measure would control adequately for this. However, although seasonal migration is a common employment pattern for Thai men in more modern times, it is very doubtful that either Bangkok or the frontier areas would have held much opportunity for extended seasonal employment for large numbers of men residing in the core agricultural areas during the 1950s.

Third, our measures of the influence of marriage on fertility could be confounded by other factors. In particular, unlike an actual TFR, the Rele procedure could be influenced by differences in female age distributions. If some provinces had higher proportions of women in prime reproductive ages than other provinces, then fertility differentials among provinces could be due to differences in age structure. We examined whether the proportion of women in prime reproductive ages (i.e., the proportion of women age 25-34/women age 20-54)[22] was correlated with fertility and found that it was not. Another problem with our measure of marriage that we are unable to explore further is that the proportions married in 1960 does not perfectly reflect exposure to childbearing during the first half of the 1950s, when these children were actually born. However, it is difficult to imagine scenarios in which our measure of marriage would not provide an adequate proxy measure for exposure to childbearing in the same area earlier in the decade.

Fourth, since many of the persons migrating to Thai frontier areas were already married, this probably served to lessen the degree to which marriage patterns could affect fertility in the

[22] These women would have been age 20-29/ age 15-49 five years earlier, at the end of the childbearing period of interest.

frontier environment. The fact that marriage does play a substantial role apparently reflects the extent to which marriage patterns affected the fertility of second or subsequent generation migrants and first-generation migrants who were single when they moved. The limitations of the marriage variable thus serve to make the overall observed fertility differentials even more remarkable (see footnotes #11 and #16 for a discussion of alternative measures of marriage employed).

After considering these alternative explanations, we conclude that a surprising amount of control of fertility within marriage is apparent. We speculate that some degree of the regional variations in marital fertility between the frontier and densely-settled areas could be due to changes in coital activity that may be related to perceptions about the ability to support a large family and to bequest land to children. Even if the changes in behavior are not conscious in the modern sense of decision-making, it seems that the behavioral changes were motivated by external conditions that affected the economic welfare of families and their progeny.

This interpretation may be at odds with some versions of demographic transition theory, but the findings are consistent with other theoretical frameworks. Overall, our empirical findings correspond extremely well with Easterlin's bequest model. Thai parents in the early 1950s appear to have considered the availability of agricultural land one generation hence in their childbearing decisions. But a possible alternative explanation is Caldwell's (1989) wealth flows hypothesis, which is often invoked to explain fertility differentials. It follows from a wealth flows perspective that children may be particularly valuable to parents in frontier areas because of the labor they provide to parents; also, children may be more expensive to parents in more densely settled areas because of the costs of education. Both of these possible mechanisms should be

diminished substantially by our elimination of urbanized areas from the analysis, and by our control for modernization.

To further explore whether low levels of child education might inflate fertility in frontier areas, we employed a proxy measure of the extent of childhood education in each province: the proportion of 10-year-old children having 0 years of education. While there was substantial variation among provinces on this variable (3% - 17%), this measure of the extent of childhood education was not associated with either density or fertility.[23] A wealth flows perspective thus fails to adequately explain the fertility differentials found between Thailand's frontier and core rural areas.

We conclude with three caveats resulting from shortcomings in the historical data we employ. First, since we measure fertility indirectly by adjusting child/woman ratios, differential childhood mortality is a potential source of variation in our fertility measure. A related problem is possible differential undercounting of young children. It is quite likely that differential mortality and enumeration do exist among the rural provinces, but these processes almost certainly serve to make our estimates conservative rather than overstated. Childhood mortality and underenumeration are most likely higher in frontier areas than in long-established regions, so

[23] Our measure of the extent of childhood education was, however, associated with our marriage variables. For example, female singulate mean age at marriage is strongly negatively associated with our child education measure ($r = -0.49$; $p = 0.000$), indicating that provinces with high percentages of uneducated children also have early female marriage. However, inclusion of the childhood education variable in our multivariate models does not change the substantive interpretations.

We have been unable to locate data on possible wage differentials in rural Thailand during this era, but Feeny (1982, p 133) reports that rural wages for Phitsanulok (a sparsely settled province with one of the highest fertility rates during the early 1950s) and Angthong (a densely settled province with one of the lowest fertility rates during the early 1950s) were about the same during the early 1930s.

adjustments for these undercounts would probably make our reported differences in fertility even stronger. [24]

A second issue involves the extent to which parents were able to foresee future prospects for agricultural expansion. To the extent that increasing technology brings marginal land under cultivation, especially via irrigation, one might argue that parents may not be able to anticipate which areas will experience agricultural expansion during the subsequent generation. For example, there were several large dams built in Thailand during the 1960s and 1970s, which probably could not have been anticipated during the early 1950s. However, these large-scale projects were in areas peripheral to the Thai heartland where the major expansion took place.

Ultimately, the question of whether young Thai adults in the 1950s could anticipate the future availability of land is an empirical one. Our results, based upon multivariate analysis of national census and agricultural data, indicate that not only were they indeed able to do so, but that they were also able to adjust their fertility decisions accordingly. This conclusion is consistent with earlier studies that discount the potential role of unanticipated technological change. Ingram (1971), focusing on the period ending in the 1950s, has demonstrated that it was expanding cultivation and not technology that led to the increase in Thai rice production. This undoubtedly began to change somewhat during the 1960s, and although we recognize that farmers could not have been aware of future technological change, they apparently were able to predict which areas held promise for agricultural expansion, a key assumption of our model that is strongly supported by the empirical results.

[24] Lowering family size through infanticide in the core areas is improbable as a common response given the Buddhist context.

A third issue involves the difficulties of separating the effects of rural population pressure from the forces of modernization. One might ask: what were the migrants seeking by moving? The two most plausible alternatives appear to be that their aims were 1) to exploit available agricultural land at the frontier, and 2) to take advantage of occupational opportunities arising from modernization. While both phenomena were occurring in Thailand during this period, our thesis revolves around the first mechanism. We attempt to remove most of the effects of the second by omitting the Bangkok metropolitan area and a few other highly urbanized provinces from the analysis.[24] This solution is not entirely adequate since our provincial aggregations contain urban areas within them. Keyes (1976), in fact, argues that the primary response to population pressure in the Northeast was not migration to the frontier, since by the 1930s the remaining land had but marginal agricultural utility (see Ingram 1971 for an alternative view), but rather growth in nonagricultural employment.[25] And he is undoubtedly correct to some extent, given the substantial migration streams to Bangkok and some other urban areas.

This issue is also problematic in studies of the American frontier. Easterlin (1976) finds a strongly positive relationship between land availability and fertility in New York State during the early part of the 19th century, although Guest (1990) finds that by the mid-19th century, land availability had little relationship with fertility in this state; economic well-being, education, and Baptist religious affiliation were all inversely associated with various measures of fertility. By the mid-19th century, New York had little land available for agricultural expansion; the frontier had

[24] Omitting Bangkok proper removes 18% of the lifetime migrants in 1960 and 19% in 1970.

[25] Keyes does not completely discount the former mechanism, however, and reports that many individuals were migrating to land available in Udon (although some may have gone seeking work resulting from the increasing U.S. military presence there), Kalasin, and Khon Kaen in early 1960s, and Chiang Rai during the early 1970s.

been filled. It is at this point that forces of modernization are likely to take hold, and the general negative association between fertility and affluence will become apparent. We believe that this process was beginning in Thailand during the 1950s in areas where the frontier had already filled, especially in the densely settled areas around Bangkok. But it is very unlikely that during this era substantial opportunities existed for modern sector employment, especially for the Thai young adults living in the provinces we include in our analysis (see Table 1).

It is admittedly difficult to answer definitively the question of what the migrants did upon arrival at their destinations, since we do not have occupational data. However, since most of the migration during this period was rural-to-rural (especially in our subsample, since we omit Bangkok and some other urban areas), we conclude that most of them must have been engaged in farming. And since there was much expansion of land under cultivation in the areas of high in-migration, concurrent with relatively high fertility, we also conclude that much of the negative relationship between population density and fertility found in these rural provinces can be best explained using a frontier-effect paradigm.

This conclusion has important implications for classic demographic transition theory, as well as for theories emphasizing the innovation and diffusion of new ideas about fertility control. If married couples are able to adjust their childbearing outcomes to a given opportunity structure, assumptions about natural fertility regimes existing prior to the demographic transition must be reconsidered. Apparently Thai couples moving to the frontier were able to adjust their behavior in such a way that led to increased fertility, *vis B vis* the levels found in the sending core areas. Whether these behavioral changes involved conscious decisions about the frequency, timing, or nature of coital activity, we do not know. But whatever the mechanism was, the differentials

reported here belie the widely held assumption that prior to the advent of modern contraceptives, variations in family size were completely determined by traditional cultural norms about intermediate variables unrelated to fertility goals.

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Figure 1: Thailand and mainland Southeast Asia

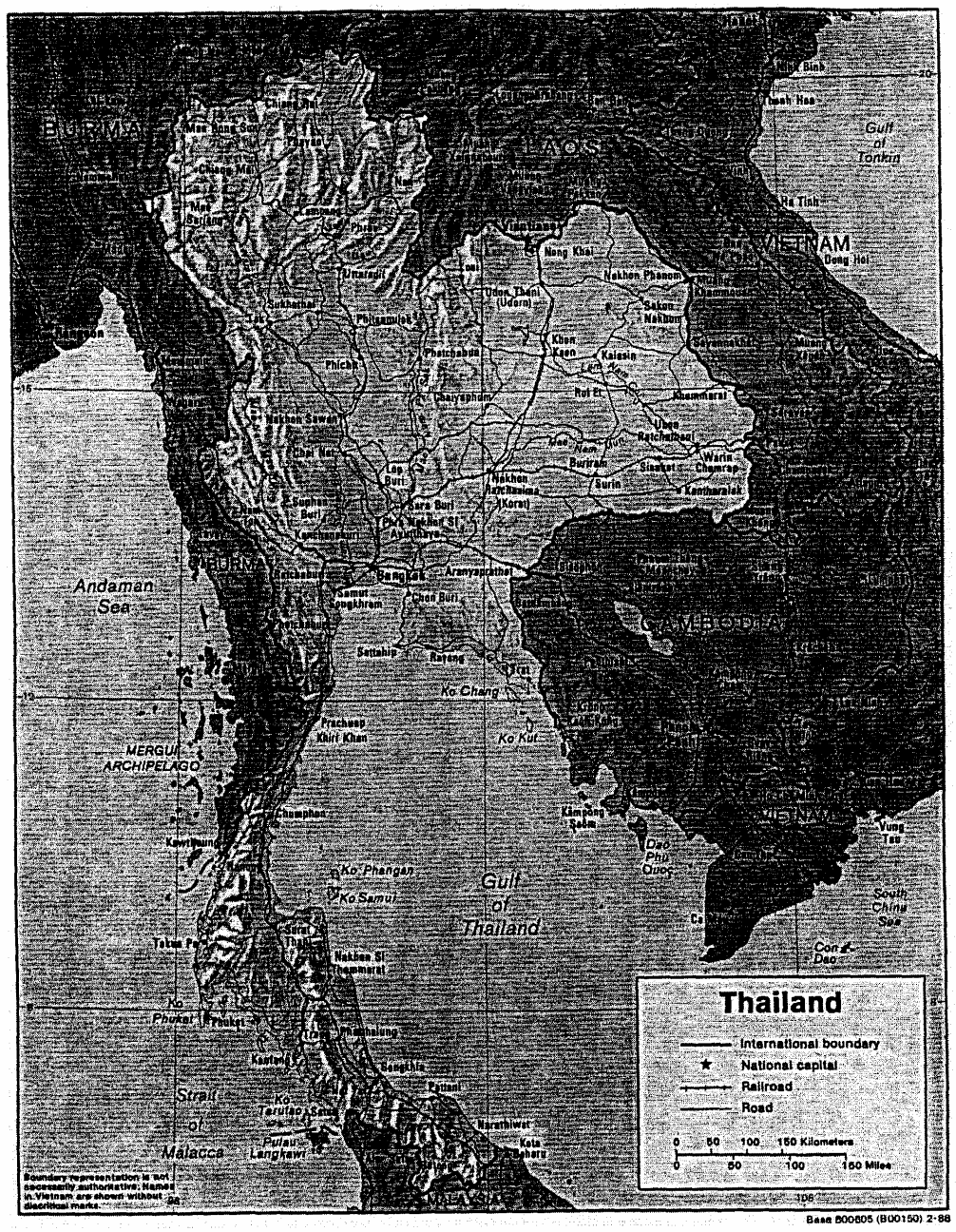


Figure 2: Hypothesized relationships

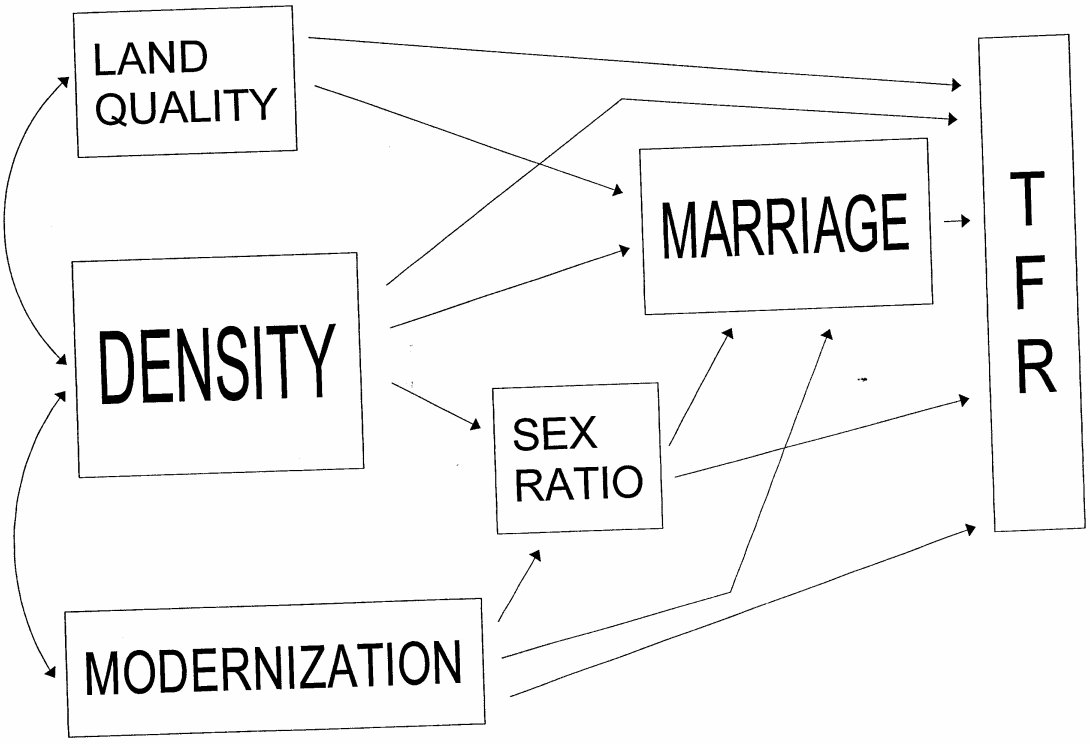
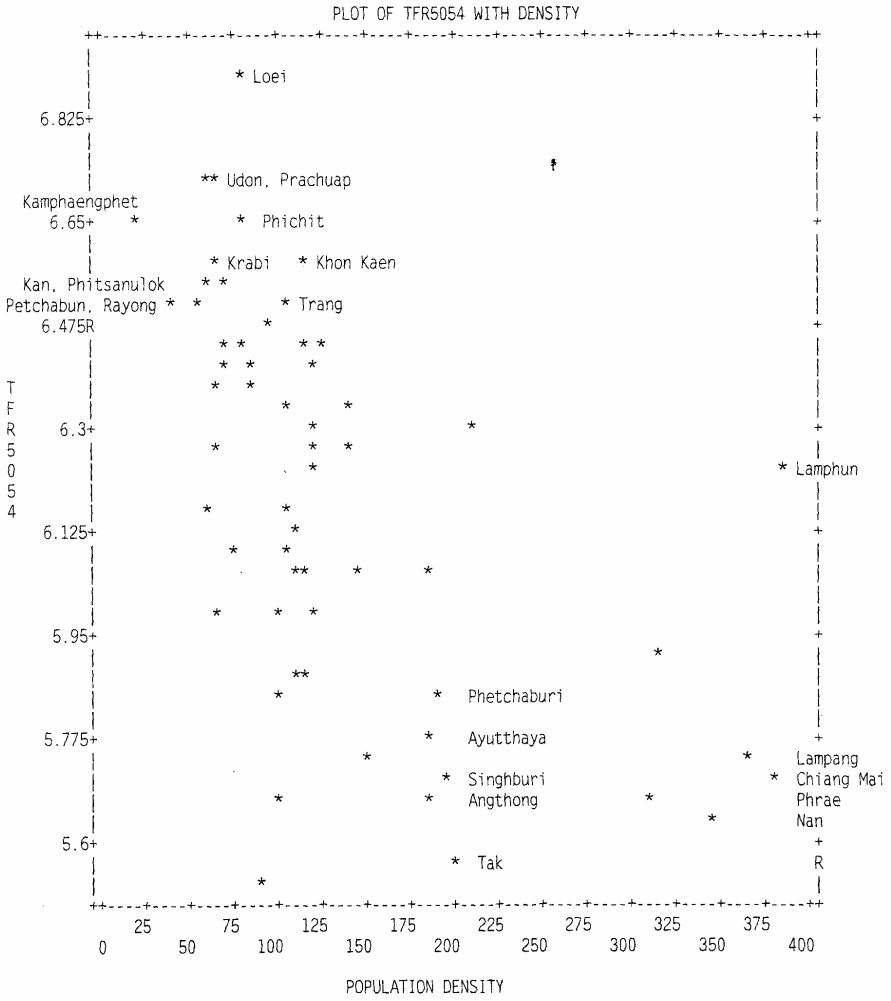


Figure 3: Bivariate plot of density and fertility



59 cases plotted. Regression statistics of TFR5054 on DENSITY:
Correlation -.56170 R Squared .31551 S.E. of Est .28406 2-tailed Sig. .0000

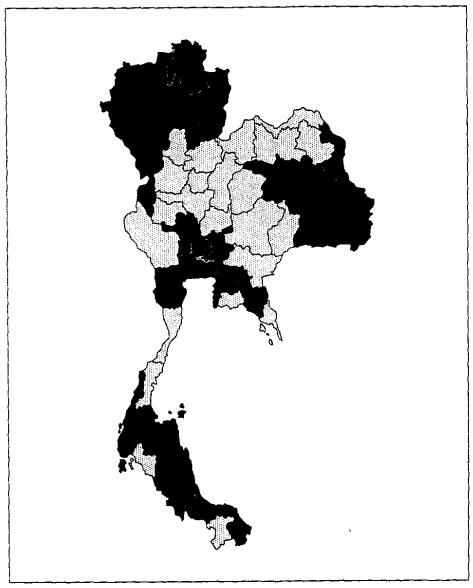


FIG 4: POPULATION DENSITY
Thailand: early 1950s

140 to 1438: high	(26)
97 to 139: moderate	(25)
21 to 96: low	(23)

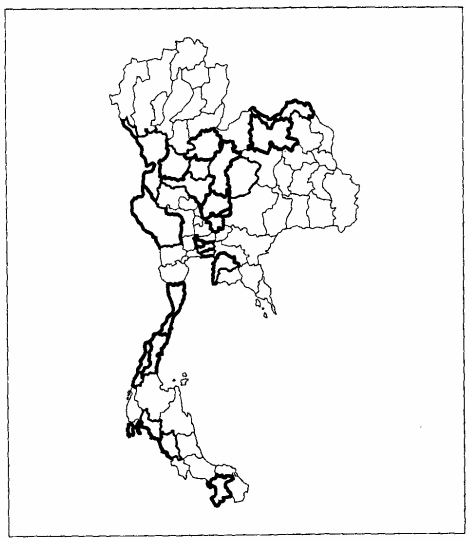


FIG 5: IN-MIGRATION
Thailand: late 1950s

0.031 to 0.115: high	(23)
0.001 to 0.0309: low to medium	(51)

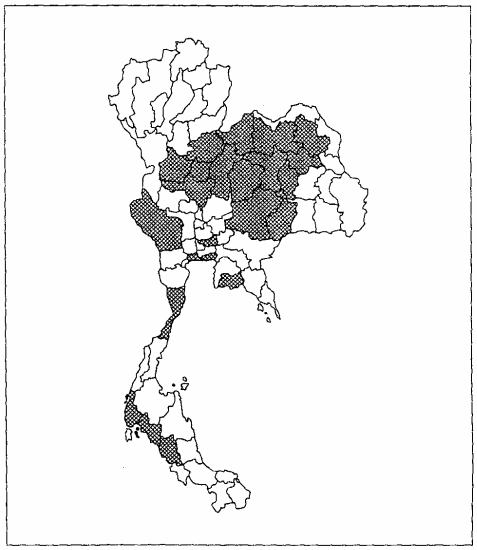


FIG 6: FERTILITY (TFR)
Thailand: early 1950s

6.4 - 6.9: high	(23)
4.8 - 6.4: low to medium	(51)

Table 1: Variables in the analysis

Variable	n = 71 mean	n = 59 mean	min val	max val
TFR 1950-54	6.1	6.2	5.5	6.9
POPULATION DENSITY	180	132	22	386
PROPORTION LIVING IN AG HOUSEHOLDS	76%	79%	54%	94%
LAND QUALITY	237	237	81	476
SEX RATIO OF YOUNG ADULTS	0.93	0.93	0.75	1.31
PROPORTION OF WOMEN MARRIED	76%	76%	69%	86%

NOTES:

TFR 1950-54 is a Rele estimation of the Total Fertility rate for the period 1950-54.
Source: 1960 Thai Census; UN 1993.
Population density is the 1947 population / the number of square km under cultivation in 1978.
Sources: 1947 Thai Census; Thailand National Statistical Office 1982.
Proportion living in agricultural households is the proportion of the population living in agricultural households in 1960. Source: 1960 Thai Census; Thailand Statistical Office 1963.
Land quality is the average number of kilos of rice produced per rai of land.
Source: Thailand National Statistical Office 1963.
Sex ratio of young adults is the number of men age 20-29 / the number of women age 15-24.
Source: 1960 Thai Census.
Proportion of women married is the proportion of women age 20-54 who are currently married in 1960.
Source: 1960 Thai Census.

TABLE 2: MULTIVARIATE MODELS

Table 2a: Probit models of proportions married

Predictor variables		PROPORTION OF WOMEN AGE 20-54 WHO ARE MARRIED MODEL 1	MODEL 2	MODEL 3
Log population density	b	-0.15	-0.20	-0.23
	b/se	-53.6	-63.9	-71.3
Log proportion living in agricultural households	b		0.16	0.58
	b/se		11.8	40.0
Log land quality	b		0.37	0.23
	b/se		90.2	51.3
Log sex ratio of young adults (men per woman)	b			1.33
	b/se			90.4
Significance of Pearson's goodness of fit chisquare statistic		0.000	0.000	0.000
(N)			(59)	

Table 2b: Linear regression models of total fertility rate, 1950-54

Predictor variables		TFR 1950-54 MODEL 4	MODEL 5	MODEL 6	MODEL 7
Population Density (*1000)	unstd b	-2.2	-2.1	-2.2	-1.2
	std beta	-0.56	-0.54	-0.55	-0.31
	p	0.0000	0.0000	0.0000	0.01
Proportion living in ag households	unstd b		0.46	0.72	-0.013
	std beta		0.12	0.20	-0.004
	p		0.29	0.12	0.98
Land quality	unstd b		0.00034	0.00016	-0.00054
	std beta		0.07	0.03	-0.11
	p		0.52	0.77	0.28
Sex ratio of young adults (men per woman)	unstd b			0.50	-0.54
	std beta			0.18	-0.19
	p			0.16	0.17
Proportion of women married (age 20-54)	unstd b				5.1
	std beta				0.60
	p				0.0001
Adjusted R squared		30%	30%	31%	48%
Significance of F test		0.000	0.000	0.000	0.000
(N)			(59)		

Notes:

The sample includes 59 of the 71 provinces existing in 1960. Excluded provinces are Bangkok, Thonburi, Samut Prakan, Samut Sakhorn, Phuket, Samut Songkram, Mae Hong Song, Kalasin, Narathiwat, Pattani, Satun, and Yala. Variable definitions and sources of data are reported in Table 1.

TABLE 3: DIRECT AND INDIRECT EFFECTS OF DENSITY ON FERTILITY

VARIABLE	TOTAL EFFECT	INDIRECT EFFECT VIA: Marriage	DIRECT EFFECT
POPULATION DENSITY	-0.56	-0.24	-0.31

Notes:

Displayed effects are standardized beta coefficients.

Appendix: Correlation matrix of the variables used in the analysis.

Correlations:	TFR	MARRIAGE	SEXRATIO	LANDQUAL	AG	DENSITY
TFR	1.0000					
MARRIAGE	.5737**	1.0000				
SEXRATIO	-.0218	.4472**	1.0000			
LANDQUAL	-.0249	.3181*	.2475	1.0000		
AG	.2778	.1736	-.4299**	-.0373	1.0000	
DENSITY	-.5617**	-.3158*	.2264	.1728	-.2912	1.0000

N of cases: 59 1-tailed Signif: * - .01 ** - .001

Variable Abbreviations (see Table 1 for definitions):

TFR: Total Fertility Rate 1950-54
MARRIAGE: Proportion of women married, ages 20-54
SEXRATIO: Sex ratio of young adults
LANDQUAL: Land quality
AG: Proportion living in agricultural households
DENSITY: Population density