

Departmental Meeting on 21 October 2008, M Umezaki

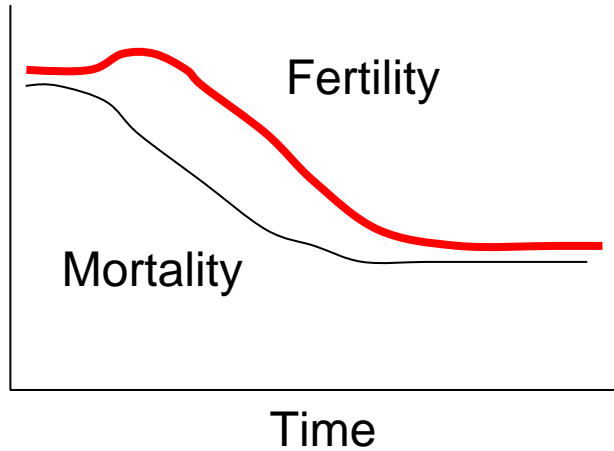
# The Effect of Labor-Saving Technology on Longitudinal Fertility Changes

**Karen L. Kramer and Garnett P. McMillan**

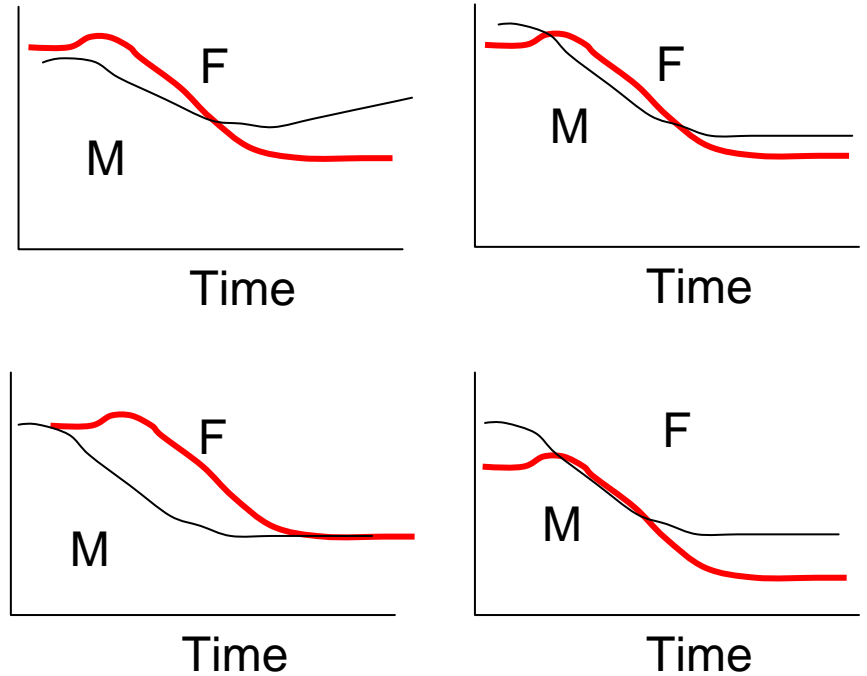
Department of Anthropology, Stony Brook University,  
Stony Brook, NY 11794-4364, U.S.A. (karen.kramer@  
sunysb.edu)/Behavioral Health Research Center of the  
Southwest, Albuquerque, NM 87102, U.S.A. (gmcmil-  
lan@bhrcs.org) 23 IX 05

**<Summary>** In many subsistence communities worldwide, labor-saving technologies such as mechanized water pumps and grain mills are introduced during the first stages of economic acculturation. These technological changes affect the efficiency with which resources are acquired and processed. If women can produce the same amount of a good in less time and if the time savings is reallocated to less energetically costly activities, the positive shift in women's energy balance can affect fertility in a number of ways. Reproductive histories collected over the past ten years show that since the introduction of labor-saving technology Xculoc Maya women begin childbearing at a significantly younger age and have a greater annual probability of giving birth and higher age-specific and completed fertility. Access to wage labor, education, and the market economy remains limited. When a change in labor efficiency takes place under these conditions, parents appear to reallocate the saved time to reproduction rather to production. Such conditions may have significant implications for the rapid population growth occurring in many small-scale societies during the early stage of economic acculturation.

# Process of “demographic transition” varies by community (population)



Demographic transition  
(National aggregate data)



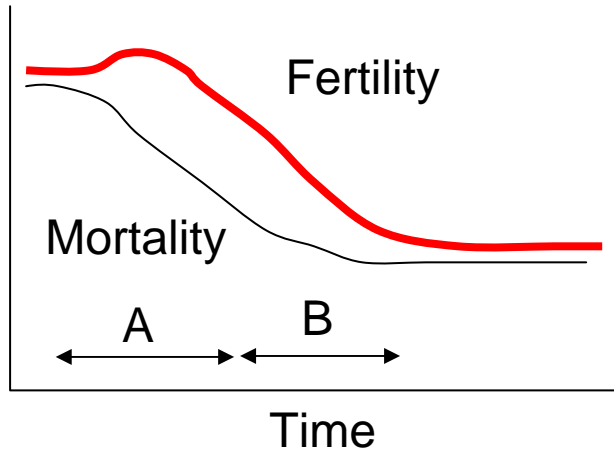
Different pictures in small-scale societies

- environment (physical, social, political)
- cultural norm
- biological back grounds

# The cause of fertility increase/decrease in demographic transition

---

## Two stages of demographic transition



Demographic transition

A: The earlier stage of transition

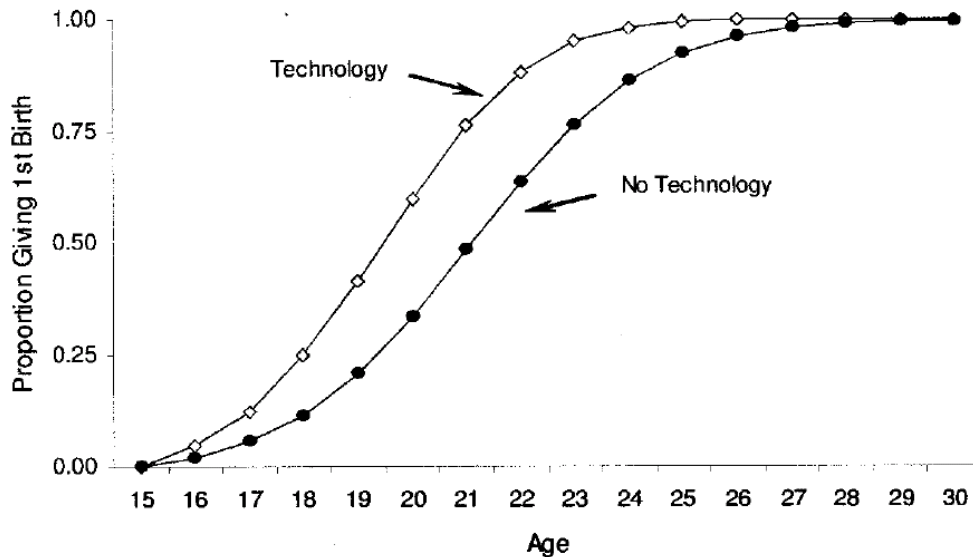
- change of the norms that suppressed fertility?
- improvement of nutritional status?
- 

B: The later stage of transition

- maternal education
  - transformation of the family system
  - introduction of contraceptive methods
- (e.g., Caldwell, 1976; Borgerhoff Mulder 1998)

# Labor-saving technology and reproduction among the Maya, Mexico

Subjects: the Maya of the Puuc region of the Yucatan Peninsula, Mexico



Introduction of labor-saving technology lowered the age at first birth (Kramer and McMillan, 1994; 1998, 1999)

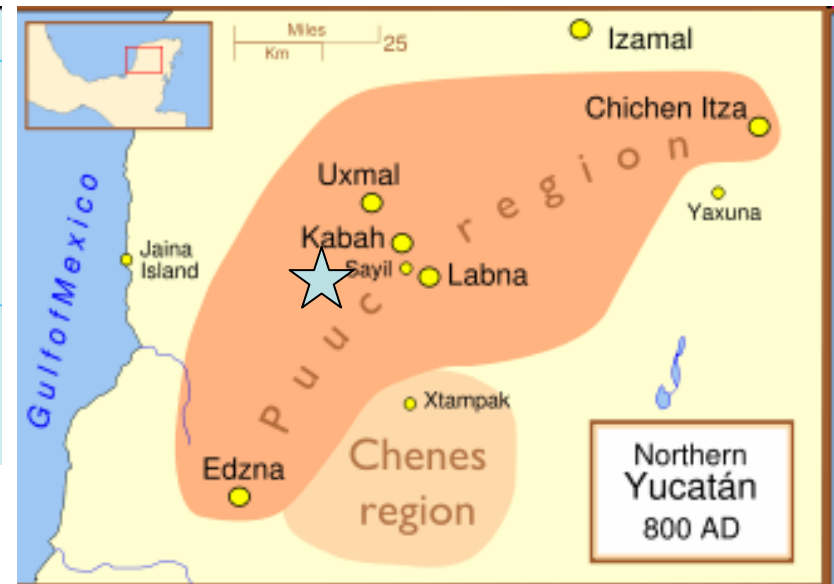
Hypothesis: Introduction of labor-saving technology increased the fertility



## The Population and Data Collection

–subsistence pattern and the extent of modernization

The Maya living in Xculoc (a small, remote village on the Yucatan Peninsula)



- Subsistence maize farmers
- In 1992-93, no electricity, running water, or motorized transportation
- **Maize mill, gas-powered water pump were introduced in the 1970s**
- Less opportunity of wage labor or market economy
  - 25% (of 52 HHs) men never participated in wage labor
  - Honey and maize for the exchange with oil, eggs, and candles

- Children stay in their parents' house until marriage (21.6 years of age for males, 18.7 years of age for females)
- Few cases of divorce
- Few widows or widowers in their reproductive age
- Of village residents over the age of 30, 8% of women and 9% of men were unmarried
- Natural fertility population (no access to contraceptive methods)
- 2-years of breast feeding

# Methods of demographic data collection

---

Study period: 1992-93, 2001, and 2003

Data: reproductive histories (60 mothers)

- In 1992-93 survey, of 284 births records for 57 living mothers, 12 died <16 yrs of age
- All children alive in 1992-93, only one died by 2001

Mortality was low, probably because of the availability of safe water (Fig 1), and adequate diet (Cotter, 2002)



Figure 1. Women drawing water from well, Xculoc, 1993.

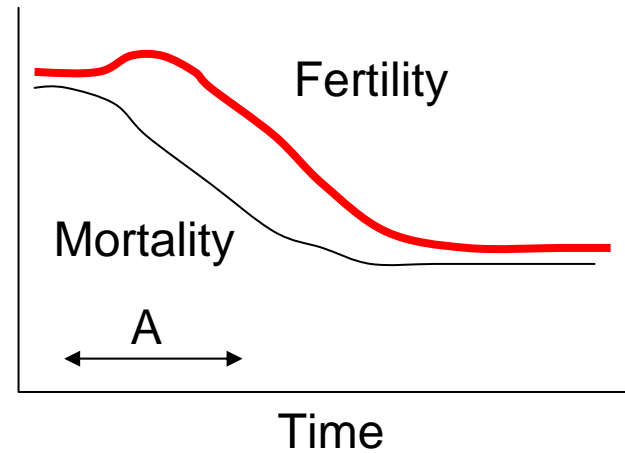


# Rapid population growth

---

Population size of the Xculoc:  
216 (1992-93) to 405 (2001),

Population increase rate  
= 3.1%/y



Demographic transition

Review: Energy availability is an underlying constraint to fertility and key to an understanding of variation in human reproductive function

---

**Energy availability**



**Fertility**

- **Heightened physical activity** and **weight loss** impaired reproductive function among female athletes (e.g., Cumming 1990; Ellison 1990; Rosetta 1993, 1995)
- **Increase in activity level** were associated with postpartum anovulation (Panter-Brick 1991; Panter-Brick and Ellison 1994)
- **Peaks in levels of subsistence labor** were associated with suppressed ovarian function even when not accompanied by negative energy balance (Jasienska and Ellison 1998, 2004)

## Review: the effect of shift in energy balance and fertility

---

**Shift in  
energy balance**



**Fertility**

- **Decrease in physical activity** was correlated with period of postpartum amenorrhea and birth interval among nutritionally stressed Ethiopian women (Gibson and mace 2002)
- **Difference in energy balance** appeared to be associated with the pace of sexual maturation (e.g., Ulijaszek 1995)
- **Preferential feeding** of pubescent girls was associated with the time to completion of sexual maturation (Gillett-Netting et al. 2004))

## Multivariate logistic regression analysis for Fig 2:

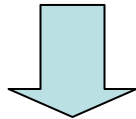
Y: beginning of reproduction in a given year (or not)

X: presence or absence (=ref) of the technology

mother's age at risk

year at risk (to measure for a general historical effect)

the interaction effects between them.



Best-fit-model:

Y: beginning of reproduction or not

X: presence or absence (=ref) of the technology (P=0.0220)

mother's age at risk

(mother's age at risk)<sup>2</sup>

ID	Y	age	Tec
1	0	16	0
1	0	17	1
1	1	18	1
2	0	16	0
2	1	17	0

# Improvement of energy efficiency in Xculoc and the impact

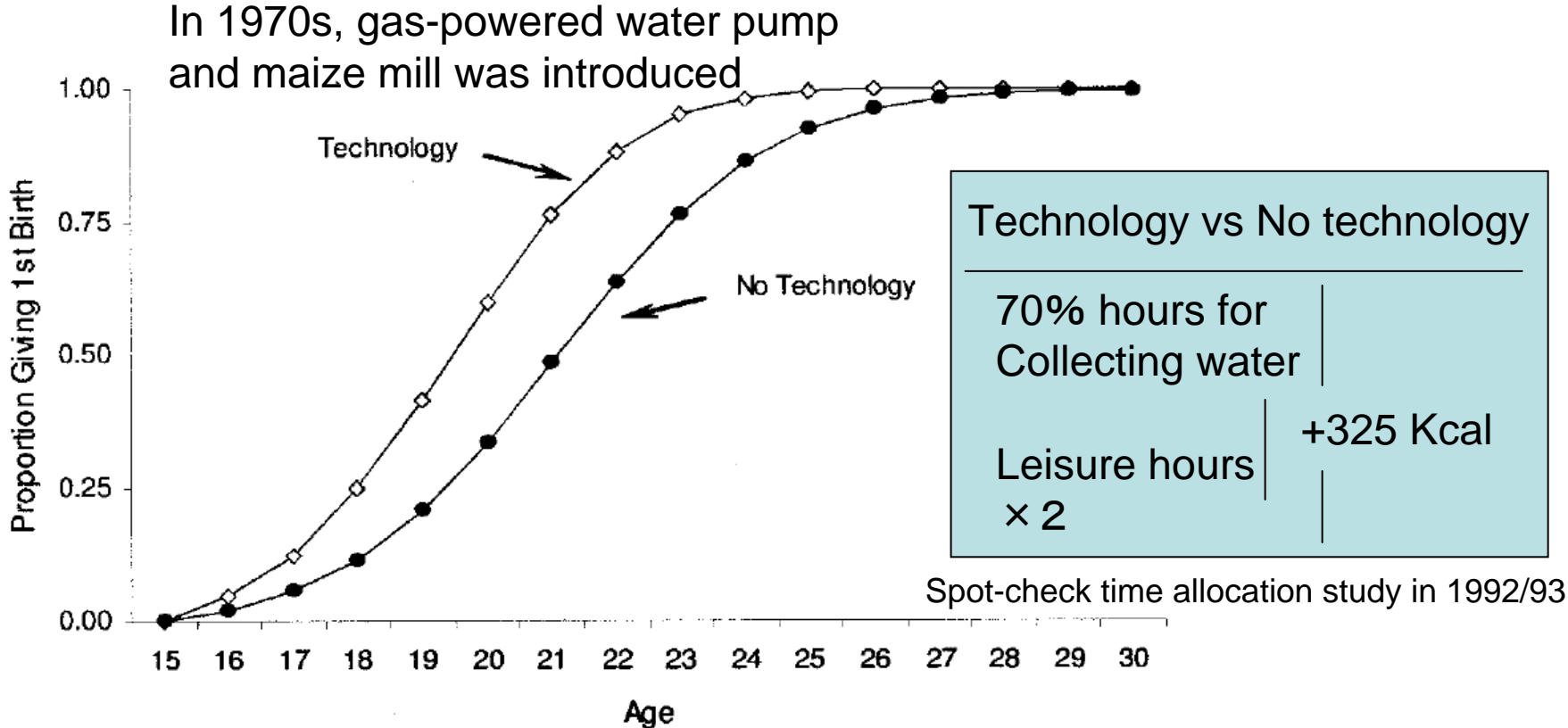
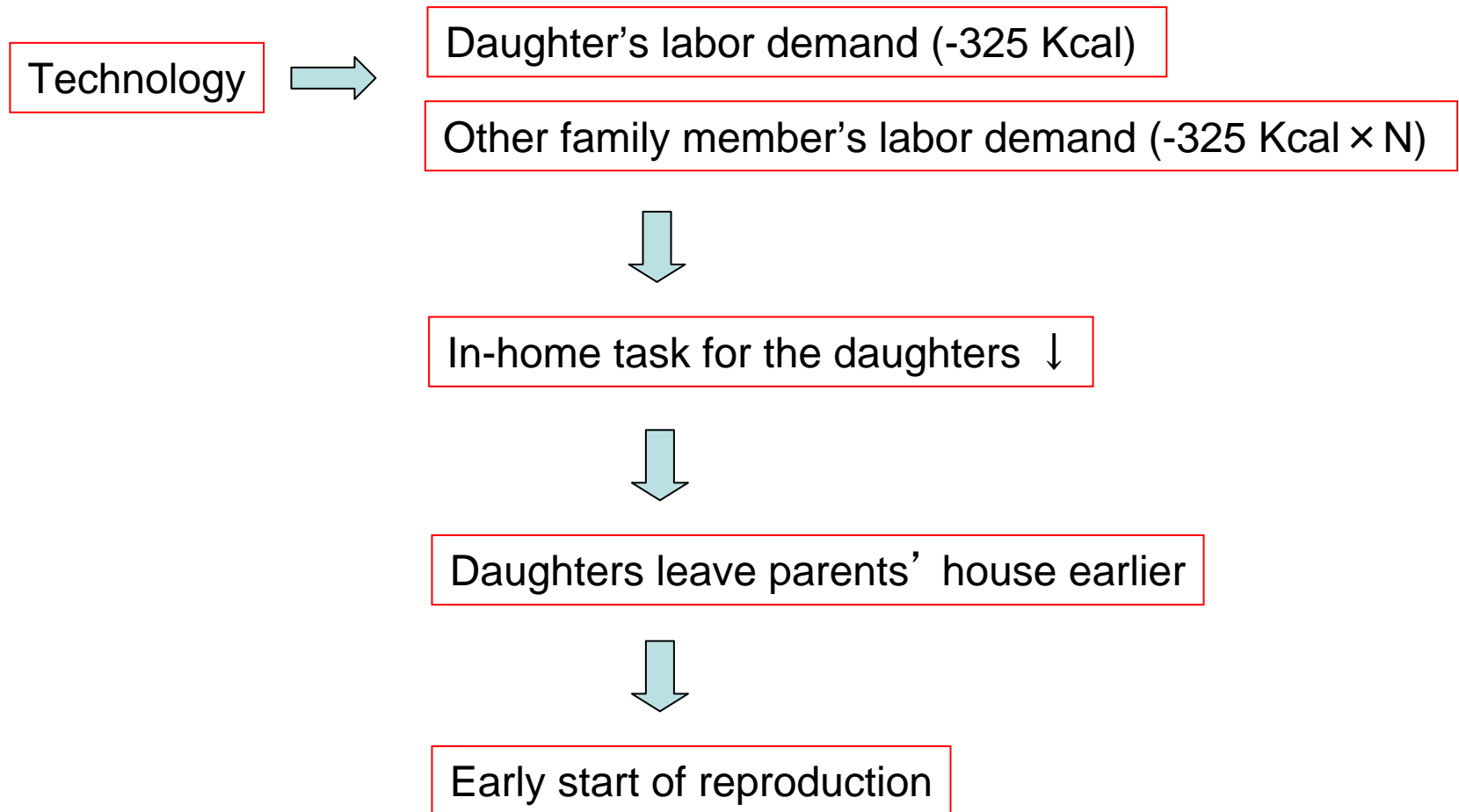


Figure 2. The fitted proportion of Xculoc Maya mothers ever having given birth ( $n = 50$ ), showing the median age at first birth at 0.5 probability and indicating, for example, that 25% of the women who started childbearing after the introduction of labor-saving technology had given birth to their first child by age 18 (after Kramer and McMillan 1999, 510).

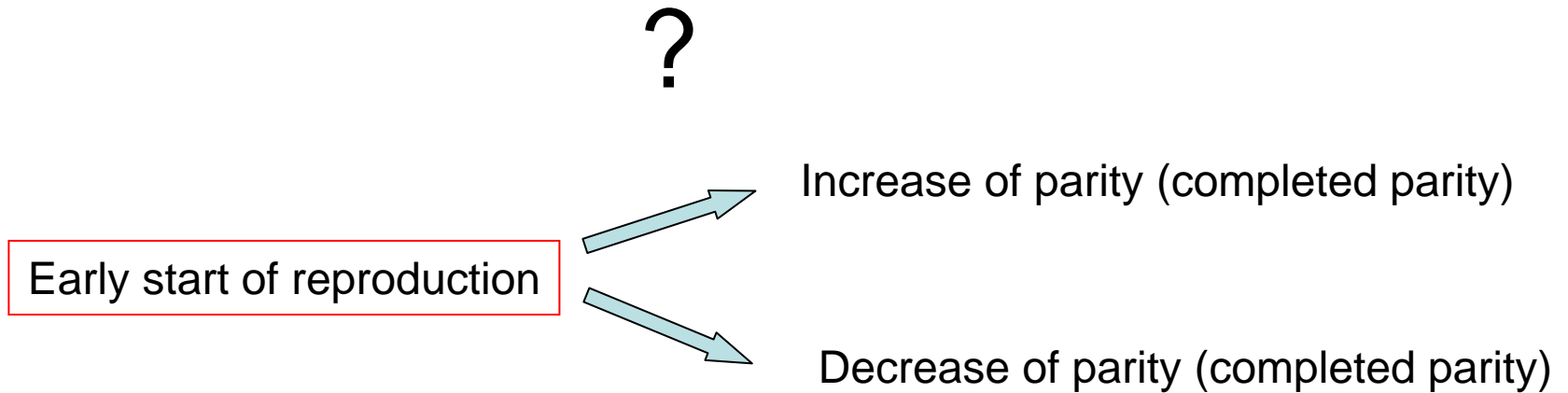
Interpretation: Technology made the daughters easy to leave their parents

---



Early start of reproduction will lead to the higher number of completed parity?

---

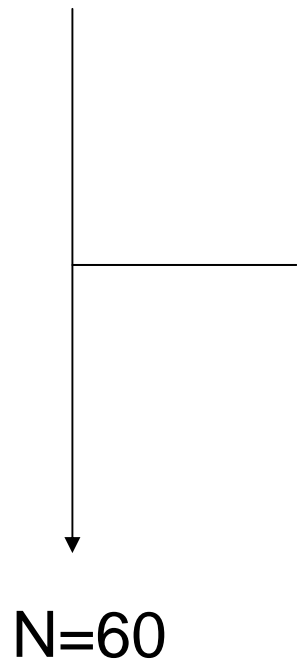


Investigation with the data collected in 2001 and 2003

## Characteristics of the subjects

---

Women who were alive and therefore interviewed in 1992,  
and had given birth to their first child after 1960



N=60

(1) Women who did not get married and (2) those who did not deliver a baby were not included.

(1) A women alive in 1960s, if she died in 1965 and had no relatives will not be counted in 1992

(2) The prevalence of sterility will not differ with respect to whether “technology” exist or not.

(3) Married women who did not give birth within 5-years (N=3) and those who gave birth to their last child before the age of 26 (N=4) were not included.

(4) Women who were interviewed in 1992 but had since emigrated were not included.



Major finding: Women who gave first birth after the introduction of labor-saving technology had higher fertility than their peers

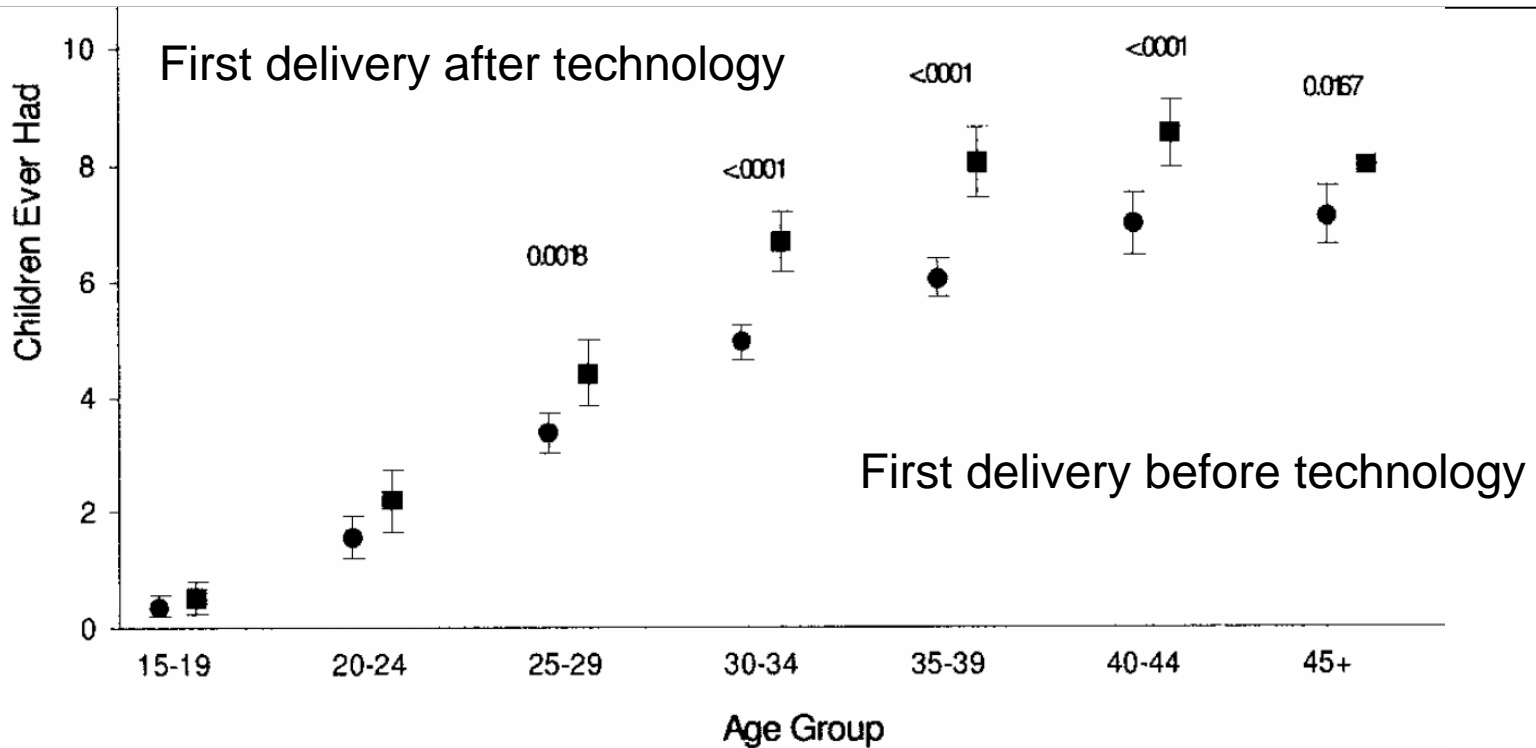


Figure 3. Age-specific fertility (mean, confidence interval, and  $p$  value) for children ever had for Xculoc Maya mothers stratified by first-birth cohort. *Circles*, before technology; *squares*, after technology. (The fertility of women over 45 in the after-technology cohort is slightly lower than for women in the 40–44-year age-group because two women in that group have 8–12 children. All the women in the 45+ age-group have 8 children.)

## Multivariate logistic regression analysis for Table 1

Y: Giving birth or not                      N=1289 person-years, 60 mothers

X: presence or absence (=ref) of the technology  
mother's age at risk  
year at risk (to measure for a general historical effect)  
first birth cohort (by 10-years)  
the interaction effects between them.

+ within-mother covariance structure (mixed model)  
(cf. Fitzmaurice et al. 2004)

Mothers who gave the first birth after the labor-saving technology gave more births than the mothers who gave the first birth before the labor-saving technology,

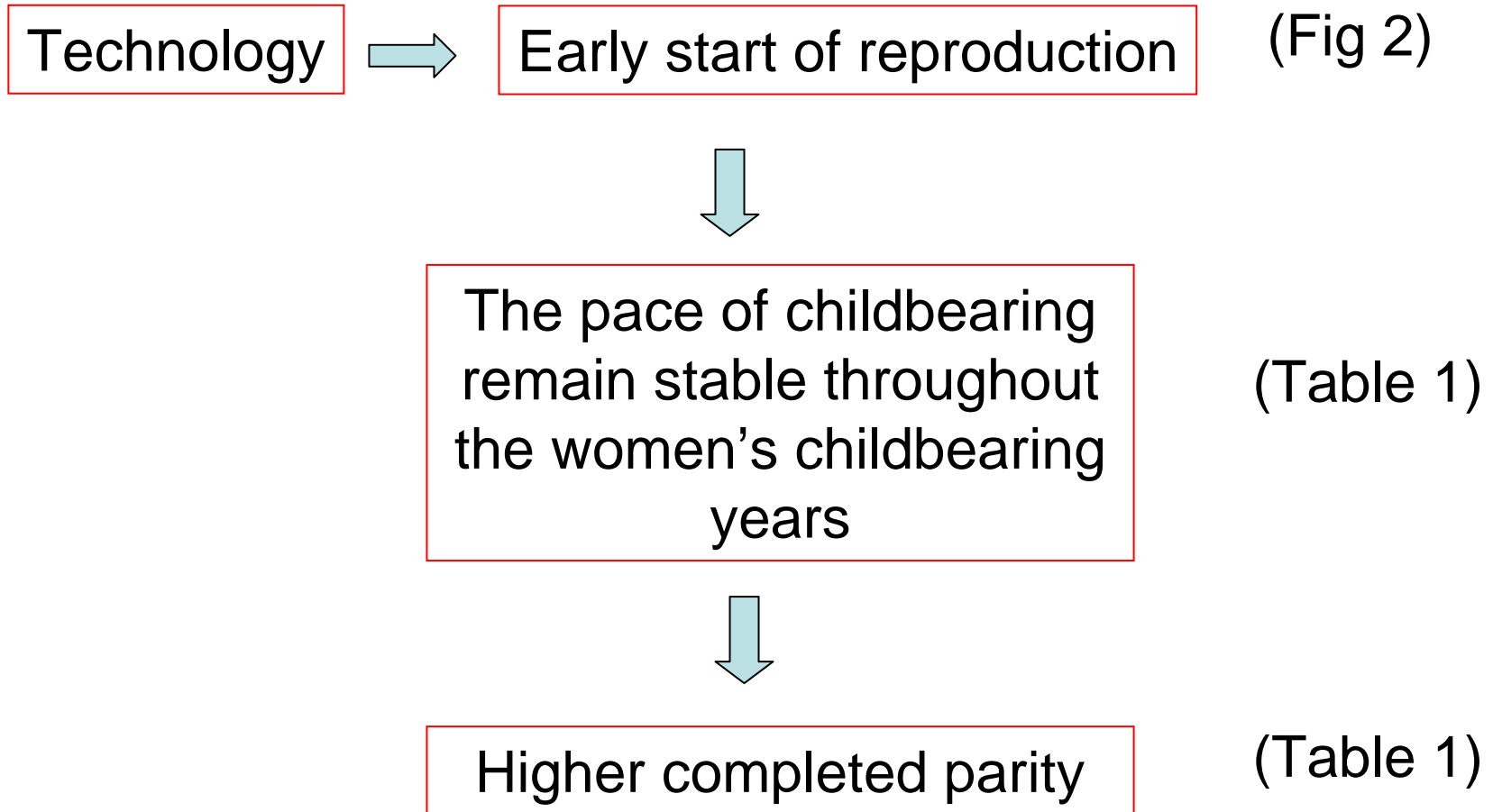
Table 1. Results of the Best-Fit Model for the Annual Probability of a Xculoc Maya Mother's Giving Birth

Variable	Parameter Estimate	<i>p</i>
Intercept	-0.4003	.0035
Age effect	0.0639	< .0001
Age <sup>2</sup> effect	-0.0011	< .0001
Year-at-risk effect	0.0074	.0021
Age/technology interaction	-0.0144	.0004
Presence/absence of technology	0.3672	.0005
Cohort	-0.1035	< .0001

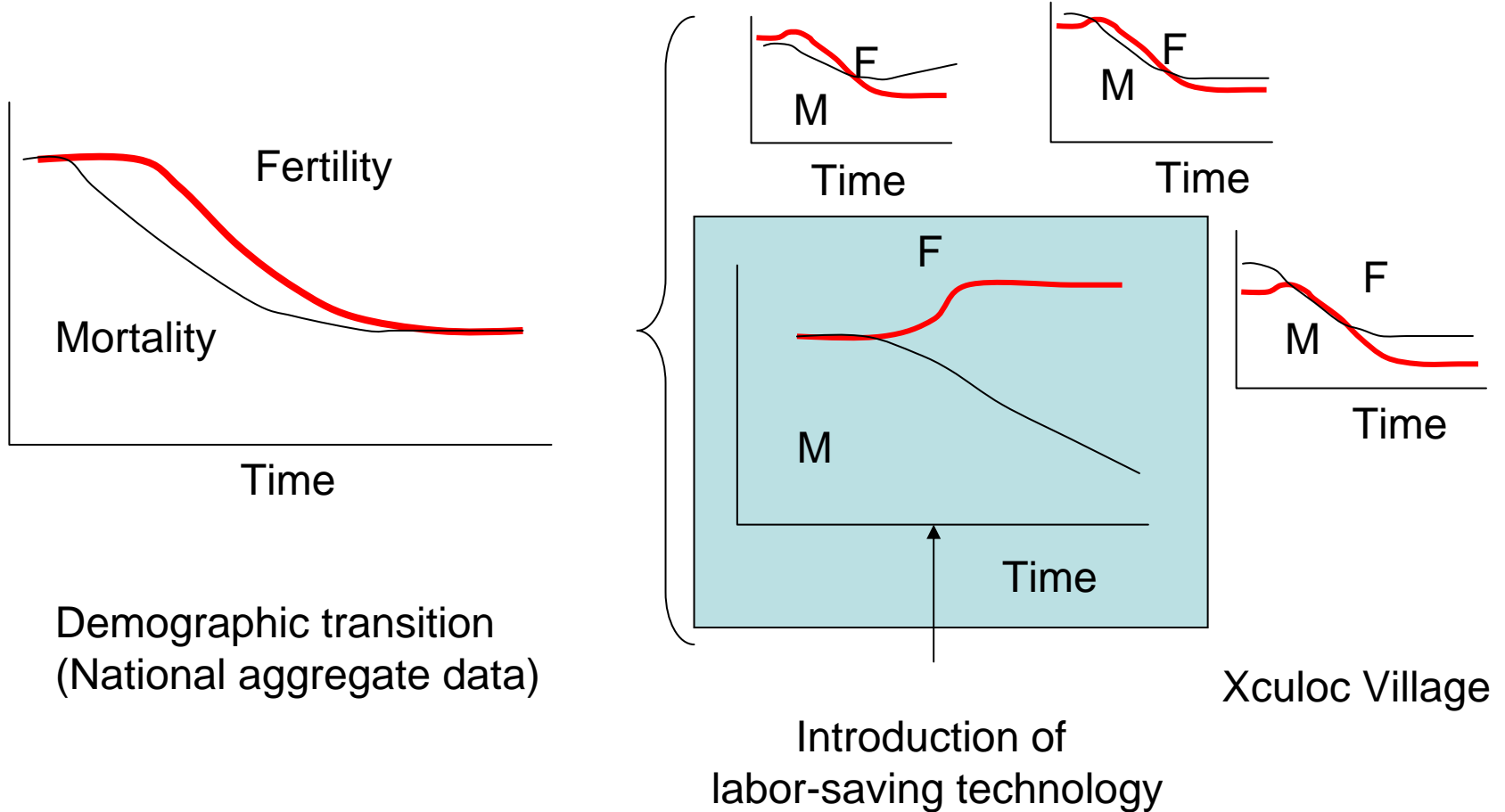
$$OR = \exp(\text{parameter}) = \exp^{0.3672} = 1.44$$

# Summary

---

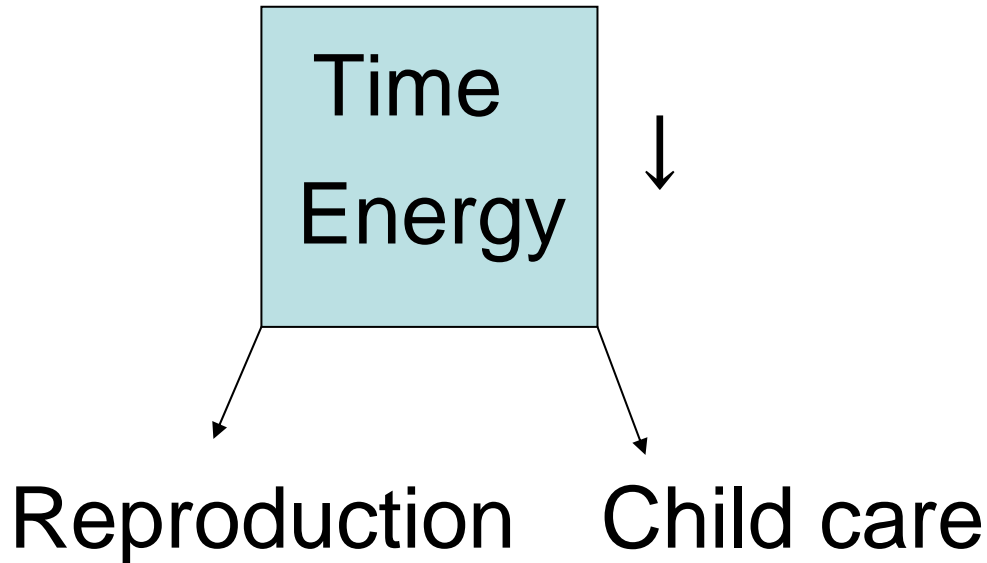


# Fertility increased during the initial stage of demographic transition: A case among the Maya of Xculoc



Nation > community (population) > individual

“Quality/Quantity trade-off” theory



- Number of children ?  
 -subsistence economy society
- Quality of each children ?  
 -market-oriented society  
 -industrialized society  
 -society that lacked the basic health care

Xculoc

- basic health care ○
- wage labor, cash economy ×

Labor-saving technology

↓

Early start of reproduction

↓

Increase of fertility

↓

Rapid population increase

## Conclusion

When a change in labor efficiency takes place in the society where access to wage labor, education, and the market economy remains limited conditions, parents appear to reallocate the saved time to reproduction rather to production. Such conditions may have significant implications for the rapid population growth occurring in many small-scale societies during the early stage of economic acculturation.

## Points

-Nation > community (population) > individual  
 Community (population) as a suitable unit of analysis

-Real pictures of demographic transition  
 Economic level, educational level?

- introduction of labor-saving technology
- change in nutritional status
- change in cultural norm
- change in family formation
- .....

