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Correlations and causal relationships between historical climatic indicators and price data

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सार – ऐसे गुणांकों को ज्ञात करने के लिए जिनके द्वारा मूल्य के आंकड़ों से पिछले वायु तापमानों का अनुमान लगाया जा सके, लिबी (1977) ने गेहूं के मूल्यों में परिवर्तन और गेहूं से मजदूरी तुल्यांकों को उपकरणों से अंकित किए गए वायु तापमानों से संबंध स्थापित किया था ।

किन्तु जनसंख्या (सामान्यतः मांग की) में परिवर्तन का मूल्यों पर निर्णायक प्रभाव को अनदेखा कर दिया गया है । गेहूं के एवज में मुद्रा के परि-वर्तित होते हुए मान का प्रावधान भी अपर्याप्त है, और वायुतापमानों और अनाज के मूल्यों के बीच सुझाया गया संबंध लम्बे समय तक स्पष्ट नहीं होता है ।

तदनुसार मूल्य के आंकड़ों से सहसंबंधों से व्युत्पन्न तापमान के पैमानों की वैधता को स्वीकार नहीं किया जा सकता है ।

ABSTRACT. In order to generate coefficients by which air temperatures in the past may be estimated from price data, Libby (1977) relates changes in the price of wheat, and in the wheat equivalents of wages, to instrumentally recorded air temperatures.

However, the crucial effects on prices of changes in the population (and of demand generally) are neglected; the allowance made for the changing value of money in terms of wheat is inadequate; and the suggested relationship between air temperatures and grain prices is not evident in the long term.

Accordingly, the validity of temperature scales derived from correlations with price data cannot be accepted.

1. Introduction

In a recent article in this journal, Professor Libby (1977) correlates changes in the *'silver'* price of wheat and in wheat equivalents of wages with instrumentally-recorded air temperatures, in order to generate coefficients by which air temperatures in the more remote past may be estimated from price data. As the establishment of a clear association between changes in climatic and economic variables would be a major achievement of scientists and historians concerned with long-term historical change, and as the paper has been mentioned in studies of climate and history by distinguished scholars (Lamb 1977 : 462; Bryson & Murray 1977; 76), it is imperative to note weaknesses in its underlying model. Correlations are of value only if they are associated with an acceptable explana-

tion of causation; and in economics as in science, inadequacy in the logical structure or specification of the causal models vitiates conclusions based thereon (*e.g.*, de Vries 1980 : 605-8).

Libby's model is based on the implicit proposition that variations in air temperature bear a constant relationship to variations in the supply of wheat, which in turn affects its market price in a regular way. It is recognized that two major related variables affecting wheat prices changed in the period under review (1250 AD to the present) : population rose and the value of money declined. However, the crucial effect on price of changes in population—and demand generally—is neglected, the allowance made for the changing value of money relative to wheat is inadequate, and the suggested relationship between

air temperatures and grain prices is not evident over the long term.

2. Methodology

The fundamental error in the model is that supply is emphasized as a determinant of price to the exclusion of consideration of demand. The causal relationship implicit in the model is that air temperatures (and hence climate for which they are treated as a proxy) have affected the quantity of grain through influencing harvests, which in turn has determind the trend of grain prices and of the *real* value of wages. However, the emphasis on supply in a study of long-term conditions is misplaced. Price is determind by the interaction of supply and demand, and until the 19th century demand was the more important in that it showed the greater variation in long-run trend.

In examining supply conditions in agriculture, it is intuitively obvious that fluctuations in the weather — by affecting the harvest yield — can affect the quantity of grain available and therefore, as demand is relatively constant in the short term, its price. However, this inverse relationship which exists in the short term between yield and market price does not hold in the long terms. On the contrary, as far as evidence is available it indicates that movement in long-run average yields in Europe was the consequence, rather than the cause of price variation. Over time, yields appear to have been directly correlated with prices, the causal connection between price and productivity being the profitability of effort and investment in the agrarian sector (Slicher van Bath 1977 : 82).

Demand, the other determinant of grain prices, depended in the long run largely upon the size of the population; and population fluctuated widely during the relevant period. A population decline, beginning perhaps early in the 14th century and dramatic in the century following the Black Death of 1348—51, resulted in a greater fall in demand for grain than in its supply, and wheat prices declined markedly. Resumption of population growth in the late 15th or early 16th centuries, and consequent pressure on resources,

was a major cause of the general inflation which characterized the 16th and early 17th centuries, and earned the appellation of the 'price revolution' (Ramsey 1971 : 12). At the same time, the labour abundance created by the rising population led to a downward pressure on real wages. For these reasons, rather than reflecting a climatically-induced variation in supply, the trend of the purchasing power of wages was a mirror image of the trend of long-run population change (Abel 1980 : 293). This relationship ceased to exist in the 19th century when increased agricultural efficiency, the expansion of farming in non-European lands (Jones 1979 : 35ff), and improvements in transport technology, made greatly increased supplies of grain available to European markets.

In general, any effects of climatic change on agricultural productivity, and through this on prices, would have been submerged in the demonstrable effects of demographic, economic, and technical change (Anderson 1981a; 1981b); a conclusion calling into question indices of climate based on prices.

3. 'Normalization' for monetary factors

The allowance made for price inflation is inadequate. In the key series cited, wheat prices have been expressed in ounces of silver per kilogram of wheat rather than in units of the money of account, *i.e.,* wheat prices are normalized (p. 243) by computing the ratio of wheat prices to the (penny) price of sterling (silver per ounce). While this would in principle be useful in eliminating the effects of debasement of the coinage, it neglects the other *'monetary'* sources of price increases. These are variation in the availability of precious metals for monetary purposes, and in the efficiency of the use of a given stock of coin; the latter reflecting the development of credit instruments and financial institutions. To take one example, the quanity of monetary silver — as distinct from the quantity of silver in the money — varied considerably in Europe. A chronic scarcity was experienced in the late Middle Ages, while from the late 15th century

the supply was replenished from the central European mines, and in the 16th and early 17th centuries from those of Mexico and Peru (Miskimin 1977 : 20ff). Or again, the use of various forms of paper money, well established by the 17th century, progressively supplemented the supply of metallic currency. An additional point is that it is not appropriate to supply an index of debasement of English coinage to the prices of wheat quoted in Dutch guilders, because the two currencies were subject to out-of-phase variations in value occasioned by factors pecular to each.

4. The Data

The diagrams present a number of puzzles. There is no obvious way whereby the ineresting similarity of the temperature coefficients derived from the temperature trends and 'silver' price of wheat index (Rs) for 1745-1800, 1800-1875, and 1800-1900, can be rigorously tested for significance. Further, the reasons for the selection of these periods are not clear. The criterion specified is movement in the series from peak to valley, but the remarkable temperature trough about 1700 is ignored, and it is difficult to discern a 'valley' about 1875 in the trend of either Rs or of air temperatures. 'Peaks' in the temperature and (inverse) price trends at 1900 are shown only by the termination of the graph. In terms of the implicit model, rising air temperatures in the 19th century (a proxy for climatic amelioration) should have been associated with falling prices, these variables presumably being linked by an increase in supply due to improvements in the harvests. Yet the late 19th century was notorious for spells of bad weather and poor harvests (Parry 1978 : 171-4). In any case, the veritable flood of grain imports in the final third of the 19th century would render nugatory any postulated relationship between grain prices — determined on a world market — and air temperatures in central England.

Finally, inferences concerning air temperature which are drawn from the application of the temperature coefficients to the long-run change in the 'silver' price of wheat (p. 250) are not in accord with other estimates of the nature of the European climate during the last millennium. It is generally accepted that a medieval warm period or optimum, was followed by a deterioration of the climate to the Little Ice Age, the most intense phase of which occurred in or about the seventeenth century (e.g., Lamb 1972: 236). However, although raininess seems to have increased towards the end of the thirteenth century, there was hardly a climatic minimum as claimed by Libby (p. 249). Temperatures were still high (Lamb 1977 : 430), and not lower than those of the Little Ice Age as would be inferred from the Rs diagram (Libby : 249). Similarly, the local climatic 'pessimum' about 1800 — coincident with the great economic stress and financial disruption of the Napoleonic Wars— does not appear to have been as severe in England as that shown by the temperature data as having occurred about 1700. The latter 'pessimum' however finds no reflection in the trend of the silver price of wheat (p. 249).

5. Conclusion

In view of the problems of methodology and data in this model, and the general uncertainty surrounding the causal relationships between climatic parameters and market prices even in climatically 'marginal' areas of Europe (e.g., Pfister 1978 : 242), it would seem proper at present to reject the validity of temperature scales derived or extrapolated from correlations between movements in recorded air temperatures and wheat prices.

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