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Workload and Seasonal Variation in Birthrates: Some International Comparisons*

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RECENTLY NURGE (1970) explored the relationship between the seasonal pattern of birth rates and work load. Examining a month-by-month record of children born each year from 1886–1965 in the German peasant village of Burkhards, Nurge concluded that "more babies are born in the period when there is less work to be done." More recently, Thompson and Robbins (1973) re-examined the question of seasonal variation in conceptions employing monthly data from peasant populations in rural Uganda for 1957–1966 and Mexico for 1963–1970. Their "findings did not support, and in fact appeared to contradict the hypotheses proposed by Nurge which stress the importance of workload as a major determinant of seasonal variation in conception and birthrates". At the same time Thompson and Robbins were concerned with methodology. Although stressing the tentative nature of their findings "pending more carefully designed research", they demonstrated the importance of using "eclectic, multivariate models for exploring the multiple effects of socio-cultural and climatic variables on seasonal variations in the frequency of conception and birth."

The purpose of this paper is fourfold: first we comment on Thompson and Robbins' results in light of a more reasonable length of interval between conception and birth. Second we reassess Thompson and Robbins' conclusion regarding the importance of the relationship between workload and seasonal variation in conception relative to other factors such as rainfall, temperature and migration. Third we suggest that spectral methods provide a further means for examining seasonal fluctuations and apply this technique to the data collected both by Nurge (1970) and by Thompson and Robbins (1973). Finally we report briefly on our own investigations wherein, employing fairly extensive and wide ranging data, we attempt to relate the seasonal pattern of births to economic and cultural factors in various historical and social circumstances.

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Some Remarks on Method

Nurge as well as Thompson and Robbins calculate months of conception by "counting back nine months from month of birth".[1] Thus a birth in January is related to conception in May, leaving on average an eight month birth interval. The numbers of weeks in eight months is roughly 35. On average it is estimated that the birth interval is 38 weeks.[2] Thus only those births occurring in the last nine or ten days of the month would on average be correctly registered as conceptions eight months ago. In our example the births in the first three weeks of January should be attributed to conception in April (rather than May). We therefore have related the data to conception a full nine months before birth.

In their analysis Thompson and Robbins dichotomize all variables as lying above or below the mean and assign a value one or zero respectively. They justify this on the ground that other authors have found a curvilinear relation between climatic variables and conception, and that this dichotomization will "prevent the relationship from being suppressed". Using this method, Thompson and Robbins find that monthly conceptions in Uganda are best explained by rainfall and in Mexico by migration (zero order correlation coefficients $r = 0.645$ and $r = 0.400$ respectively). We agree that it may be easier to get a correlation if the figures are dichotomized as zero and one. All that is needed for a relationship is that the average number of conceptions in months with higher than average rainfall be greater than for months with lower than average rainfall. In fact we find that the zero order correlation coefficients using an eight month birth interval in both Uganda and Mexico are hardly affected by removing the dichotomization.[3] This correlation procedure using the original data does assume that the relationship, if any, will be a straight line. However, the plot of average rainfall against average monthly births appears from the few observations to be sufficiently close to a straight line. Despite the weakness of fitting anything with such few observations, we feel that linear regression analysis on non-dichotomized data, so that no information is lost, is equally appropriate as the use of correlation coefficients by Thompson and Robbins. Further, as well be seen particularly in the case of Mexico, the regression method shows the nature of the relationships rather more clearly.

Thompson and Robbins Reconsidered

With the illegitimate assumption of an eight month birth interval we find

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[1] Although Nurge (1970) writes "A necessary assumption I have used in my analysis is that the gestation period is nine months", she relates conception to births with an eight month interval.

[2] See Allan F. Guttmacher, *Pregnancy and Birth:* Cygnet. He estimates that on average there are forty weeks from the first day of the last menstrual period. We have made the normal assumption that conception occurs two weeks from this date.

[3] Detailed results are available from the authors on request.

as did Thompson and Robbins that rainfall is the only "significant" factor affecting conception in Uganda. The regression coefficients for workload and temperature are not significantly different from zero but are in accordance with Thompson and Robbins' result in terms of sign, indicating that (if anything) the level of conception decreases as workload and temperature increase. The combination of rainfall and temperature also results in a regression equation which is significantly different from zero with a moderately "better fit" ($R^2 = 0.58$ rather than 0.43 with rainfall alone.)However the effect of temperature is still not significantly different from zero at the 5% level.

Table 1

Monthly Conception in Uganda – 8 Month Lag Between Conception and Birth
Regression Coefficients. Conception Dependent Variable

Constant	*Temp.*	*Rain*	*Work*	*R^2* [a]	*S.E.* [a]	*F.* [a]
859.82	− 9.677 (8.76)[b]			0.1087	31.4	1.22
144.32		11.226* (4.097)		0.4289	25.10	7.51**
188.75			−12.250 (19.97)	0.0363	32.61	0.38
941.95	−11.463 (6.36)	11.817* (3.72)		0.5802	22.69	6.22**

a R^2 is the coefficient of multiple determination.
S.E. is the standard error of estimate.
F is the value of the F statistic. The F figures with a double star are significant at the 2½% level.
b The figure in brackets is the standard deviation of the regression coefficient in the line above.

Notes

a The regression coefficients of work added to rain and temperature and rain, are not included as they are not significant and did not improve the R^2 value by much.
b A star indicates that a regression coefficient is significant at the 5% level.
c The conception figures are derived from the sum of the birth figures for the nine years 1956–1968 inclusive without taking an average per year.

It is very interesting that with the assumption of a nine month interval between conception and birth, rainfall disappears as a significant factor and temperature and work remain not significant. The regression coefficient of rain against conception is now 4.32 (standard deviation 5.25). The proportion of variability explained by rainfall decreases from 43% in the case of an eight month birth interval ($R^2 = 0.43$) to 6% ($R^2 = 0.06$) with a nine month birth interval. As mentioned above, if the average birth interval is eight months three weeks, roughly a quarter of the births (those at the end of the month) are attributed to the correct month of conception by Thompson and Robbins' "eight month interval" procedure. If rainfall is a causal factor in these conceptions (it does have a significant correlation coefficient), we would also expect rainfall to be at least close to significant, when the nine month interval with roughly around three-quarters of the conceptions attributed to the correct month, is used. This is clearly not the case. We can only conclude that rainfall is not a direct causal factor.

Table 2

Monthly Conceptions in Uganda – 9 Month Lag Between Conception and Birth
Regression Coefficients. Conception Dependent Variable

Constant	*Temp.*	*Rain*	*Work*	R^2	*S.E.*	*F.*
268.20	−1.197 (9.27)			0.0017	33.19	0.02
169.15		4.317 (5.25)		0.0634	32.15	0.68
178.38			18.875 (19.45)	0.0861	31.76	0.94

Note:
Any combination of temperature, rain or work does not give a regression significantly different rom zero, so these combinations have not been included.

Furthermore, an examination of the pattern of births in each of the years 1958 to 1966 (inclusive) leads to the conclusion that the seasonal pattern of births is not very consistent from year to year. Of the nine years, January was the month of highest births in five cases, April twice, March and December each once. Only in one instance (1959–1960) was January the month of second highest births and in this case June has an equally high number.[4] Further, there was no discernable pattern of the months of lowest births. It is of interest here (as Thompson and Robbins calculate) that according to a X^2 test there is no significant seasonal pattern in 1956, 1964 and 1965. In two of these years, January was the maximum birth month. It is not enough to say that there is a seasonal pattern for six of the years taking each separately since there is no guarantee (and it does not appear to be the case) that the same pattern occurs each year. Our use of spectral analysis to test for seasonality overcomes this problem and we shall attempt to interpret this lack of seasonality in light of Thompson and Robbins' data from Amealco, Mexico and other studies we have recently completed.

We now turn to the analysis of Thompson and Robbins' data from Amealco, Mexico. In the case of Mexico there is no doubt of the existence of a consistent seasonal pattern. (See Graph I). It is thus of interest to find what factors are associated with this pattern. As mentioned above Thompson and Robbins state that urban migration has a "strong negative association" with conception in Mexico. But in fact the direct correlation coefficient of ±0.40 quoted in the text, is not significantly different from zero at the 5% level.[5] It is also true that

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[4] See Thompson and Robbins (1973), for the record of monthly births.

[5] The true correlation coefficient could be equal to zero and yet the sample value be as low as −.4 in 9.9% of cases.

Table 3

Monthly Conception in Amealco, Mexico – 8 Month Lag Between Conception and Birth Regression Coefficients. Conception Dependent Variable

Constant	*Rain*	*Temp.*	*Work*	*Migration*	R^2	*S.E.*	*F.*
806.20	0.435 (0.562)				0.057	86.02	0.560
742.72		4.907 (10.40)			0.022	87.59	0.223
850.20			−38.914 (50.37)		0.056	86.03	0.597
850.38				− 68.625 (49.70)	0.160	81.16	1.907
918.71			91.111* (48.27)	−114.181* (50.49)	0.398	72.41	2.98

Note:
The figures for conception are derived from the sum of the birth figures for the eight years (1963–1970 inclusive) without dividing by the number of years.

workload has only a weak correlation with conception (with eight month birth interval r = —0.237, significance level 22.9%). Rainfall and temperature are equally weak. Using Thompson and Robbins' dichotomized figures the correlation of rainfall with conception is 0.260 and using actual figures 0.238. As expected from this we find that if conception is regressed on each factor alone, the coefficients of the equations are not significantly different from zero. However both workload and migration become important when they are considered together. Both regression coefficients are then significantly different from zero at the 5% level.[6] (See Table 3). Some such thing should have been suspected from Thompson and Robbins' results. Their partial correlation coefficient relating conception to migration with workload fixed, is —0.602 rather than the direct correlation coefficient of −0.400. Also the correlation coefficient relating conception to workload with migration fixed, is —0.532, whereas if migration is not controlled it is —0.237. One advantage of regression over correlation analysis in this context is that variables that are significant only when taken together become much more obvious.

On an examination of the figures it is apparent that a high level of conception is associated with the lull between planting and the maize harvest (that is, August and September) and that although workload falls again in the winter months of December, January and February, increased conception is precluded by the migration of men to urban centers.

It must be noted that the relationships just calculated assume an eight month interval between conception and birth which we have already criticized. Roughly one-quarter of the births are of course attributed to their correct

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[6] Nonetheless the F statistic is such that the overall regression is not significantly different from zero at the 5% level possibly indicating that not all variables have been included or that our characterization of workload and migration is inexact.

conception month by this method. The question is, does our reasoning still hold when a nine month birth interval is assumed? At first sight, our thesis seems less credible when, with the assumption of a nine month interval, rainfall becomes the statistically significant variable with migration and workloadnot significant either by themselves or jointly. Temperature is also not important (see Table 4). However, this negative result may be due to the classification of July as a high workload month rather than a low workload month. Thompson and Robbins state that there is some disagreement on the workload level for July and it would appear that if the work in July consisted of planting continued from June, that this may be completed before the end of the month. One must remember the average conception-birth interval is eight months three weeks rather than nine months, so that births at the beginning of April would be conceived on average perhaps ten days into July and births in the middle of April toward the end of July. Thus with a full nine month lag assumed between conception and birth, conceptions attributed to any month should fall towards the later part of the month. (Conversely, with an eight month lag between conception and birth, conceptions attributed to any month should occur at the beginning.) Given this argument it would seem appropriate to assume July is a low work month when we use a nine month birth lag. With this, workload and migration again become statistically significant at the 5% level when used together to explain conception. This time not only are the individual coefficients significantly different from zero at the 5% level, but the overall regression, as indicated by the F statistic is significant at the 5% level (see Table 5).

Table 4

Monthly Conception in Amealco, Mexico
– 9 Month Lag Between Conception and Birth
– July a High Work Month (See Text)
Regression Coefficients. Conception Dependent Variable

Constant	*Rain*	*Temp.*	*Work*	*Migration*	R^2	*S.E.*	*F.*
769.95	1.176** (0.44)				0.413	67.85	7.035**
679.95		8.541 (10.16)			0.066	85.59	0.707
836.20			−14.914 (51.64)		0.008	88.19	0.083
848.37				−62.625 (50.49)	0.133	82.44	1.539
890.71			−56.444 (57.79)	−90.847 (57.30)	0.225	82.19	1.305

In this situation rainfall is still correlated with conception (significant at the 2½% level), however this does not prove that it is a causal factor. We wish to argue that the workload-migration hypothesis has more intuitive plausibility. The fact that workload and migration are only characterized as high or low could very easily lead to a less than perfect fit. This interpretation is strengthened by the observation that when all three variables are in the same equation, there is an obvious case of multicollinearity with no variable, not even rainfall, statistically significant, and very little increase in explanatory power (the R^2 increases from 0.508 to 0.557 with the addition of rainfall). The zero correlation coefficient of rainfall with migration (—0.642) is in fact significantly different from zero at the 5% level, indicating that rainfall is highly correlated with migration.

Table 5

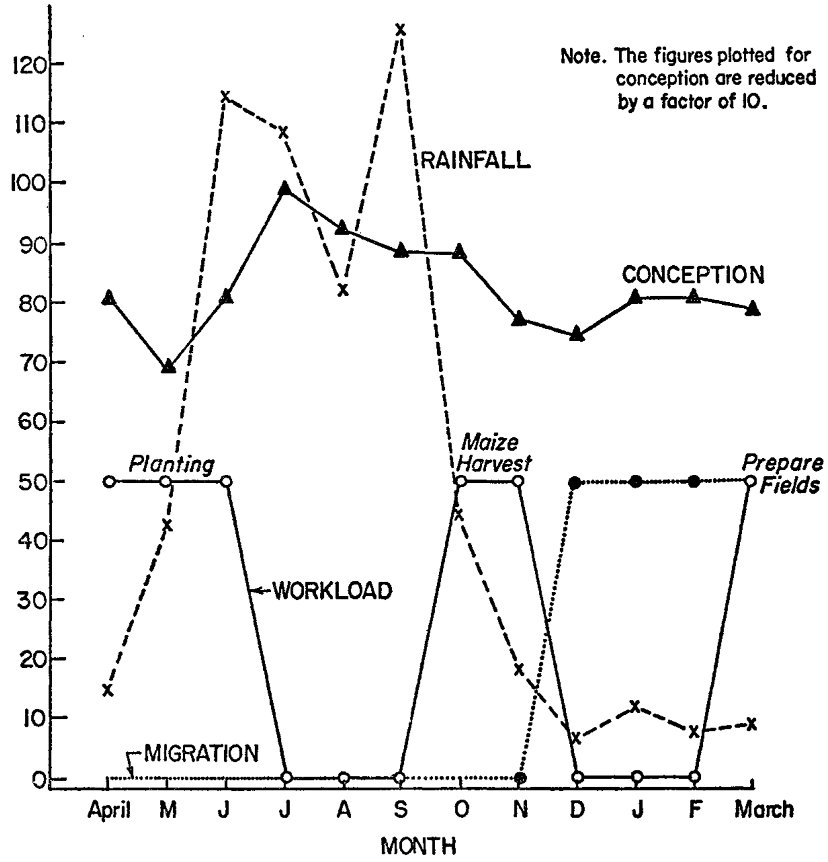
Monthly Conception in Amealco, Mexico
– 9 Month Lag Between Conception and Birth
– July a Low Work Month (See Text)
Regression Coefficients. Conception Dependent Variable

Constant	*Rain*	*Temp.*	*Work*	*Migration*	*R.*	*S.E.*	*F.*
769.95	1.176**				0.413	67.83	7.035**
	(0.443)						
679.94		8.541			0.066	85.59	0.707
		(10.16)					
863.33			– 71.667		0.196	79.38	2.445
			(45.83)				
848.38				– 62.625	0.133	82.44	1.539
				(50.49)			
914.48			–102.286*	–105.762*	0.508	65.49	4.642*
			(42.88)	(40.42)			
853.19	0.646		– 78.955	– 53.401	0.557	65.91	3.351
	(0.686)		(49.66)	(67.52)			

Assuming July is a month of low workload the relationships are illustrated in Graph I. The three month period when conception is highest, July, August and September, corresponds to the lull in work between planting and maize harvest. The fact that conception is still low in the low work months of December, January and February is explained by high migration.

Worlkoad as a Factor Determining Seasonality of Births

Thompson and Robbins (1973: 680) claim that Nurge (1970) "assigns a disproportionate emphasis to the association between workload and birthrate". Other factors such as rainfall, temperature and migration are considered just as important. For instance, in the case of Buddu, Uganda, they indicate (using an eight month birth interval) that rainfall increases conception; yet with a nine month birth interval we have shown that rainfall loses its significance. Furthermore from the data, the pattern of births in Buddu is not regular. This lack of pattern is confirmed by spectral analysis. Thompson and Robbins argue that migration is unimportant for Buddu and that "the workload situation in Uganda is complex not only because of recent agricultural innovations, but because agricultural activity seems rather evenly distributed throughout the year." Thus the lack of seasonality in conception could be a result of a fairly even



workload. The difference between a workload stated to be high and one stated to be low by Thompson and Robbins may be too small to have any effect.

In the case of Mexico, Thompson and Robbins argue that migration is the important factor. We have shown that when combined with migration, workload is also significant and that the two together give a much better fit than migration alone. It seems very plausible that a light workload would increase conception but only if the men have not migrated to the city to seek or accept temporary employment. Thus from our reanalysis of the data used by Thompson and Robbins, it seems that workload (or workload plus migration) may indeed be the factor(s) requiring most emphasis in determining the monthly level of conception.[7]

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[7] Nurge (1970) puts forward a number of hypotheses some of which do not hold for the Mexican or Uganda data; e.g. conceptions increase when workload is high because of increased physical fitness. The high births in Burkhards, Germany in March were related to conception in July (in the heavy summer work period). However with a nine month birth interval births in March should be related to conception in June, when the heavy summer work is only just beginning. (Haying begins in June). Thus it is not clear whether

It is particularly interesting that this finding is in accordance with the results of other studies that we have recently undertaken using data from very different areas: Belgium between 1636 and 1795 (Spencer, Hum, Deprez 1974) and Jamaica between 1880 and 1938 (Hum, Lobdell, Spencer 1975). Both studies indicate that for rural communities the pattern of agricultural activities is an important determinant of the pattern of births. Both workload and migration would be indicators of this pattern. We shall discuss these studies further in the next section on spectral analysis.

Spectral Analysis to Further Investigate Seasonality

Seasonality in data series may be fruitfully investigated by the use of spectral methods.[8] Spectral analysis is, in essence, an analysis of the variance of a time series in terms of frequency. Frequency is simply the inverse of the intuitive concept of "period". For a variabale containing a cycle of specific period (or frequency) the importance of this cycle can be measured as the reduction in variance effected when this component is removed. Spectral techniques are therefore appropriate for detecting regular periodicities in data possibly composed of a mix of different cycles ranging from short term seasonal fluctuations to longer term movements extending perhaps over periods of several years. Once a data series is decomposed into its component frequencies, one may then speak of the relative strength of various cyclical components by referring to the spectrum, which is simply the plot of the amplitude of various components against frequency. If the estimated spectrum reveals clear peaks at certain frequencies, then this suggests that cycles of particular lengths are important. On the other hand, if the estimated spectrum is flat, this indicates that fluctuations about the mean are completely random; that is, the series is a sequence of uncorrelated readings since all components are equally present.

Spectra for Buddu, Uganda and Amealco, Mexico, employing the published data of Thompson and Robbins (1973) and for Burkhards, Germany,[9] were estimated, with and without detrending. In some instances, a number of different "lags" were tried as well. The estimated spectra for Uganda and for Burkhards were without pattern and erratic, indicating virtually no seasonal pattern whatsoever. However, the estimated spectrum for Amealco, Mexico clearly indicated the presence of a seasonal component and its spectrum shape

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this hypothesis would hold with a nine month interval. However, the statements regarding workload at various months are not sufficiently clear to warrant further analysis. Also the level of births in each month is small with many months of no births. This makes statistical analysis more difficult.

[8] It is not possible to give a full account of these statistical techniques within a short compass of space. Application of spectral methods to the problem of seasonality in births is given in Spencer, Hum and Deprez (1974).

[9] The monthly record of births for Burkhards, Germany was generously made available to us by Dr. Nurge. She also enclosed copies of her field notes and other pertinent information. We should like to take this opportunity to express our sincere appreciation for her co-operation.

was remarkably similar to spectra obtained for month-by-month records of birth in rural Belgium (1636–1795) and Pavia (1577–1700) and studied by Spencer, Hum and Deprez (1974). The birth pattern in rural Belgium differed from that of the urban center of Liege in that there was an increase in conceptions after the harvest was completed giving some support to the workload hypothesis. Pavia, a small city in Italy with close ties to the countryside, retained the rural pattern. It is indeed significant that spectra obtained from contemporary Mexican data compares so favourably with historical European demographical data.

Additionally, a further investigation of the relationship between workload and the seasonal variability of births for Jamaica in the period 1880–1938 was undertaken by Hum, Lobdell and Spencer (1975). As well as exploring other factors of a socio-economic nature, it was hypothesized that parishes given over to the cultivation of highly seasonal crops for staple export would have a relatively marked seasonal pattern of workload distribution. On the other hand, parishes in which the agricultural activity is organized for domestic production often used practices of crop rotation which ensures continuous supplies of domestic foodstuffs. This leads to a more evenly distributed workload rhythm. To show that the variability of birthrates (measured by the coefficients of variation) differed between export and domestic crops classical analysis of variance techniques were employed. In fact the variability of birthrates among parishes dominated by export crops was significantly greater at the 1% level.[10] Spectral analysis was also applied to the birth records of each of the fourteen administrative parishes of Jamaica over the whole period and two sub-periods. Using this method it was also found that parishes given over to cultivating staple exports had a markedly higher seasonal component. It is clear that spectral techniques represent another important tool for "exploring the multiple effects of socio-cultural and climatic variables on seasonal variations in the frequency of conception and birth." (Thompson and Robbins, 1973: 676).

One of the problems of the Jamaican study was that only quarterly data was available. However we were able to make a rough correspondence between the period of harvest for the main seasonal export crop, sugar, and the level of conception. In fact, as expected by the workload hypothesis, conception was least in this heavy workload period.

We conclude that although other factors such as temperature, rainfall, cultural factors may have some influence on the seasonal pattern of conception, workload and migration are the more important variables.

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[10] The parishes were classified in as objective a manner as possible by employing acreage figures for various crops and plantations for each administrative parish of Jamaica. For a discussion of the economic, historical and social circumstances of Jamaica during this period together with the full statement and tests of the hypotheses see Hum, Lobdell and Spencer (1975).

Concluding Remarks

This paper has re-examined contradictory evidence associating the workload pattern and seasonal variation in birthrates. Assuming a nine-month interval between conception and birth, multiple regression methods were employed to reassess the conclusions reached by Nurge (1970) and Thompson and Robbins (1973). In addition, spectral techniques were used to ascertain the presence of seasonality. We conclude that light workload will increase conception but seasonal migration patterns are also very important since during periods of light workload men may seek temporary employment outside the village. Our wider data set however should sound a note of caution in attempting to apply general hypotheses to different historical and social circumstances. While spectra estimated from a variety of data sources were remarkably similar it must be pointed out that analysis of the Uganda and Germany data revealed no seasonal pattern at all. On the other hand, Mexican data revealed a clear pattern as did the authors' previous work on rural Belgium and certain Jamaican parishes dominated by staple export cropping patterns.

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