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**SEASONAL PATTERNS IN BEHAVIORAL ECONOMICS: SEASON AS
ENDOGENOUS IN THE ECONOMIC MODEL OF THE CHILDBEARING
DECISION**

by

HADASSAH BALSAM LUWISH

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment
of the requirements for the degree of Doctor of Philosophy, The City University of New
York

1996

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Abstract

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by

HADASSAH BALSAM LUWISH

Advisor: Professor Michael Grossman

The current study looks at conceptions with three different destinies: those that will end up as legitimate births, those that will end up as illegitimate births, and those that will end up aborted. These three behavioral categories of conceptions are examined from an economic/social perspective to determine their dependence on seasonal economic and social factors such as month of year, unemployment rate, and weather and climate variables. The optimal temperature for conception is found to be between 50 and 62 degrees Fahrenheit. The seasonal pattern is found to be the same in the United States and in Canada, allowing for their differing climates. Europe, as in previous studies, is seen to have a different pattern.

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All errors in the following investigation are my own.

Table of Contents

	Page
Title Page	I
Approval Page	II
Abstract	III
Acknowledgments	IV
Table of Contents	V
List of Tables	VI
List of Charts (figures)	VII
Body of Text	
Introduction	1
Part I: Graphical Analysis	16
Part II: Regression Analysis	23
Conclusion	44
Appendix 1: Figures	45
Bibliography	55

List of Tables

	Page
Table 1: Definitions of Independent Variables	23
Table 2: Definitions of Dependent Variables	28
Table 3: Conception Regressions, States, 1982-1990	33

List of Charts (Figures)

	Page
Fig. 1. Marriage pattern in Canada and in the United States	45
Fig. 2. Normal monthly temperature and conceptions implied by live births in 4 regions of the US, 1982-1990.	45
Fig. 3. Average US temperature by year.	46
Fig. 4. Per-woman conception index, US, by month, average over 9 years.	46
Fig. 5. American and Canadian conception patterns in current study and existing literature.	47
Fig. 6. The European conception pattern, for legitimate and illegitimate live births.	48
Fig. 7. Conceptions implied by induced abortions and by illegitimate births, 82-93, US States as available.	49
Fig. 8. Variation in the North American conception pattern from lowest to highest regions, 1982-1990.	50
Fig. 9. Monthly aggregate conception rate implied by all live births, standardized, U.S., 1982-1990.	51
Fig. 10. Annual patterns of per-capita conceptions, Canada, 1982-1990.	52
Fig. 11. Variation in temperature and fertility rates, by year, 1982-1990.	53
Fig. 12. Effect of monthly average temperature on conceptions that result in all live births, US, 1982-1990.	54
Fig. 13. Effect of monthly average temperature on conceptions that result in legitimate births, 31 US States, 1982-1990.	54
Fig. 14. Effect of monthly average temperature on conceptions implied by abortions assuming a 2-month average gestation, 20 US States, 1982-1990.	54
Fig. 15. Effect of monthly average temperature on "unplanned" conceptions (that result in abortion or illegitimate birth), 20 US States, 1982-1990.	54
Fig. 16. Effect of monthly average temperature on conceptions that result in illegitimate births, 31 US States, 1982-1990.	54

Introduction: The Psychological vs. the Economic Approach to Human Motivation

“Is there any way to predict what he’ll do next?”
“It’s what shrinks do worst,” Susan said. “We’re pretty good at explaining human behavior but we’re an embarrassment at predicting it.”
- from *Crimson Joy* by Robert Parker

Science has been defined as “knowledge covering general truths or the operation of general laws”. Various branches of scientific endeavor focus on truths about different aspects of the world around us. Botany, for example, focuses on the operation of plants; marine biology, on living creatures of the ocean. Economics and psychology both attempt to understand human behavior.

Two levels can be distinguished in scientific understanding: predictive and non-predictive understanding. Non-predictive understanding allows ad-hoc explanation why A occurred. It limits its scope of understanding by not attempting to explain why B did not occur, or C, or D, ad infinitum, taking into account all possible alternate courses of behavior. Thus, non-predictive explanation allows us to state that behavior A increased the person’s gross utility, but does not allow us to state that it increased his net utility, i.e. was the optimal behavior he could have chosen. It does not, therefore, allow prediction of what he will do.

Since psychology and economics both try to understand human behavior, what is the difference between their approaches? Psychologists model human behavior as depending on “irrational” and highly variable determinants such as childhood experiences, past reinforcements, insecurities, etc. (Simon, 1986). Since such determinants are often completely or partially unobservable to the psychologist before

the fact, his understanding is often after the fact rather than predictive. I.e. it is difficult for a psychologist to predict which patient will commit suicide, but easy to explain why a given patient was a suicide risk. Economists model human behavior as forward-looking, aimed toward a rational “optimization” goal, abstracting from irrational and individualistic motivations. Thus, economic theories lend themselves more than psychological ones to the prediction and setting up of testable hypotheses. The rub, however, is that economics doesn’t utilize all available information; the economic practitioner disdains to delve into the individual, irrational biases that led to a given observed human behavior, and this limits the “fit” of economic models.

Behavioral Economics

An attempt to merge psychological and economic insights, “behavioral economics”, attempts to include the most readily generalizable and observable biases and influences into the optimization model. To the extent that these biases have effects and are known in advance, the “assumptive realism” of economic theory (Gilad et. al, 1984) can be improved by including them in the model. Behavioral economics attempts to create economic models that recognize that economic man, notwithstanding the convention of reducing his motivations and thought processes to a series of mathematical equations, is not a computer. Behavioral economics argues that by including the insights of psychology into the systematic irrationalities of human existence, rather than modeling the human mind as a computer, the discipline of economics can increase its predictive ability.

For example, one observable influence of behavior which is not included in the standard economic model is the gender of the person under study. If females and

males differ from a psychological viewpoint and face different social influences, and hence behave in predictably different ways given the same economic incentives, then taking this into consideration can improve economic modeling. Thus, Dalton and Marcis (1987) take a behavioral economic perspective when, in studying determinants of job satisfaction among young adults, they take into account that males and females may value different job characteristics differently.

Another (potential) systematic influence on behavior is when the behavior is taking place, or season. Recent work in psychology focusing on the traumatic effect of season on the small segment of the population who suffer from “Seasonal Affective Disorder” has led to increasing recognition that season exerts potentially fundamental influences on the behavior of the entire population. Unlike many psychological constructs, seasonality is not ignored in the standard economic model, but is rather specifically addressed and removed as an influence to isolate the effect of more “interesting” motivators of behavior. Seasonal effects are thus made “exogenous” to standard economic models, and considered devoid of scientific interest. The current study attempts to introduce season into the prediction of the economic demographic biological/psychological/economic decision to bear children.

In introducing the effect of environmental (season and climate) variables on childbearing behavior into a standard model of (“rational”) determinants of the decision to have children (e.g. economic conditions), the occurrence of marriage, and social conventions, the present “behavioral-economic” investigation attempts to improve the fit of an economic model of childbearing by including more of the available information. In doing so, it unites the literatures of two disciplines: a small literature in the field of

economics investigating the decision of the timing of children (Ward and Butz, 1980), and a large literature in the field of demography on the seasonality of human births.

The Demographic Literature on the Seasonal Pattern of Conception

The seasonal pattern of births (and conception, regarded as nine months previous) has been examined for numerous countries in numerous time periods and has always shown significant seasonality, i.e. systematic differences from rectilinearity. The pattern of conception found tends to be quite consistent in a given location for a block of successive years, but is then often modified to another pattern which stays for another block of time (Cowgill, 1964). Conceptions, thus, do not occur randomly around the year, but are determined differentially by causal factors related to season that prevail in each location/time period.

Although the literature is large and has been going on for decades, these causal factors have been difficult to model successfully and to identify with a degree of success that would allow extrapolation of the conception pattern to another location and time period. Some causes that have been suggested for the seasonality of conceptions are the seasonality of social conventions such as the seasonal pattern of marriages or of vacations and holidays, and the seasonality of weather and its biological effects on fertility, called "biometeorological control". Intuition tells us that all of these causal factors suggested certainly influence conception patterns, in individual cases; and yet the literature demonstrate that none of them work well alone as predictors of the significant overall conception pattern. The theory in its present development is convincing at after-the-fact explanation of seasonal conception [as based on a

combination of these determinants (and perhaps others)], but is not extendible to the true understanding represented by before-the-fact prediction.

Marriages

The literature demonstrates resoundingly that the seasonality of marriages is not the major determinant of the seasonality of conceptions. There are three major pieces of evidence against the pattern of marriages as determining the pattern of conceptions. Firstly, the birth distribution of illegitimate children (whose parents were not married) in a given location and time period is the same as the birth distribution of legitimate children whose parents were married. (Kevan, 1979) Even aborted fetuses have been shown to have the same implied monthly variation in conceptions that would be predicted from women delivering both legitimate and illegitimate children (Cohen and Bracken, 1977). Secondly, the seasonal pattern of first births, to which the seasonality of marriage would presumably be most strongly related, is (Kevan, 1979) found to be most the same as the seasonal pattern of subsequent births. (Becker, 1981 and Mathers & Harris, 1983) Even first births have not been found to be related to month of marriage in a systematic way, but have significant percentages spread out across the first two years of marriage; this relationship is confounded by the fact that a substantial proportion of brides are pregnant at the time of marriage (Erhardt, Carl L. et al., 1971) Thirdly, nations with similar seasonal patterns of marriages (e.g. Canada and the U.S.) have radically differing seasonal patterns of births (figure 1, marriage pattern in Canada and in the United States).

Although the seasonal pattern of marriage does not explain the pattern of conception, married state does influence the seasonality of births, as the seasonal pattern of illegitimate and legitimate births are not identical. The amplitudes of rhythms based on legitimate births are usually lower than those based on illegitimate births (Roenneberg and Aschoff, 1990). Thus, marriage and/or family planning moderate rather than determining the observed conception pattern.

Holidays

The second hypothesized determinant of the conception pattern, holidays, has been tested in the literature by examining conception patterns and comparing them to vacation and holiday patterns. The consistent pattern of December as a high conception month across industrialized nations in both the northern and southern hemispheres--the United States conception peak is in December, and Canada and Britain have minor peaks in December—is credible evidence that this “holiday effect” is operating. The argument is that during periods of celebration people become more relaxed and have more time for recreation, and they have more time for sexual behavior and fertility rises. (Kevan, 1979) Sexual activity does seem to respond to free-time; the extreme example of the peak in babies nine months after a blackout in New York City in 1955 demonstrated (Low, 1956). In Britain, contraceptive sales peak in the summer (James, 1971), and conceptions do also. However, in the United States conceptions trough in the summer, showing that this “holiday effect” may not extend to all vacation time, and in any case is not a comprehensive explanation of conception patterns.

Biometeorology

Biometeorological determination of conception patterns is the effect of climate variables on human conception patterns. Seasonal climate affects conception patterns, potentially, through the exertion of both biological and behavioral effects. Biological effects on human biological fertility are based on the animal model of a reproductive season. Behavioral effects may occur when the weather or climate affects human activities in a way that changes the amount of sexual activity and hence exerts an indirect effect on conceptions. For example, hot, sunny “beach” weather may cause socializing; snow may send people out to the ski slopes in a skiing town; activity-reducing weather such as rain may pin people indoors and lead to increased or reduced sexual activity.

Biometeorological causation of the seasonality of conceptions implies that nations with similar climates will have similar seasonal conception patterns, and that nations in the southern hemisphere will have conception patterns shifted by 6 months from those of the northern hemisphere, as their seasons are (Erhardt, 1971) The first testable implication fails, i.e. the conception patterns of nations with similar climates differ significantly. Most egregiously, in the U.S. conceptions rise from the summer until December, peaking in December, while in Europe, with similar climates, conceptions fall from the summer until December where for just the month of December alone they have a minor (holiday) peak (see figures 5 and 6). Thus, in Europe, conceptions are above average in the late spring and early summer, and in the U.S., in late fall and early winter. A large number of countries, some exposed to U.S.

culture and some not, have changed in the post-war era from resembling the European pattern toward a greater resemblance with the US pattern (e.g. Puerto Rico; Roenneberg and Aschoff, 1990). This large difference between North American conception rhythms and those of the rest of the world, which cannot be explained by climate, forced Cowgill (1966) to the conclusion that although conception patterns in general stem from many contributing causes, in North America, conception rhythms are primarily controlled by social factors, whereas elsewhere, the rhythms are most correlated with environmental factors. Biometeorological effects on conception patterns are evidenced in Europe by the reversal of the European conception pattern in the southern hemisphere (New Zealand, Australia, South Africa) (Parkes, 1976), and evidence themselves (though perhaps secondarily) in North America by the systematic change in conception peaks and troughs as one moves north-south in North America (Huntington, 1938). As one moves north-south within the US, national factors are held constant while climate changes predictably (see figure 2 (top), normal monthly temperature in 4 regions of the US). In different states of the United States, although conceptions are peaking at differing months of the year, conceptions systematically show a peak during months when temperatures are between 5° C (41° F) and 20° C (68° F) (Roenneberg and Aschoff, 1990). Around the U.S. States, then, conception should peak in whatever time of the year experiences this temperature range, e.g. autumn and spring in temperate climates, winter in a hot climate, summer in a cold climate. Conception should trough in whatever time of year is least temperate e.g. major conception trough from summer in temperate climates and minor trough from winter, summer in a hot climate, winter in a cold climate. Huntington (1938) verified

that the summer changes from the conception peak to the conception trough as you move downward in eastern North America, which is implied by biometeorological causation since the summer in the north is the temperate time of year, but the spring and fall are in central North America, and the winter is in the hot south. In Quebec and Maine conceptions are most numerous in June, July, August and September; in Connecticut there is a slight decline in July; in New Jersey this is more pronounced and lasts through August; North Carolina exhibits a minimum of conceptions from July through September; and in Florida conceptions trough tremendously in this same period. Huntington concludes, "If there were no complications due to migrations and other cultural factors, the month of maximum conceptions would have almost the same temperature everywhere...", which he considers to be approximately 67° F. He also notes that although extreme cold and great heat are both detrimental to reproduction, the detrimental effect of heat extremes is much worse, a phenomenon which is also evident from Roenneberg and Aschoff's 41°F to 68°F optimum, a rather cool range of temperature.

As has been noted, climate effects may also operate behaviorally. In the present study, explanatory variables include temperature, which has been identified as the critical climate variable in biometeorological determination, as well as measures of behavior and activity-limiting weather such as precipitation, sky cover, clear days, and sunshine.

Behavioral theories of seasonal birth patterns operate by affecting seasonal patterns of unprotected sexual activity, and biometeorological theories by affecting the "conception hazard" for given a certain amount of unprotected sexual activity. Studies

in the demographic literature have attempted to elicit whether there is a seasonal pattern to sexual activity in three ways: by surveying people or examining diaries, from seasonal patterns of sales of birth control, or from seasonal patterns of sexually transmitted diseases. One study in which married couples kept diaries of their sexual relationship (Udry and Morris, 1967) found June-July peaks and late August and early February troughs in coital activity. When these patterns of sexual activity and U.S. conception patterns for similar demographic-group populations were compared, however, no relation was found. Further, since the conception patterns of married and unmarried couples are the same, having shown that sexual activity is not determining conceptions for these married couples implies that it cannot be determining conceptions in general. A look at sales of contraceptives in Britain showed that they peak in July and trough in February, and conceptions peak in June (James, 1971) and trough in February. Thus, no significant correspondence is observed. In New York City, the incidence of sexually transmitted diseases combined with estimates of their inception points to increased sexual activity in the winter (personal communication, NYC Dept. of Health).

Fetal Loss

The standard assumption in the demographic literature on the seasonality of births is that they reflect an underlying seasonal pattern of conception. Alternatively, (Roenneberg and Aschoff, 1990) the number of conceptions could be constant throughout the year and the chances of an embryo's survival dependent on the season, or there could even be seasonal changes in the length of pregnancy. However, we will

show that limited evidence from the seasonal pattern of stillbirths and miscarriages does not support that as the determinant of the birth pattern, and the general assumption of conceptions as determining the underlying seasonality of births is supported.

A large literature exists examining the seasonal patterns of: stillbirths, spontaneous and induced abortions, and prematurity and postmaturity. Stillbirths in the U.S. peak in spring and summer (April, May and June; or August for perinatal deaths.) There may also be a mid-winter minor peak. They are below average in October, November and December (Kevan, 1979, Keller and Nugent, 1983), However, this varies by region and is different in Europe, where spring-summer is the low period for stillbirths and fall-winter, the high (Slatis and De Cloux, 1967). This pattern implies that use of live births only to represent conceptions will underestimate conceptions in Jul-Sep, or November, and overestimate relative conceptions in Jan-Mar.

Spontaneous abortions (miscarriages) peak in the summer (Chang, 1963), in March through June in Canada (Cohen and Bracken, 1977), in March, April and May in India and in February and March in Finland. However, there is evidence that observed seasonal patterns of miscarriages are artifacts of varying numbers of gestations in progress at different times of the year, i.e. that the miscarriage rate is constant (Warren, 1980) In the absence of a strong seasonal pattern for fetal loss, the conception rhythm literature continues to rely on Huntington (1938) conclusion that the inclusion of lost embryos does not materially alter the general seasonal rhythm of conceptions as inferred from the curve for live births alone.

Prematurity has been found in some studies in the U.S. and Europe to show no seasonal changes and in others to show seasonal changes. Premature births in the U.S.

have been shown to trough in the winter and spring and then peak in summer (June-July) or early fall. Postmaturity in Finland is greater during the warmer time of the year, i.e. late spring, summer, and early fall, but it is unclear whether this is a cold-climate or general phenomenon (Timonen, S. et al., 1965, & Cooperstock and Wolfe, 1986). This implies that some births that would have taken place in late fall will be shifted toward early fall and summer by their prematurity, and use of the 9-month average will underestimate conceptions in Jan-Mar. Since prematurity troughs in winter or spring, conceptions in spring or summer will be overestimated.

It can be seen that the Jan-Mar overestimation of conceptions that seems to follow from current understanding of the stillbirth pattern will be counteracted by the Jan-Mar underestimation of conceptions that follows from the currently understood prematurity pattern.

The range of oscillation of birth (conception) in previous studies varies from approximately 5% to 60% of deviation from the annual mean, but in the majority of cases (Roenneberg and Aschoff, 1990), as well as in the cases presently studied, does not exceed 20%. Unlike the annual rhythmicity of animal reproduction, therefore, the rhythm of human reproduction only becomes evident in large population statistics. Thus, the bulk of human conception appears to be independent of seasonal influencing factors, and the observable rhythmicity relates only to a minority of the total number of conceptions. However, the systematic nature of this rhythmicity around the globe justifies and indeed demands an investigation to isolate social, biological, and economic contributing factors (Roenneberg and Aschoff, 1990.)

The current investigation has two parts. The first part investigates the pattern of conception in the U.S., 1982-1993, according to whether they are imputed from records of induced abortions, all live births, or live births to unwed women. The second fits a model of the effect of season on conceptions of different behavioral types to isolate the effects of some of the different aspects of season which have been argued to determine the timing of births: climate, economic conditions and societal customs.

The Extreme Case of Seasonal Affective Disorder

Although economists focus on rational forces behind peoples' actions, researchers in other fields have noted that normal human behavior is seasonal. In biology, food intake, sexual activity, productivity and conception have been shown to have seasonal patterns. Even controlling for the holiday season, daily calorie intake has a significant peak in the fall and trough in the spring, leading average body weights to rise in fall, hold steady in winter, fall in spring, and then hold steady in summer (De Castro, 1990). Adults perform simple arithmetic more slowly when weather is turbulent than when weather is good, and that accuracy of telegraphers and productivity of factory workers declines in extreme hot or cold environments. Happiness scores in one study were inversely related to relative humidity and directly related to sunshine. A study of factory efficiency in Connecticut found that peak productivity occurred in November, while minimum productivity occurred from January to March (Huntington, 1938). The accident rate in a factory with 5,000 workers was highest in April in two successive years studied (Licht, 1964). As rainfall increased in Kyoto, Japan, activity in the police lost-and-found decreased, although wind and daily temperature did not affect Kyoto's lost-and-found activity.

Human seasonality has gotten attention recently, as the psychological syndrome of “Seasonal Affective Disorder” has become the darling of the media. SAD is a gripping idea because it strikes a high percentage of the normal population and it escapes the “hysterical” stigma of much of mental illness by being seasonal and hence affecting the person in a predictable manner; further validating the existence of the syndrome is evidence that it may respond to scheduled exposure to bright light (Lewy et al., 1989). Symptoms occur in the late fall and early winter which are a highly exaggerated level of the standard “winter blahs”, and include fatigue, increased duration of sleep, inability to concentrate and focus, overeating with carbohydrate craving, weight gain, diminished interest in sexual intercourse, and social withdrawal. Eighty percent of patients diagnosed with SAD are female, but evidence from random population surveys suggests that this may be merely the result of a greater propensity among female sufferers to seek help. The syndrome is thought, based on a close tracking of reported symptoms with various environmental variables that vary in winter, to be caused by sunlight deprivation, largely because prevalence surveys show a ten-fold increase in the prevalence of SAD complaints from the southern US to the north. However, other variables which vary in winter, such as temperature, may be involved. Surveys of the US population have led to estimates of 6 percent of the US population suffering from clinical (extremely debilitating) SAD and a further 14 percent suffering from subclinical (mildly debilitating) SAD. In Florida, however, only 1.4% of people have clinical SAD, and in northern states such as Washington State, the figure is 10.2%. The mechanism with which sunlight deprivation causes psychological symptoms is as yet unclear, although sunshine has been shown to affect levels of three

behavior-influencing hormones (melatonin, serotonin, and dopamine) (Blehar and Rosenthal, 1989).

The second part of the current study examines the effect of four distinct variables influencing the SAD culprit, level of sunshine: precipitation, sunshine, sky cover and clear days, on conceptions. By comparison with the SAD symptomology, one would expect sunshine to have a positive effect on conceptions. Surprisingly, it will be seen that in the normal population sunshine exerts a negative effect.

The present study, therefore, extends the existing research into the pattern of conception by 1) examining separately influence on three subsets of conceptions: conceptions that result in births to married women, in births to unwed women, and that are ended by induced abortion. From a behavioral point of view, conceptions that end up being aborted are distinguishable from conceptions by unwed women, which in turn are different from conceptions to married women; the determinants and influences of each category of conceptions may very well differ. 2) including an *economic* variable which affects the planning of children and 3) including a greater number and better quality weather variables. Previous studies (e.g. Roenneberg and Aschoff, 1990) use normal monthly precipitation as an explanatory variables; here, actual occurred precipitation and temperature for a state and month is used, along with state/month normals for sunshine and for two variables previously unexamined: sky cover and clear days.

Part I: Three Categories of the Observed US Seasonal Conception Pattern in the Last Decade: to Married Women, to Unmarried Women, and To Women Who Will Abort.

Part I of the study investigates the pattern of conception in the U.S., 1982-1993, according to the sociological context of the conception: whether these conceptions are imputed from records of induced abortions, all live births, or live births to unwed women. The investigation is done with graphical analysis.

Methodology

Data Collection

Live births (i.e. all live births, i.e. to all women) by **state and month** are tabulated in the U.S. government annual publication *Vital Statistics of the United States*. However, to eliminate any influence of marriage patterns, fifty state health departments were contacted and asked for data on monthly live births to unwed women, as well as monthly abortions performed. Some states do not collect abortion data at all, and many states were not able to do the special runs required for this type of data, or requested prohibitive fees. In the end, data was received from thirty-three states on illegitimate births and from twenty-two states on abortions performed. The states sent between two and eleven years each, leading to 3300 state-months of data on unwed births and 1848 state-months of data on abortions performed. Data on live births by Canadian province was received from the government of Canada (Statistics Canada).

Adjustment for Differing Month Length

Both abortion and live birth to resident unmarried women numbers were adjusted to allow for the varying numbers of days in each month before analysis. The states were then divided into regions based on average latitude north of the state; the

“lowest quarter” of the U.S. was defined as all states with average latitude below 33 33 00, the “second lowest quarter” as all states above this but below 36 67 00, the “second highest quarter” as all states above this but below 41 67 00, and the “highest quarter” as all states above this. Summary statistics of conceptions by month were taken for each region, and graphed.

Imputing Conceptions from Observed Births and Abortions

The conception time is regarded as being 9 months before delivery, as is the standard method (Chang et al., 1963, Timonen, S. et al., 1965, Bernard et al., 1978, Ogum and Okorafor, 1979 and others), and as three months before the induced abortion took place (also the standard method; e.g. Warren, 1980). Nine months is a better average of time from conception until delivery than it is from gestation until abortion; abortions, although they take place at an average gestation of about seven weeks or almost two months, take place in high percentages from the first month after conception until the third (*Abortion Factbook*, 1992) While the similarity between the unwed birth-implied conception curves and the abortion-implied curves (see figure 7) arguably supports the two-month approximation, differences between the abortion-implied and birth-implied curves could be because of fundamentally different seasonal patterns between conceptions that end up being aborted and conceptions that end in live births, or because of greater inaccuracy in the abortion-derived curve. In any case, the current study utilizes both two-month and three-month approximations of gestation at the time abortion is induced, where it is kept in mind that the two-month approximation is empirically more accurate.

With regards to the nine-month estimate on births, it should be noted that delivery times are actually a fixed number of days rather than “months” which have varying numbers of days. Delivery occurs, on average, 38 weeks after conception. 38 weeks is 266 days, while 9 months equals between 273 and 275.5 days, depending on which nine-month-period we are talking about. If every sequence of 9 months contained the same number of days, e.g. 273 days, then counting back 9 months rather than 266 days would be counting back 273 days rather than 266 days. Some conceptions would therefore be attributed to the month before they actually happened. Still, every month would get attributed the same percent of conceptions from the month after it, and the distribution of conceptions would not be skewed. However, some nine-month periods have as little as 273 days or as many as 275.5 days. It is less likely that a conception will be attributed to the month before it actually happened if 273 days are counted back rather than the actual 266, and it is more likely if 275.5 days are counted rather than the actual 266. Therefore, months followed by 9-month periods which are shorter than average will have more conceptions attributed to them than attributed out of them, i.e. will have their conceptions overestimated. Months followed by longer than average nine month periods will have more conceptions attributed out of them than into them, i.e. will have their conceptions underestimated. This implies that conceptions in April, March, May and February will be underestimated; conceptions in June, July, November and December will be slightly overestimated; and conceptions in January, August, September and October will be even more overestimated. The current study does not attempt to correct for these systematic problems; further work to calculate the order of magnitude of the errors

involved and the correction factors if the errors are deemed significant will improve the accuracy of this type of analysis.

Previous Graphical Results

Kevan (1979) studied the US conception pattern between 1964 and 1974, and the Canadian conception pattern between 1960 and 1974. His results are graphed as the right-side graphs in Figure 5. Cowgill (1966) studied the conception pattern in England & Wales (1939-1961) and in Sweden (1901-1961). Her results are graphed as Figure 6.

A picture is worth a thousand words, and the graphs in figures 5 and 6 must be examined to appreciate all the information they contain about the conception patterns in the US, Canada, and Europe. An attempt at verbal analysis might say, stylistically:

Kevan shows that the US conception pattern from months 1 to 12 (January to December):

- 1) falls until month 5
- 2) rises a little bit (a "minor peak") **FALLS, RISES SLOWLY**
- 3) rises slowly until month 11.

Kevan shows that the Canadian conception pattern from months 1 to 12:

- 1) falls until month 5
- 2) rises steeply at month 5 and stays high until the end of the year. **FALLS, RISES STEEPLY**

Cowgill shows that the European conception pattern from months 1 to 12:

- 1) rises until months 6
- 2) stays high until month 8 **RISES SLOWLY, FALLS SLOWLY**

3) falls until month 11.

Figure 6, which is derived from data in Cowgill (1966), also shows that the legitimacy of the births considered does not affect the general conception pattern. Verifying Roenneberg & Aschoff (1990 p. 204) 's conclusion, we can see that unwed births seem to vary more around the year than legitimate, (or “have a rhythm with a higher amplitude”), but follow the same pattern.

Current Graphical Results

Since the vast majority of abortions are performed on unwed women, sociologically speaking, it is plausible that conceptions that will result in induced abortion are closer cousins to conceptions that will result in unwed birth than to conceptions that will result in legitimate births. Thus, figure 7 graphs the conceptions that end in abortion and that end in unwed births for four regions of the United States (lowest to highest), 1982-1993 for state/years that data was attained. Abortions are imputed via the standard 3-month gestation at the time of abortion assumption (the first column) and via the more accurate 2-month assumption (the second column). When both of these aborted-conception pattern graphs are compared to the unwed conception graphs (the third column), the 2-month graph is more similar to the unwed conception graphs. The 2-month graph shares with the unwed graph:

- 1) the month-six minor peak
- 2) the month-11 major peak followed by the falling toward month 12
- 3) the “fattening up” of the summer months as one heads down the column toward the higher regions of the US.

The more recent US and Canadian conception patterns, by vertical region, are shown as Figure 8. Roenneberg and Aschoff's result for slightly earlier US panel data, that conceptions show a peak during months in which temperatures are between 41 and 68 °F, is seen here too. In the highest and coldest region of the US, the range of months with average temperatures below 68 is relatively large (higher graph of figure 8) and this is reflected in the lower graph of figure 8, foreground, where the summer months have high levels of conceptions in the northern US region relative to the southern. In the lowest and hottest US region, however, the upper figure in figure 8 shows that the range of months with average temperatures below 68 is small—only months in the deep winter fit this criterion—and therefore, in the lower graph of Figure 4, back, the winter months have high levels of conceptions in the southern US region relative to the northern. The progression from the lowest to the highest quarter of the U.S. can be clearly seen; in the lowest quarter the summer months are hot and depress conceptions, while in the highest they are optimal in temperature and raise conceptions. In the lowest quarter conceptions rise steeply toward the winter months, and in the highest quarter, this rise is flattened down. The holiday effects of November/December (Thanksgiving/Xmas-New Years) are also clearly seen. Figure 8 shows the results of linear extrapolation from the cross-section of three data points as one travels upwards in the US for each month (using Microsoft Excel); the remarkable resemblance between the actual and extrapolated highest US regions demonstrates the linear progressiveness of the actual pattern, the systematic effect of latitude on conception. The bottom two graphs of figure 8, which show the Canadian conceptions imputed

from live births 1982-1990, show a continuation of this progression, with the summer spike getting higher with latitude north.

Figure 9 shows nine graphs of nine different years of US conception patterns. It can be seen that the pattern is basically consistent across these years, and, following Cowgill (1966), changes slowly and is consistent across time blocks for a given location. It is interesting to compare the shapes of the whole-US graphs to the regional graphs of Figure 8 and to note which years of US history the shape looked more like the upper-regional shape (implying, perhaps, a colder year or a colder summer) and which years of US history the shape looked more like the lower-regional shape (implying a hotter year or summer). A priori, taking a step back from the paper to get perspective, it is arguable that there is a similarity to the cold-area patterns in the entire-US patterns for 1985, 1986, and 1990 (specifically, a fat/flat rising second half of the year). Figure 3, Average US Temperatures by Year, shows that while 1985 was an unusually cold year, 1986 was average, and 1990, unusually hot. Thus, it is difficult to argue that cold years' patterns resembles cold region's patterns and hot years, hot regions'.

The US conception pattern falls until May, has a minor peak in June, and rises until November, falls a bit, and rises until February. This is an accurate description of every graph shown, i.e., the pattern is consistent.

The US monthly conception pattern for conceptions that end in induced abortion, as responded to by 22 state health departments, is shown in the first two columns of figure 7. There is a notable similarity between the conception patterns imputed from illegitimate births and induced abortions.

Part II: Regression Results

Part II of the study investigates the determinants of the seasonal pattern of conceptions outlined in Part I. A model is fitted to isolate the effects of some of the different aspects of season which have been argued to determine the timing of births: climate, economic conditions and societal customs.

Table 1 provides definitions of independent variables, Table 2 provides definitions of dependent variables, and Table 3 reports regressions for various behaviorally-defined subsets of conceptions.

Table 1: Definitions of Independent Variables

All variables are by state, and the time period covered by the data is 1982-1990. Conceptions are assumed to occur nine months before births and either three months or two months before induced abortions. (Clearly, the second assumption is a far more restrictive one.) All non-dummy variables are indexes of a given state month relative to the rest of the state year to capture the effect of seasonal differences in the variable rather than inter-state or inter-year variation.

PCMARMJI - per-capita marriages in a month, by state; an index for each month in a year relative to the year as a whole. Monthly data on marriages by state is published in *Vital Statistics of the United States*, Volume III (Marriage and Divorce) for the years 1982-1987. However, this volume is unavailable at this time for years subsequent to

1987. Data for 1988 are unpublished data from the National Center for Health Statistics, and data for 1989 and 1990 are provisional data based on a 10% accounting of marriages in each state as tabulated in the Monthly Vital Statistics Report of the National Center for Health Statistics, 1990 and 1991.)

PCMRJIL1 - an index of per-capita marriages one month ago. This is the variable PCMARMJI, lagged one month within each state.

PCMRJIL2 - an index of per-capita marriages one month ago. This is the variable PCMARMJI, lagged two months within each state.

PCMRJIL3 - an index of per-capita marriages one month ago. This is the variable PCMARMJI, lagged three months within each state.

PCMRJIL4 - an index of per-capita marriages one month ago. This is the variable PCMARMJI, lagged four months within each state.

PRECIPAI - actual precipitation that occurred in a state month, in inches, as recorded at a representative weather station of the state and published in *Weather of US Cities* (Gale Research); an index for each month in a year relative to the year as a whole. This is adjusted for differing month lengths between months.

LATPRECI - an interaction term of the average state latitude * PRECIPAI, the inches of precipitation in that month index. The state latitude is expressed in radians.

SMCLRAI - the mean number of days in the state month in which the sky is clear from sunrise to sunset, as recorded at a representative weather station of the state and published in *Weather of US Cities*; an index for each month in a year relative to the year as a whole. This is adjusted for differing month lengths between months. This is the normal value for a state month over the years 1951-1980, rather than an actual occurred value for a given month and year. "Clear" is defined as average daytime cloudiness of 0.3 or less.

SMSUNI - the average percent of daytime hours subject to direct radiation from the sun as recorded at a representative weather station of the state and published in *Weather of US Cities*; an index for each month in a year relative to the year as a whole. This is the normal value for a state month over the years 1951-1980, rather than an actual occurred value for a given month and year. The percentage is given without regard for the intensity of sunshine. That is, even if partial sky cover such as thin clouds or light haze are present, it does not mitigate the full counting of an hour. It is therefore relevant to know whether such sky cover *was* present to lower the intensity of sunshine.

SMSKYI - the mean sky cover or "vertical observation" in tenths, i.e. the average amount of daytime sky obscured by any type of cover as recorded at a representative

weather station of the state and published in *Weather of US Cities*; an index for each month in a year relative to the year as a whole. This is the normal value for a state month over the years 1951-1980, rather than an actual occurred value for a given month and year.

UNEMRATI - the unemployment rate that occurred in the state during this month relative to the rest of the state year, from the Bureau of Labor Statistics; an index for each month in a year relative to the year as a whole.

AVGTMP1 - a dummy variable for the average temperature that occurred in a state/month being ≤ 23.86 degrees F (-4.67°C)

AVGTMP2- a dummy variable for the average temperature that occurred in a state/month being $> 23.86^{\circ}\text{F}$ & $\leq 33.67^{\circ}\text{F}$ (-4.67°C & 0.78°C)

AVGTMP3- a dummy variable for the average temperature that occurred in a state/month being $> 33.67^{\circ}\text{F}$ and $\leq 42.69^{\circ}\text{F}$ (0.78 & ≤ 5.79 $^{\circ}\text{C}$)

AVGTMP4- a dummy variable for the average temperature that occurred in a state/month being > 42.69 F and ≤ 47.07 F (> 5.79 $^{\circ}\text{C}$ & ≤ 8.22 $^{\circ}\text{C}$)

AVGTMP5- a dummy variable for the average temperature that occurred in a state/month being > 47.07 F and ≤ 49.96 F (> 8.22 & ≤ 9.83 $^{\circ}\text{C}$)

AVGTMP6 - a dummy variable for the average temperature that occurred in a state/month being > 49.96 F and ≤ 52.86 F (> 9.83 & ≤ 11.44 $^{\circ}\text{C}$)

AVGTMP7- a dummy variable for the average temperature that occurred in a state/month being > 52.86 F and ≤ 55.87 F (> 11.44 & ≤ 13.11 $^{\circ}\text{C}$)

AVGTMP8 - a dummy variable for the average temperature that occurred in a state/month being > 55.87 F and ≤ 58.87 F (> 13.11 & ≤ 14.78 $^{\circ}\text{C}$)

AVGTMP9- a dummy variable for the average temperature that occurred in a state/month being > 58.87 F and ≤ 61.67 F (> 14.78 & ≤ 16.34 $^{\circ}\text{C}$)

AVGTMP10 - a dummy variable for the average temperature that occurred in a state/month being >61.67 F and ≤ 64.47 F (>16.34 & ≤ 17.89 °C)

AVGTMP11 - a dummy variable for the average temperature that occurred in a state/month being >64.47 F and ≤ 69.37 F (>17.89 & ≤ 20.61 °C)

AVGTMP12 - a dummy variable for the average temperature that occurred in a state/month being >69.37 F and ≤ 74.68 F (>20.61 & ≤ 23.56 °C)

AVGTMP13 - a dummy variable for the average temperature that occurred in a state/month being >74.68 F (>23.56 °C) (this is the omitted category)

DUMMON1 through DUMMON11 - dummy variables for each of the months 1 (January) through 11 (November); December is the omitted category. Monthly dummies are included to account for factors that vary between months and affect conceptions but are not directly included in the model, such as holiday periods.

LATSUNI - an interaction term of (the average state latitude in radians)* (SMSUNI, the expected percent of daytime hours subject to direct radiation from the sun in that month/state index).

LATTMPI - an interaction term of (the average state latitude in radians)* (the index of the average occurred temperature in the state/month relative to the rest of the state/year).

TABLE 2: DEFINITIONS OF DEPENDENT VARIABLES

Primary Variables

PCAJBGXI - an index of per-capita conceptions in a month (month K) that resulted in live births nine months later, for that month in a year relative to the year as a whole, by state.

The number of conceptions in month K that will result in live births is defined as:

(live births in month K+9)

Monthly data on live births by state is published in *Vital Statistics of the United States*, Volume I--Natality, for each respective year.

PCUWBAJI - an index of per-capita conceptions in a month that resulted in illegitimate births, for that month in a year relative to the year as a whole, by state.

The number of conceptions in month K that will result in illegitimate live births is defined as:

(live births to unwed women in month K+9)

Monthly data on unwed live births by state are not published, and was requested from state health departments and received from 31 states for varying numbers of years each between 1982-1990, totaling 190 state-years.

PCABOAJI - an index of per-capita conceptions in a month that resulted in induced abortions, for that month in a year relative to the year as a whole, by state.

The number of conceptions in month K that will result in induced abortions is defined for the purpose of this variable as:

(induced abortions in month K+3)

which, although far less exact than estimating conceptions as births led nine months, is the method used in the literature. This convention of estimating conceptions as leading induced abortions by three months is not supported by the empirical average induced abortion in the US which occurs before gestation of seven weeks; induced abortions in two months would be a better estimate of conceptions of this type. The seven-week figure is derived from *Abortion Factbook* of the Alan Guttmacher Institute (1992)'s reporting that

“50% of the 1.6 million abortions (induced) each year take place at 8 weeks or less from the last time the woman menstruated (LMP); 27% at 9-10 weeks LMP; and 12% at 11-12 weeks LMP. 6% of abortions take place at 13-15 weeks LMP; 4% at 16-20 weeks LMP; and less than 1% at 21 weeks LMP or more (0.6%)”

, it being noted that conception follows the last menstrual period by about two weeks.

Monthly data on abortions performed by state is not published, and was requested from state health departments. It is not collected by all state health departments at all, and was received from 20 states for varying numbers of years each between 1982 and 1990 totaling 103 state-years.

PCABOAI2 - an index of per-capita conceptions in a month that resulted in induced abortions, for that month in a year relative to the year as a whole, by state.

The number of conceptions in month K that will result in induced abortions is defined for the purpose of this variable as:

(induced abortions in month K+2)

Derived Dependent Variables

PCCONCMI - an index of per-capita conceptions in a month, estimated as the sum of the number of conceptions in a month that resulted in induced abortions and live births
, or

(Induced abortions in three months) + (Live births in nine months)

. This index of conceptions assumes a three-month average gestation at time of induced abortion. It excludes fetal loss--conceptions that led to miscarriages and stillbirths--which, though equal to about a third of total conceptions, have been argued

to be distributed around the year in a way that does not confound the otherwise estimated pattern of seasonal conceptions.

PCUCONMI - an index of per-capita conceptions that result in unwed births or in abortions, where conceptions that ended up being aborted or as live births to unwed women can stylistically be termed “unplanned”, since conceptually they are more likely to be unplanned. “Unplanned” conceptions in a month are estimated as the sum of the number of conceptions in a month that resulted in induced abortions and live births to unwed women, or as

(Induced abortions in three months) + (Illegitimate live births in nine months)

. This index of conceptions excludes fetal loss (conceptions that led to miscarriages and stillbirths), and includes illegitimate conceptions or conceptions that end up being terminated, that in fact were planned.

PCLEGBAI - an index of per-capita conceptions in a month that resulted in legitimate births nine months later, for that month in a year relative to the year as a whole, by state.

Conceptions to married women in a month, the difference between conceptions to all women and conceptions to unwed women, are estimated as the difference between the number of live births nine months later to all women and to unwed women specifically, or

(Live births in nine months) - (Illegitimate live births in nine months)

Three of the dependent variables represent three mutually-exclusive (though not exhaustive) empirical divisions of conceptions: 1) those that result in live births 2) those that result in illegitimate live births (i.e. to unmarried women), and those that result in induced abortion. Conceptions that result in induced abortion are estimated as two variables: as 3) PCABOAJ1, assuming that conceptions precede abortions by three months, and 4) PCABOAI2, assuming that conceptions precede abortions by two months. Although the former assumption is standard in the literature, the second is supported empirically.

Three of the dependent variables represent composite variables derived from the three exclusive categories to represent conceptual categories of conceptions: 5) all conceptions, calculated as 1) and 3), those that end in live birth and those that are aborted; 6) unplanned conceptions, calculated as 2) and 3), those that end in illegitimate live birth and those that are aborted; and 7) legitimate conceptions, calculated as 1) minus 2), those that end in live birth excluding those that end in illegitimate live birth. The regressions were estimated with Stata's Generalized Least Squares for panel data "xtreg" command, assuming random effects.[5

TABLE 3 - Conception Regressions, States, 1982-1990.

Generalized Least Squares Regressions of Behavioral Subsets of Conceptions on Economic and Seasonal Variables (p values in parentheses)*

Regression**	(1) Concs that Result in Live Birth	(2) Concs that Result in Illegitimate Birth	(3) Concs that Result in Induced Abortion (avg. gest. = 3 mos)	(4) Concs that Result in Induced Abortion (avg. gest. = 2 mos)	(5) All Concs = (1 + 3)	(6) "Unplanned" Concs = (2 + 3)	(7) Concs that Result in Legitimate Births = (1 - 2)
# Marriages	.044 (.000)	.004 (.618)	-.013 (.418)	.057 (.001)	.029 (.000)	-.024 (.023)	.028 (.001)
# Marriages 1 Month Ago	.020 (.006)	.004 (.590)	-.007 (.647)	-.003 (.853)	.017 (.012)	-.008 (.421)	.029 (.000)
# Marriages 2 Months Ago	.033 (.000)	-.016 (.049)	.036 (.019)	.008 (.581)	.023 (.001)	-.011 (.269)	.033 (.000)
# Marriages 3 Months Ago	-.007 (.355)	-.035 (.000)	-.081 (.000)	.026 (.089)	-.021 (.002)	-.060 (.000)	.020 (.009)
# Marriages 4 Months Ago	.005 (.489)	-.027 (.001)	-.046 (.004)	-.078 (.000)	-.004 (.499)	-.040 (.000)	.010 (.227)
Precipitation	-.019 (.054)	-.004 (.693)	-.010 (.631)	-.014 (.491)	-1.9e-04 (.982)	-.018 (.145)	-.020 (.020)
Latitude* Precipitation	7.35e-06 (.078)	1.72e-06 (.639)	4.38e-07 (.959)	-6.59e-07 (.938)	-3.62e-07 (.921)	6.36e-06 (.234)	9.30e-06 (.010)
# Clear Days	.015 (.245)	.004 (.765)	.027 (.399)	-.024 (.469)	-.031 (.025)	.046 (.039)	.007 (.619)
Sunshine	-.190 (.006)	-.308 (.000)	-.268 (.095)	-.005 (.974)	.038 (.583)	-.406 (.000)	-.114 (.090)
Latitude* Sunshine	7.3e-05 (.003)	1.1e-04 (.000)	1.8e-05 (.784)	-4.3e-05 (.505)	-3.1e-05 (.266)	4.2e-04 (.008)	4.3e-05 (.047)
Sky cover	-.064 (.049)	-.078 (.041)	-.061 (.482)	-.028 (.744)	-.202 (.000)	-.019 (.751)	-.100 (.008)
Unemployment Rate	.017 (.252)	.049 (.002)	.003 (.922)	-.059 (.060)	-.009 (.527)	.014 (.502)	-.057 (.000)
Avgtmp1	.025 (.003)	-.012 (.129)	.036 (.008)	.032 (.019)	.027 (.000)	.007 (.388)	.055 (.000)
Avgtmp2	.028 (.002)	-.003 (.731)	.046 (.007)	.054 (.002)	.032 (.000)	.020 (.071)	.049 (.000)
Avgtmp3	.027 (.002)	.009 (.302)	.057 (.000)	.059 (.000)	.041 (.000)	.036 (.001)	.055 (.000)
Avgtmp4	.035 (.000)	.014 (.120)	.077 (.000)	.064 (.000)	.055 (.000)	.046 (.000)	.066 (.000)
Avgtmp5	.047 (.000)	-.003 (.770)	.061 (.002)	.055 (.004)	.054 (.000)	.038 (.002)	.089 (.000)
Avgtmp6	.066 (.000)	.020 (.029)	.083 (.000)	.077 (.000)	.056 (.000)	.050 (.000)	.076 (.000)
Avgtmp7	.054 (.000)	-6.6e-04 (.943)	.084 (.000)	.062 (.000)	.069 (.000)	.038 (.001)	.097 (.000)
Avgtmp8	.055 (.000)	-.021 (.017)	.075 (.000)	.059 (.001)	.061 (.000)	.023 (.036)	.110 (.000)
Avgtmp9	.050 (.000)	-.010 (.288)	.049 (.005)	.089 (.000)	.057 (.000)	.015 (.189)	.087 (.000)
Avgtmp10	.053 (.000)	-.020 (.015)	.049 (.003)	.072 (.000)	.052 (.000)	.009 (.401)	.095 (.000)
Avgtmp11	.049 (.000)	-.019 (.006)	.051 (.000)	.043 (.001)	.063 (.000)	.009 (.301)	.098 (.000)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regression**	Concs that Result in Live Birth	Concs that Result in Illegitimate Birth	Concs that Result in Induced Abortion (avg. gest. = 3 mos)	Concs that Result in Induced Abortion (avg. gest. = 2 mos)	All Concs = (1 + 3)	"Unplanned" Concs = (2 + 3)	Concs that Result in Legitimate Births = (1 - 2)
Avgtmp12	.033 (.000)	-.023 (.000)	.056 (.000)	.047 (.000)	.045 (.000)	.002 (.799)	.074 (.000)
Latitude*	-8.2e-05 (.001)	-1.1e-04 (.000)	-2.9e-05 (.657)	3.1e-05 (.641)	2.2e-05 (.438)	-1.3e-04 (.004)	-5.6e-05 (.013)
January	-.055 (.000)	-.044 (.000)	-.083 (.000)	.067 (.000)	-.048 (.000)	-.066 (.000)	-.037 (.000)
February	-.082 (.000)	-.022 (.009)	-.026 (.120)	-.026 (.126)	-.067 (.000)	-.025 (.022)	-.078 (.000)
March	-.076 (.000)	-.038 (.000)	-.076 (.000)	.033 (.100)	-.083 (.000)	-.067 (.000)	-.069 (.000)
April	-.122 (.000)	-.047 (.000)	-.063 (.005)	-.048 (.036)	-.120 (.000)	-.057 (.000)	-.117 (.000)
May	-.077 (.000)	-.034 (.007)	-.081 (.004)	-.043 (.122)	-.100 (.000)	-.045 (.013)	-.075 (.000)
June	-.093 (.000)	.034 (.015)	-.090 (.005)	-.055 (.086)	-.123 (.000)	-.002 (.917)	-.098 (.000)
July	-.087 (.000)	.074 (.000)	-.085 (.012)	-.085 (.013)	-.125 (.000)	.024 (.281)	-.122 (.000)
August	-.091 (.000)	.098 (.000)	-.166 (.000)	-.099 (.001)	-.140 (.000)	.006 (.769)	-.138 (.000)
September	-.074 (.000)	.123 (.000)	-.102 (.000)	-.187 (.000)	-.104 (.000)	.041 (.007)	-.137 (.000)
October	-.057 (.000)	.018 (.049)	.019 (.320)	-.105 (.000)	-.066 (.000)	.034 (.006)	-.076 (.000)
November	-.011 (.075)	.006 (.382)	-.014 (.006)	.023 (.104)	-.026 (.000)	-.005 (.596)	-.027 (.000)
Constant	1.18 (.000)	1.40 (.000)	1.46 (.000)	1.14 (.000)	1.22 (.000)	1.54 (.000)	1.19 (.000)
N	4982	2203	1195	1178	1195	1099	2203
Rsquared	.2166	.3336	.3816	.3912	.5638	.2532	.4554

* bolding of coefficients indicates significance at the five percent level.

** all non-dummy independent variables are indexes for state month relative to year to capture effect of seasonal differences rather than inter-state or inter-year differences.

Table 3, Continued

Discussion of Regression Results

Marriages

A priori expectations suggest that since pregnancies are more likely to be planned and aimed for after marriage, PCMARMJI, marriages during a month, will have a significant and positive effect on conceptions to married women (7), and, on all conceptions that end in live births(1), and on all conceptions overall (5). This assumes that the pool of newlyweds added each month contains a noticeable percentage of the existing pool of people desiring children. Marriages should have no effect on conceptions to unwed women(2). However, since unwed women are more likely to terminate a pregnancy than wed women --they terminate 56% of their pregnancies as opposed to the 29% induced abortion rate for all women, (*Abortion Factbook*, 1992, p.37), marriage should have no effect or a negative effect on conceptions which end up being aborted (3). Table 3 shows that the marriage rate has the expected significant and positive effect on conceptions that result in live births (1), all conceptions (5), and conceptions that result in legitimate births (7), but has a positive effect on conceptions that are aborted if we assume a two-month average gestation (4).

Marriages one month ago PCMRJIL1 has a positive and significant effect on conceptions that result in legitimate births (7) and on conceptions that result in live births (1). Since unwed births are not affected significantly, increasing legitimate conceptions increases total live births. Marriages two months ago (PCMRJIL2) reduces conceptions that result in unwed births (2), increases conceptions that result in legitimate births (7), and increases their sum conceptions that result in live births (1). It also increases one measure of conceptions that end up in abortion (3), and hence, since

live births and abortions increase, increases their sum all conceptions (5). Marriages three months ago (PCMRJIL3) similarly reduces conceptions that result in unwed births (2), and increases conceptions that result in legitimate births(7), but has no significant effect on their sum conceptions that result in live births (1) since the negative effect on unwed births and the positive effect on legitimate births are canceling out. Conceptions that result in abortion calculated via the 3-month scheme are reduced (3), and hence the sum of conceptions that result in births or abortions, all conceptions (5), is reduced. Marriages four months ago (PCMRJIL4) reduces conceptions that result in unwed births (2) and in abortions (3&4), hence reducing their sum “unplanned conceptions” (6), but the effect on legitimate births has petered out (7), and there is no significant effect on conceptions that result in live births (1) or on all conceptions (5).

In summary, it can be seen that marriages have a positive effect on conceptions that result in legitimate births (7) for three months after the marriages occur; a negative effect on conceptions that result in illegitimate births from two to four months after the marriages occur (2); a positive effect on conceptions that result in live births for two months after the marriages occur (1); a positive effect on conceptions that are aborted in the month the marriages occur and two months later, and then a negative effect three and four months later; a positive effect on all conceptions (5) in the month the marriages occur, a smaller positive effect two months later, and a negative effect three months later as the negative effect on conceptions type (2) and type (3,4) kick in, and a negative effect on unplanned conceptions in the month the marriages occur, and between two and four months later.

Weather: Light and Precipitation

Precipitation (PRECIPAI) has a negative effect on conceptions that result in legitimate births (7) and a marginally significant negative effect on conceptions that result in all live births (1). Latitude*precipitation (LATPRECI), the interaction of latitude north with occurred monthly precipitation index, is positive for those same two types of conceptions; i.e. the negative effect of precipitation on these conceptions is lowered at higher latitudes. Normal clear days for a month in a state (SMCLRAI) reduces all conceptions (5) and increases “unplanned” conceptions (6) Sunshine (SMSUNI) has a negative effect on conceptions that result in illegitimate births (1), but no significant effect on conceptions that result in legitimate births or in abortions, leading to a negative effect on two variables that include the illegitimate birth conceptions: conceptions that result in all live births (1) and “unplanned” conceptions (6). This goes against the Seasonal Affective Disorder analogy where sunlight increases activity. The specific behavioral effects of sunlight are, it would seem, highly dependent on the specific behavioral variable being measured.

One would expect this negative effects of sunlight on illegitimate births to be lower where there is less of it overall, e.g. at higher latitudes, and the impact of relative sunlight of one month compared to another is in fact lower at higher latitudes as shown by the positive coefficient on the interaction latitude*sunshine (LATSUNI.) Put differently, at higher latitudes, the optimal index of sunshine for conception is higher; conceptions peak at a relatively more sunny time of the year; although the absolute amount of sunshine at which conceptions peak at higher latitudes may be lower than at

lower latitudes. Sky cover (SMSKYI), has a negative effect on all conceptions (5) caused by negative effects on conceptions that result in legitimate births (7) and conceptions that result in illegitimate births (2). It is tempting to speculate that sky cover's negative effect on conceptions is related to the mechanism whereby sufferers from Seasonal Affective Disorder reduces creative activity of all sorts in insufficient light; however, sunlight's negative effect on conceptions demonstrates that the only thing we can be sure of at this point is our own ignorance about the complex effects of season on the normal population.

Unemployment Rate

The unemployment rate index for a month in a year relative to the rest of the year is included to account for economic conditions. The economic theory of families' timing of children predicts that transitory reductions in family income will reduce transitory consumption of "child services", i.e. cause people to put off starting or enlarging their families (Ward and Butz, 1980.) Assuming imperfect access to capital markets, unemployment causes people to put off financial commitments, and in this context delay planned conception, based on an income effect. Although they have more forced leisure time so the time cost of inputting time to childcare activity is temporarily lower, the unemployed's time is needed for job-seeking activity, and the temporary nature of the forced leisure time prevents it from having a large effect on the opportunity cost of raising children. It is therefore unlikely that the small lowered time cost of raising children will dominate the dramatically lowered income and security which affect the decision to plan a birth.

Unplanned conceptions, however, do not depend on the demand for children but merely on the rate of sexual activity/birth control use. Birth control use could be reduced from the income effect of transitory unemployment. Sexual activity could be increased from the increased leisure time, since the opportunity cost of inputting time to it will have fallen, or reduced if the unemployment has psychological effects on the utility from it vs. other leisure activities. It is an empirical, psychologically-based question whether sexual activity and hence unplanned conceptions are increased or decreased in the unemployed.

Economic theory therefore predicts a negative effect on planned conceptions from unemployment, since forward-thinking economic agents who plan their children carefully will be more likely to plan children when they are employed; however, less forward-thinking economic agents who tend to conceive unplanned children may conceive more during unemployment since their unemployment gives them more leisure time in which to do so. The data here show that higher unemployment reduces conceptions that result in legitimate births (7), and increases conceptions that result in illegitimate births (2). To the extent that legitimate births are more likely to be planned than illegitimate, this is consistent with a priori expectations. However, the index of unemployment does not have an effect on conceptions that result in abortions assuming a three-month gestation, and has a marginally significant negative effect on conceptions that result in abortions assuming the more accurate two-month gestation.

Unemployment therefore discourages conceptions by married women, encourages conceptions in unmarried women who will then carry them to term, and discourages conceptions to women who will then abort them.

Temperature

Since previous research into the effect of environment on conceptions indicates that either extreme of temperature reduces conceptions, and that there is an optimal temperature for conception, the index of average temperature that occurred in the state in a month was not put in as a single variable whose coefficient would assume a monotonic relationship between conceptions and temperature, but rather as indicator variables for the temperature during a state/month having been in a certain range. These indicator variables depend on the actual occurred temperature and not, like the rest of the variables in the regression, on an index of that month relative to the year it was in for the state. This allows calculation of the optimal range of temperature for conceptions of various behavioral types.

National Climatic Data Center data on monthly average temperatures achieved in each state was used, as tabulated in the book Weather of U.S. Cities (Gale Research).

The temperature dummies AVGTMP1-AVGTMP12, it can be seen in Table 2, have highly significant effects on conceptions that result in legitimate births and that result in abortion, and significant effects in the hotter range of temperatures for unwed births. It should be noted that, as definitions of variables in Table 3 indicate, AVGTMP13 is not extremely hot in any absolute sense--it represents average occurred temperatures in a state/month above 74.68F - but is rather the highest subset of observations on temperature; it can be broken down into two ranges of temperature, but since even AVGTMP12 already showed the negative effect of increasing heat,

AVGTMP13 is at the heat extreme enough already that it does not contain the peak range in any case.

The optimal temperature ranges for conception from the regressions (highest significant coefficient on an AVGTMP indicator variable) are:

for conceptions that result in all live births (1) -- $50^{\circ}\text{F} > T \leq 53^{\circ}\text{F}$

for conceptions that are aborted (3-mo. avg. gestation) -- $53^{\circ}\text{F} > T \leq 56^{\circ}\text{F}$

for conceptions that result in legitimate births -- $56^{\circ}\text{F} > T \leq 59^{\circ}\text{F}$

for conceptions that are aborted (2-mo. avg. gestation) -- $59^{\circ}\text{F} > T \leq 62^{\circ}\text{F}$

These optimal temperatures are within the optimal range of the previous studies, though lower than Huntington's optimum of 67°F .

The negative coefficient on the interaction of latitude and temperature (LATTMPI) indicates that at higher latitudes, positive effects of rising temperature as the optimal temperature is approached from below are lowered, and negative effects of rising temperature index in the negative-effect range are raised. Put differently, at higher latitudes, the negative effects of cold extremes are smaller and the negative effects of warm extremes are larger. Since this temperature is absolute rather than relative to the year average, it is to be expected that a given cold temperature has a lower effect in the cold latitudes where it appears in a relatively warm month of the year than in the warm latitudes where it appears as the coldest weather of the year.

For conceptions that result in live births (1), for example, the highest coefficient is on AVGTMP6 (.066) and the lowest is on AVGTMP13 (0). This implies that the

conception index (PCAJBGXI) in a month will be greater by .066 in the temperature range of AVGTMP6, between 50.0°F and 52.9°F, than in the temperature range of AVGTMP13, which is an average temperature of 78.2 °F. Since the mean of the live birth dependent variable PCAJBGXI is 1, since it is an index normalized around the number 1, this implies an average increase in the index of 0.066, or seven percent. Since the mean of PCAJBGX is 1.32e-03, an increase in the index of 0.066 implies an average increase in per-capita conceptions that result in live births of 8.71e-05 from this change in temperature range from the least optimal range to the optimal one, or 8.71 conceptions per 100,000 people per year. This seven percent difference could be because of behavioral differences in reproductive activity at different temperatures, or from biometeorological effects of the differing temperature on fertility on ability to conceive. In a public health context, perhaps people who are having trouble conceiving children would increase their chances somewhat by moving to a colder climate; what is interesting is the surprisingly low temperature at which conceptions peak compared to the temperature that is most comfortable for human beings.

Figures 12-16 show the effects of temperature on conceptions resulting in all live births, in legitimate births, in abortion, in either abortion or illegitimate births, and in illegitimate births, respectively. The similarity between the four patterns supports the contention that the AVGTMP variables are capturing a biological effect of some sort, and the differences may be due to some behavioral effect of temperature which differs between these categories of conceptions. Conceptions that will end in legitimate births vary more with temperature than do any of the other categories of conceptions (e.g. compare figures 13 and 14). The reason for this may be behavioral: the behavioral and

biological effects of temperature may reinforce each other more for married couples than for unmarried couples. For example, when the temperature is above or below the biological optimum for conception, married couples may reduce coital frequency more than unmarried, thereby exacerbating the negative effects of nonoptimal temperature on conceptions for legitimate births.

Month

It can be seen from the cells for the month dummies for January through November (DUMMON1 to DUMMON11) in Table 3 that month has a highly significant effect on all behavioral categories of conceptions. This variable does not capture the full effect of month on conception pattern, but rather the effect of month without the temperature, weather, marriage-custom and economic condition effects of different months which are included in the regression. It therefore captures the social conventions regarding the different months of the year, e.g. holidays and vacation patterns, as well as climate variables not included in the specification.

A priori, since holiday affects coital frequency rather than any of the economic determinants of the optimal time to bear children, one would expect unplanned conceptions to be more responsive to societal conventions regarding holidays than planned conceptions. A look at Table 3 confirms this; the “societal” effects of month on conception are greatest on conceptions that end in abortion, and greater for unmarried than for married women.

Conclusion

The current study has looked at conceptions with three different destinies: those that will end up as legitimate births, those that will end up as illegitimate births, and those that will end up aborted. The optimal temperature for conception was found to be between 50 and 62 degrees Fahrenheit. Economic, societal and biometeorological determinants of conception patterns were identified and modeled using U.S. and Canadian data.

APPENDIX 1: FIGURES

Observed Monthly Patterns: Background

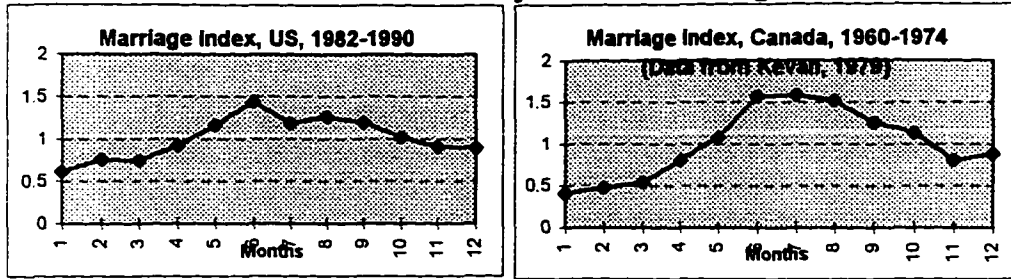


Figure 1. Marriage pattern in Canada and in the United States (standardized monthly rates)

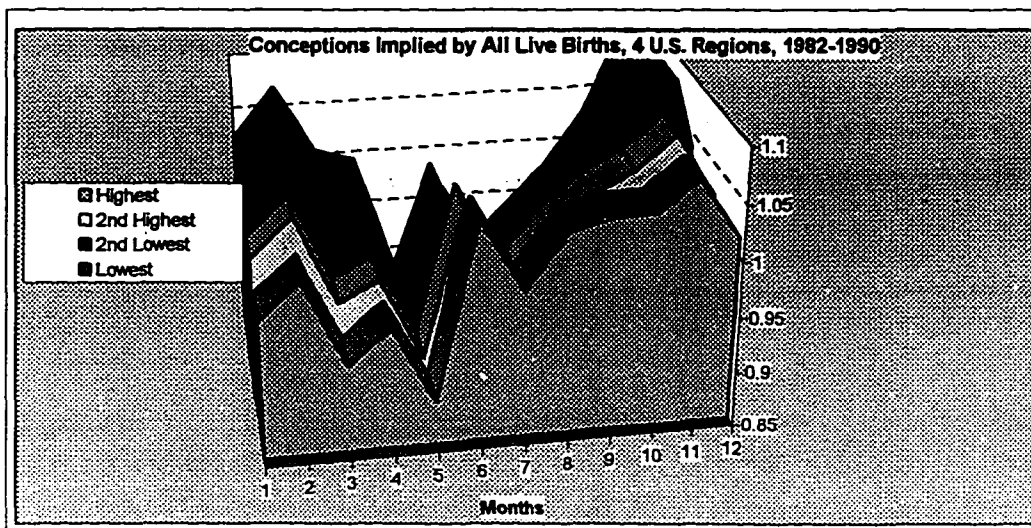
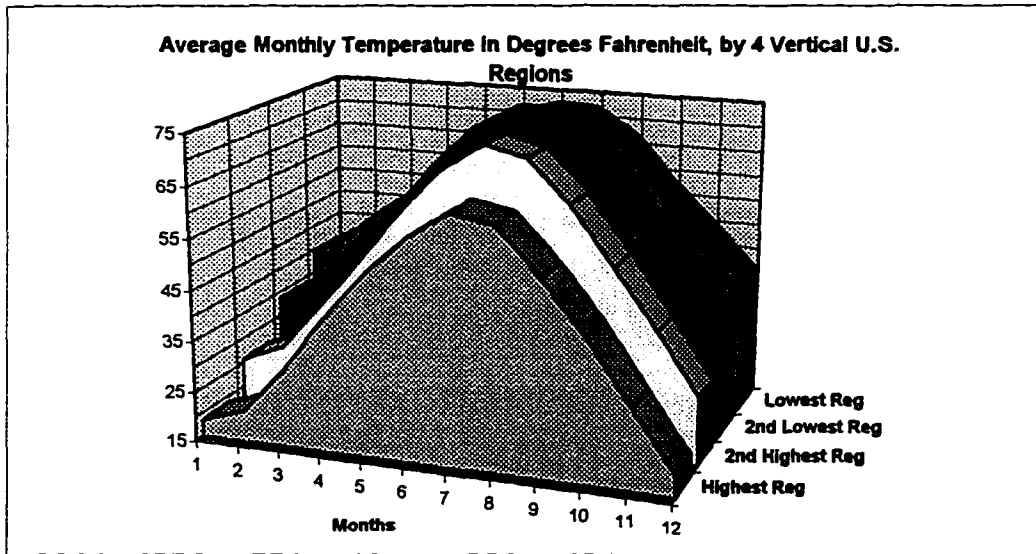


Fig 2. Normal monthly temperature and conceptions implied by live births in 4 regions of the US, 1982-1990 (deg F). Conceptions systematically show a peak during months in which temperatures are between 5° C (41° F) and 20° C (68° F) (Roenneberg and Aschoff, 1990).

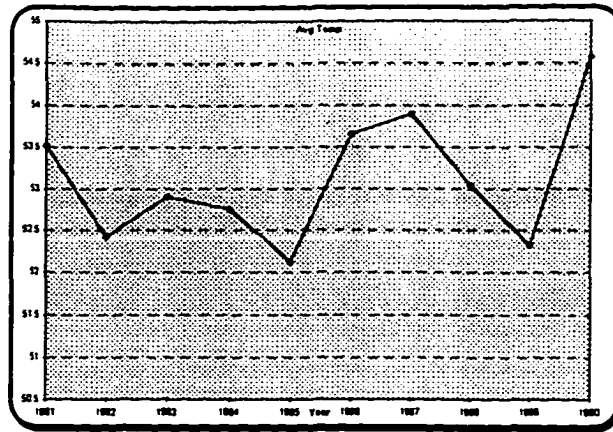


Figure 3. Average US Temperature by Year, degrees Fahrenheit

FIGURES
Observed Monthly Conception Patterns

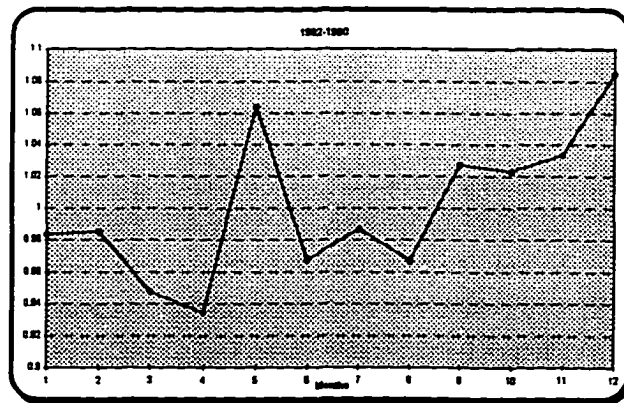


Fig.4. Per-Woman Conception Index, US, by Month, Avg over 9 years

Variation with Location in Current Study and in Existing Literature

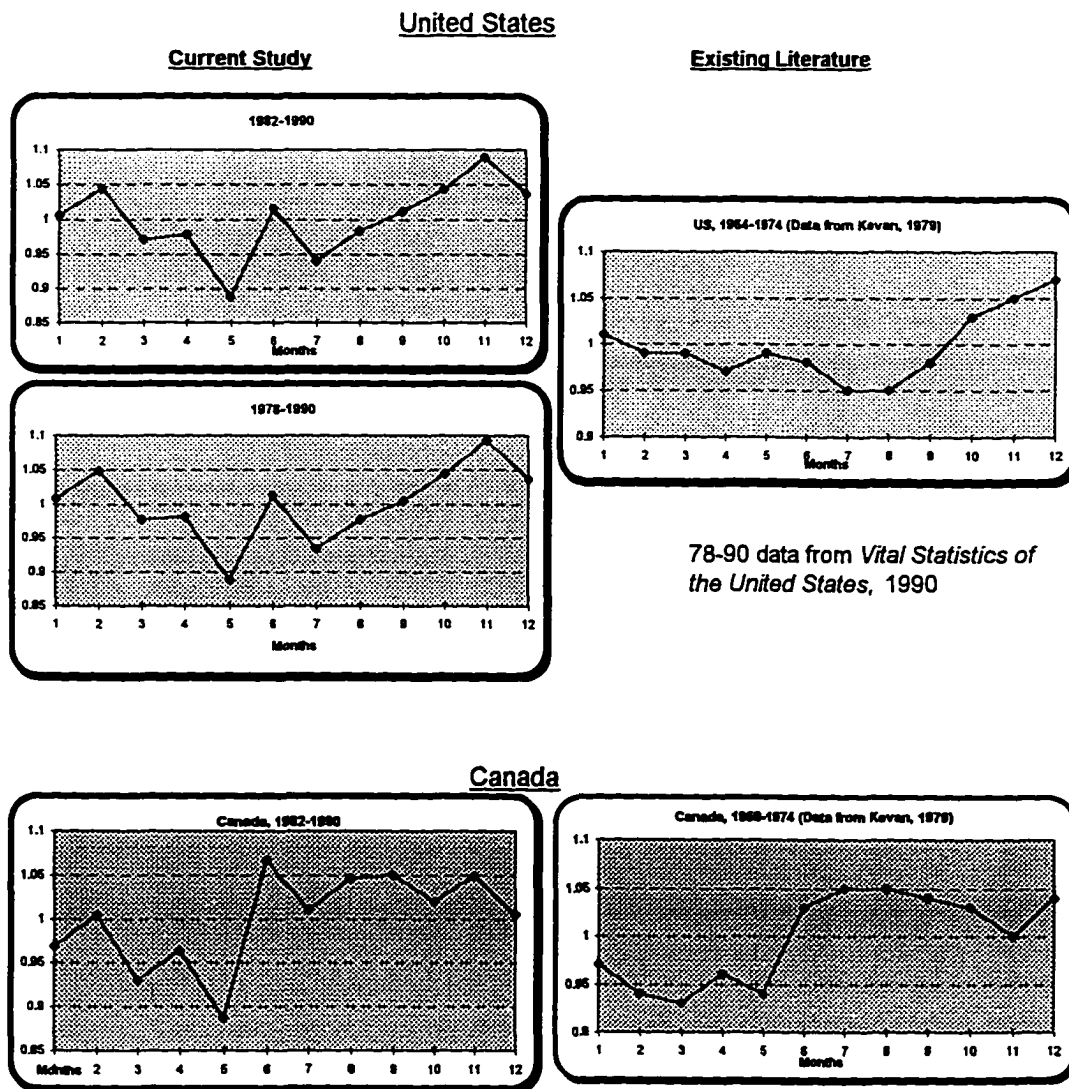


Figure 5. American and Canadian conception patterns in current study and existing literature (standardized monthly rates of conceptions that result in (aggregate) all live births).

Europe in Existing Literature

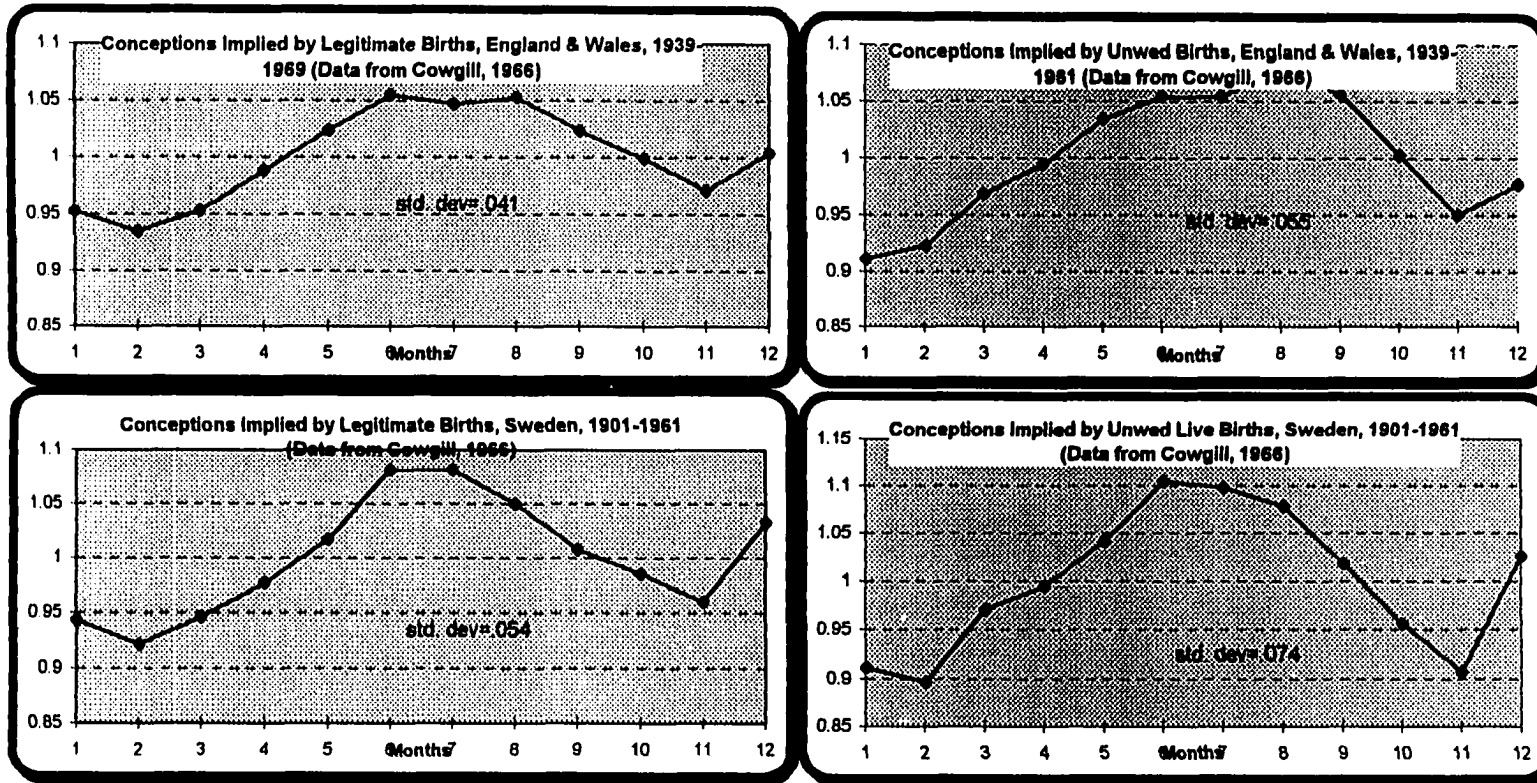
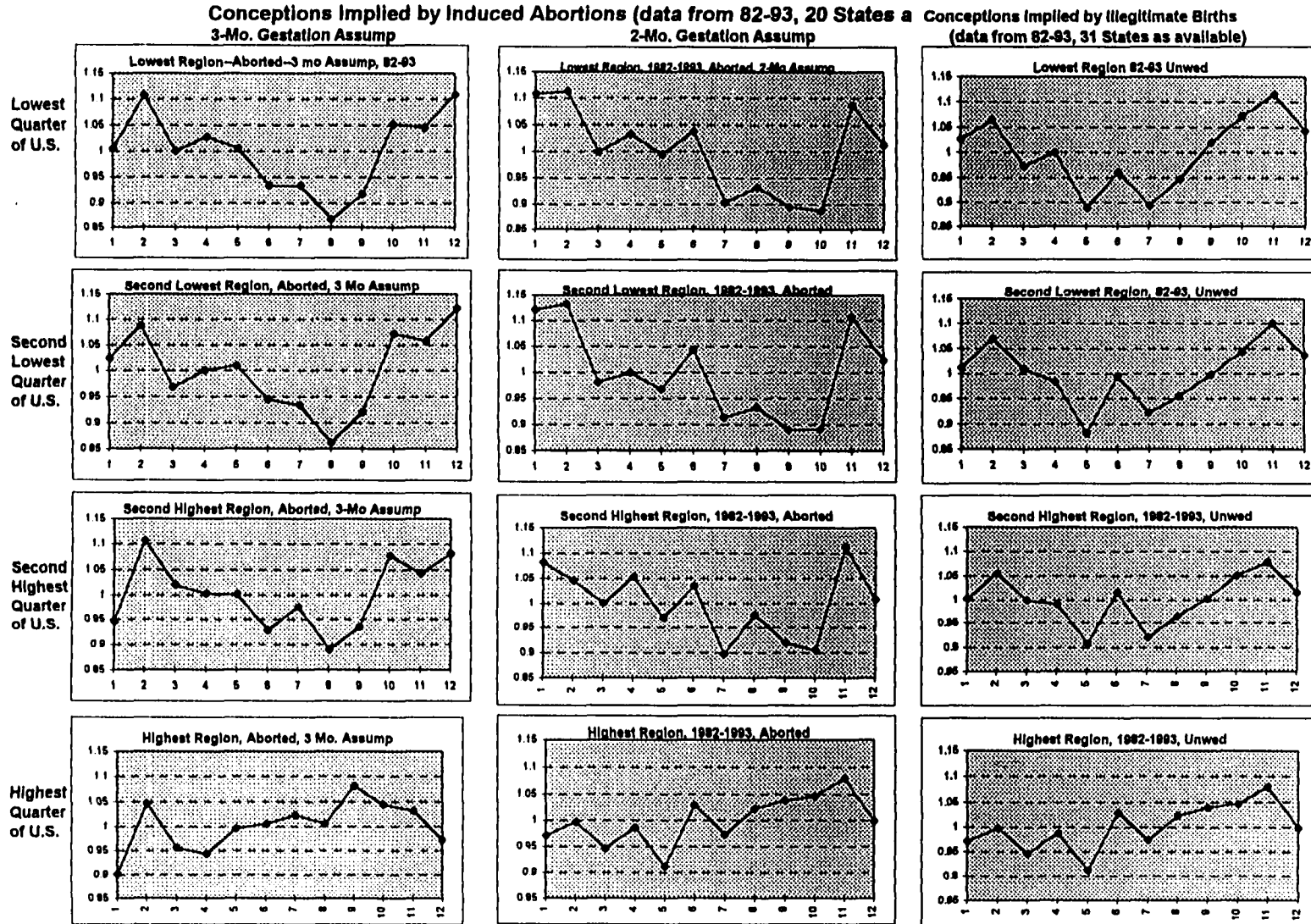


Figure 6. The European conception pattern, for legitimate and for illegitimate live births (standardized monthly rates of per capita conceptions; note that for both countries the variation in the unwed births is greater).

Fig. 7. Conceptions Implied by induced abortions and by illegitimate births, 82-93, US States as available.



Variation with Latitude

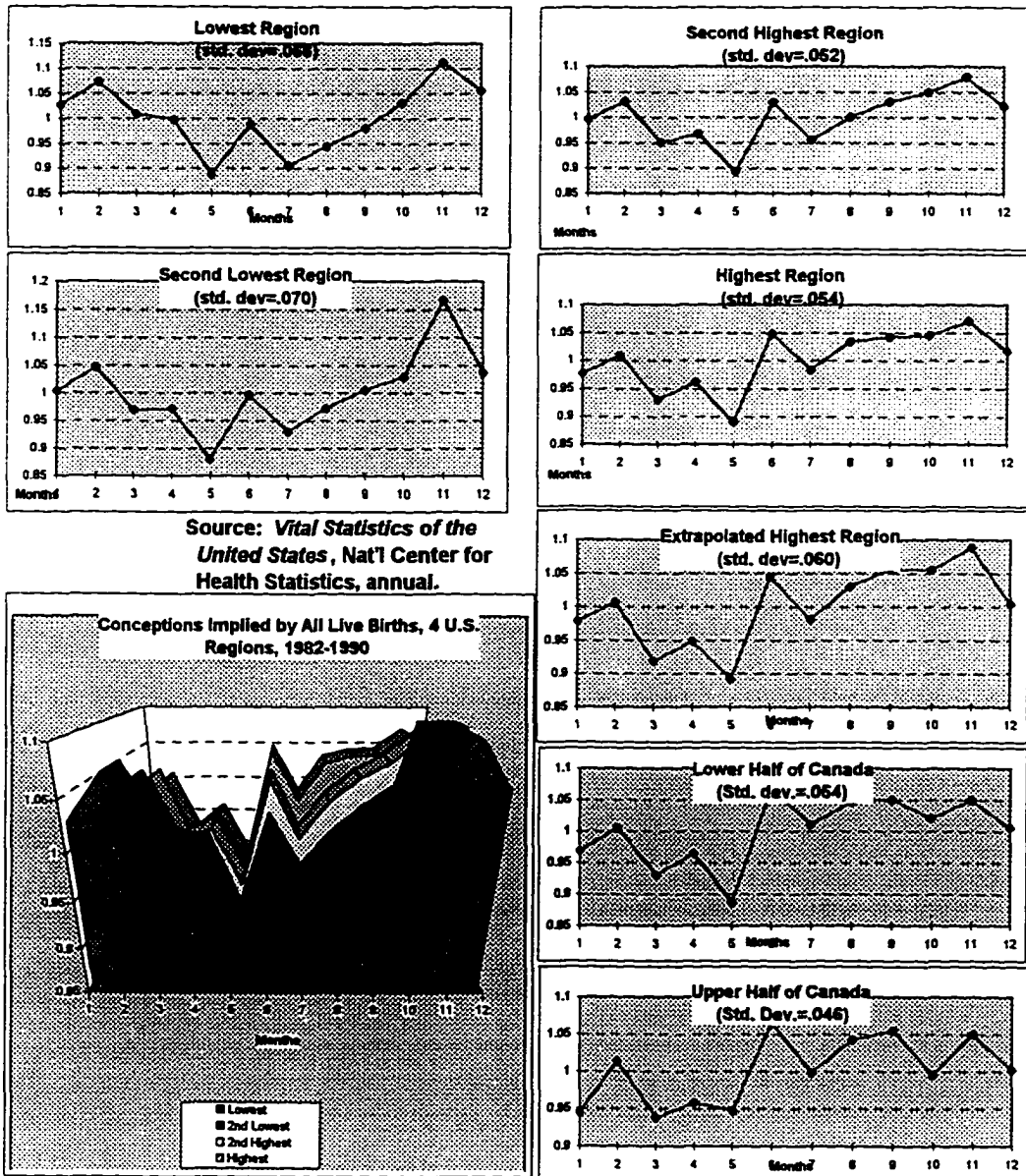


Figure 8. Variation in the North American conception pattern from lowest to highest regions (standardized monthly rates of conceptions implied by all live births, 1982-1990, by vertical quarter of the U.S and vertical half of Canada)

Variation with Time: United States (Aggregate)

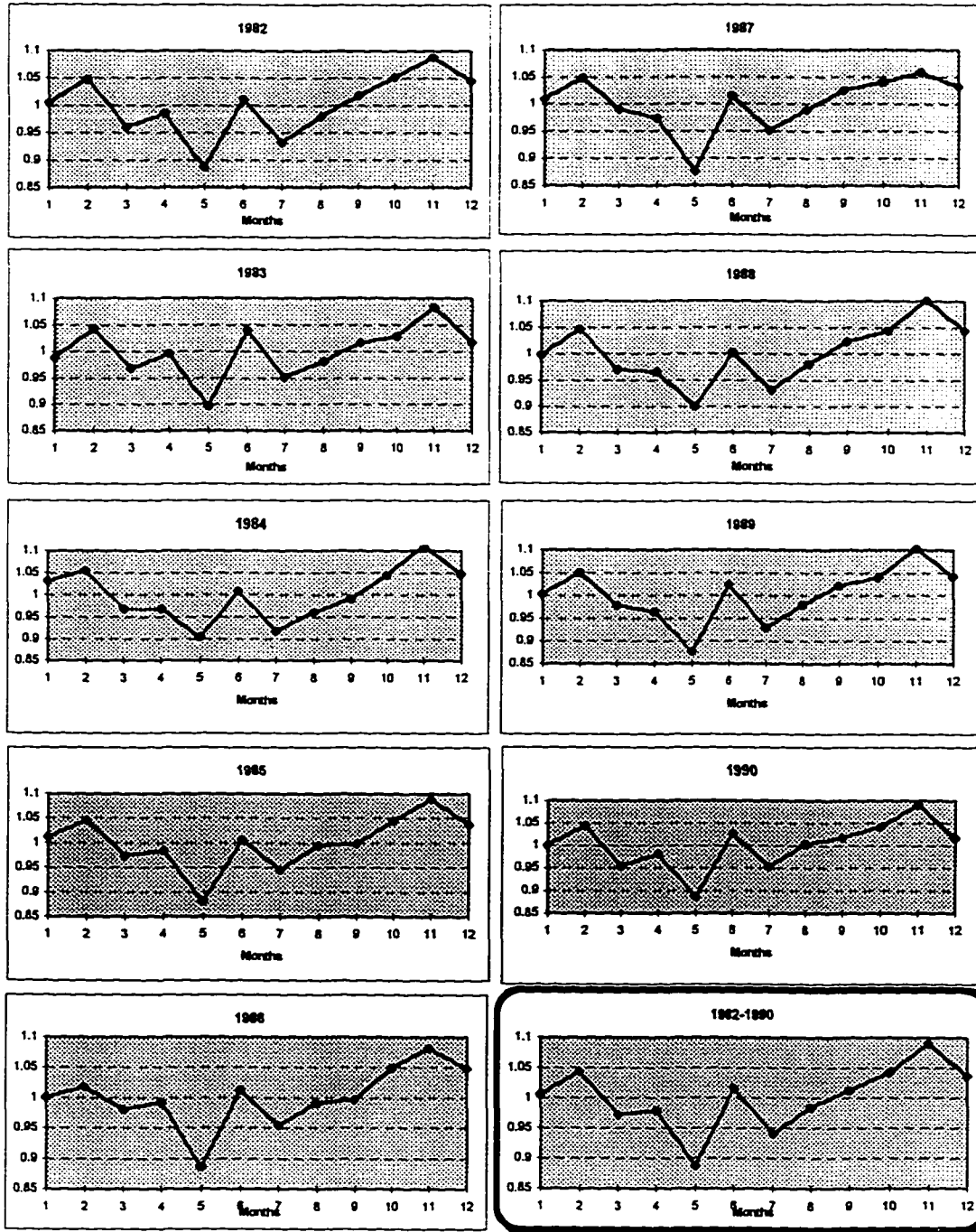


Figure 9. Monthly aggregate conception rate implied by all live births, standardized, U.S., 1982-1990.

Variation with Time: Canada

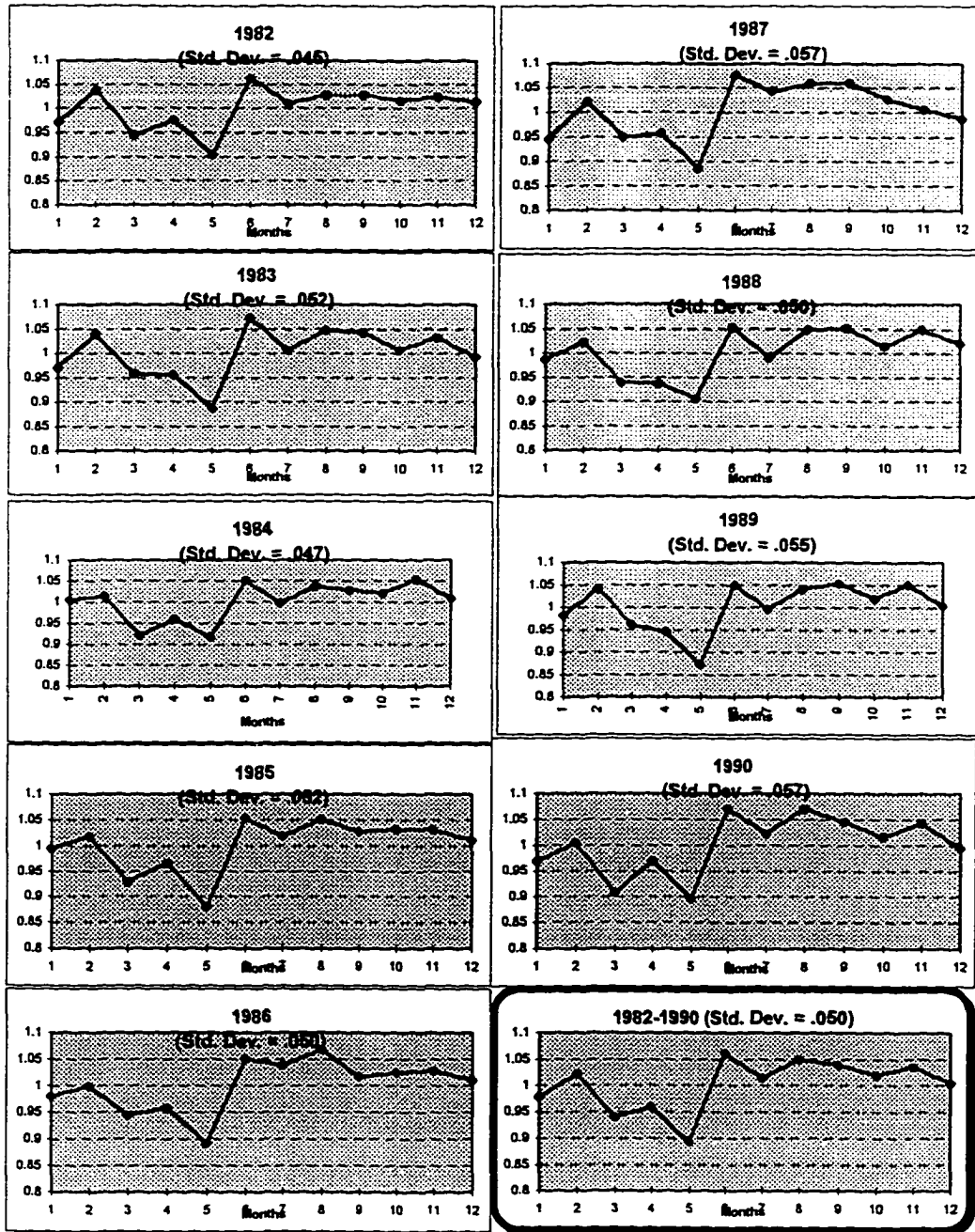
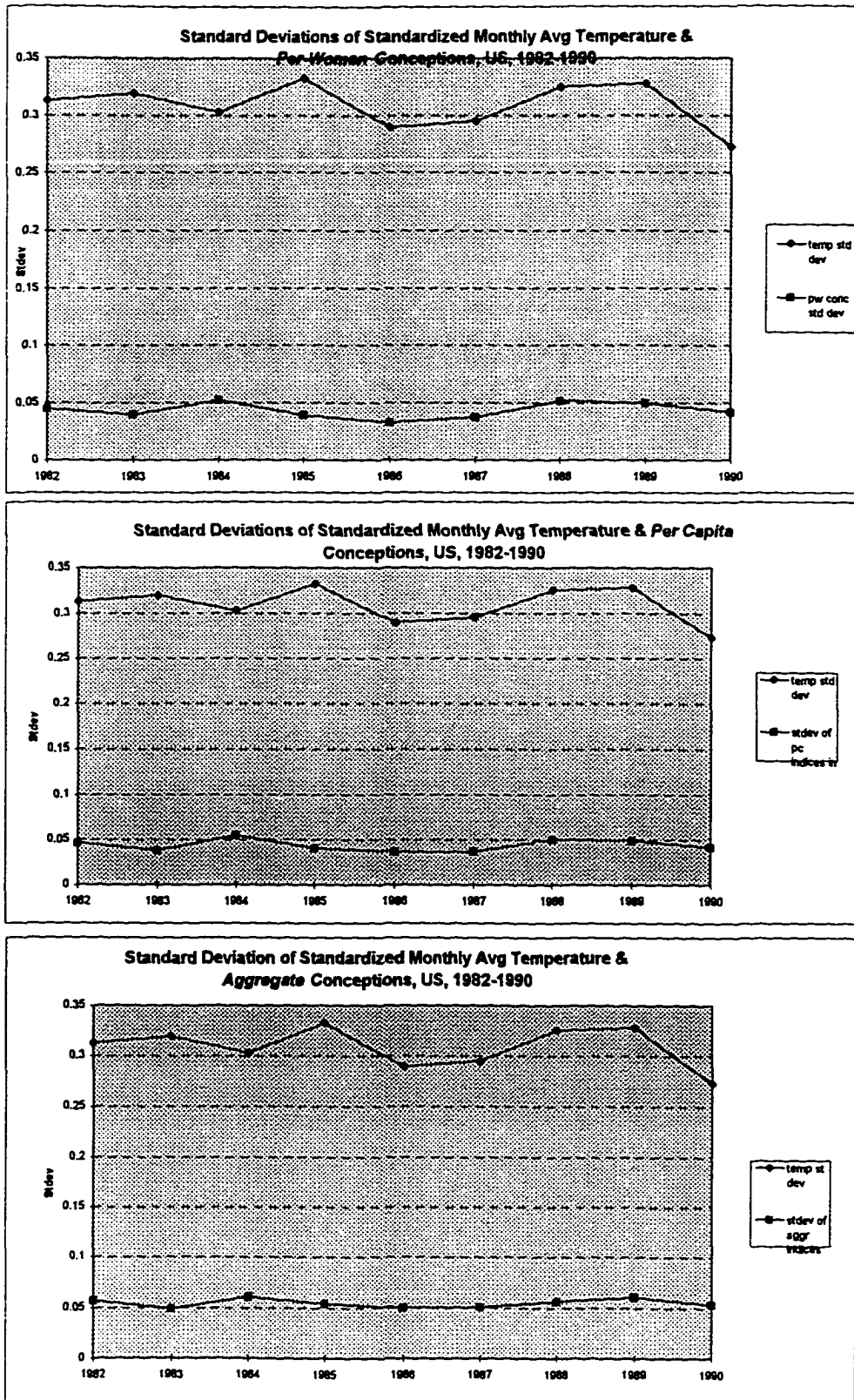


Figure 10. Annual patterns of per-capita conceptions, Canada, 1982-1990. (standardized monthly conceptions per-capita implied by all live births).

Figure 11. Variation in Temperature and Fertility Rates, by Years 1982-1990.



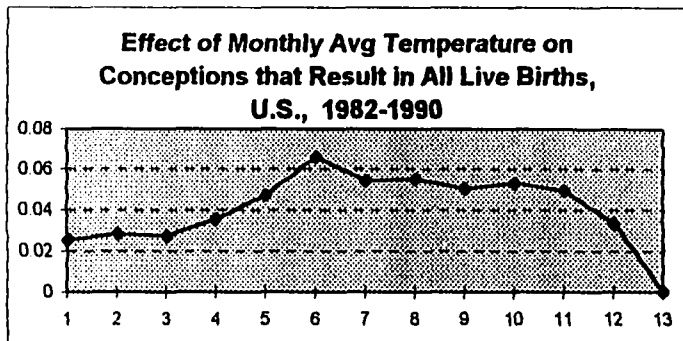


Figure 12

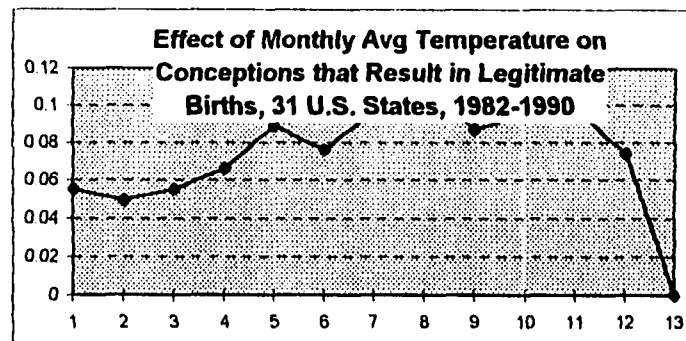


Figure 13

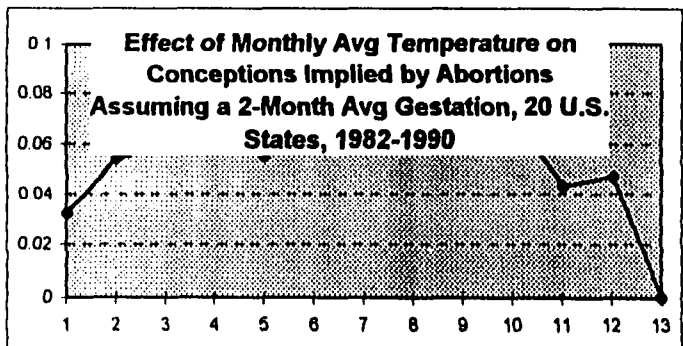


Figure 14

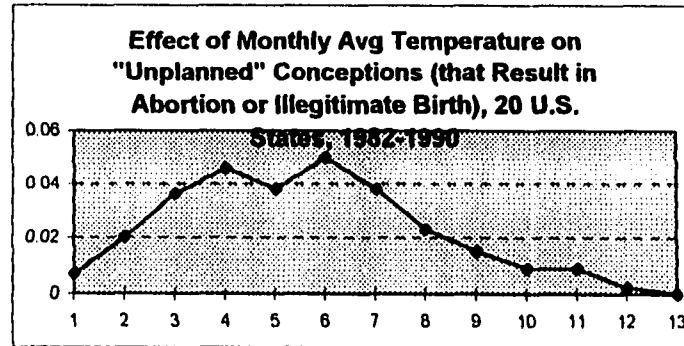


Figure 15

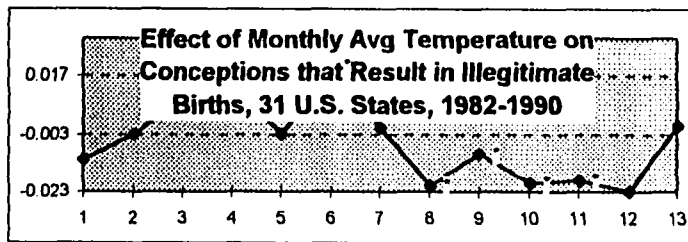


Figure 16

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