Forecasting by Means of Cycles

By E. R. DEWEY

A primary use of cycle knowledge is to enable us to forecast. It is the business of science to predict.

Obviously, if there are rhythmic cycles in a series of figures, and if these cycles are of non-chance origin, the presumption should be that they will continue. And mostly they do. Thus, a mere projection of these cycles will normally throw light upon the future.

The purpose of this article is not to tell you how to find the cycles, or how to definitize, evaluate, and project them. All of this has been treated elsewhere. The purpose here is two-fold: first to show that cycle knowledge is useful for projecting trend and randoms as well as for projecting cycles as such; and second to show that there are certain pitfalls with which you should be acquainted before you attempt to project cyclic behavior into the future.

As has often been stated, a time series – a succession of numerical values arranged in order of time – has three factors (or elements, or components): 1) trend, 2) the cycle or cycles, and 3) randoms. A knowledge of cycles is of help in projecting all of these three elements into the future.

TREND PROJECTION

First of all let me speak of trend. Trend is that element in a time series that changes its direction slowly. It is the element that represents growth. It is the upward sweep that you see when you chart the figures on a sheet of graph paper. This upward sweep can be idealized in any one of a number of different ways and this idealization can be projected into the future to show what the underlying growth element will be if growth obeys the same laws in the future as it seems to have obeyed in the past.

Projection of a trend is very tricky and will not be discussed in detail at this point. What I want to point out here is merely that the upward sweep that you see when you look at a chart of a time series is not the real trend at all. It is a mixture of trend, cycles, and randoms. To know what the true trend has been you need to remove the randoms and the cycles. Smoothing processes of one sort or another, or curve fitting, will remove the randoms and the short cycles. But normal procedures of this sort will not remove the longer cycles. However, the longer cycles *must* be removed before we can know what the underlying trend really has been and is. And knowing what the trend has been and is, is a prerequisite to projecting it.

Let me give you an example. Suppose a certain series of figures has evidenced normal growth and, in addition, has a 50-year cycle cresting in 1850, 1900, and 1950. That is, the *cycle* will be going up from 1875 to 1900 and from 1925 to 1950. Conversely the *cycle* will be going down from 1850 to 1875, from 1900 to 1925, and from 1950 to 1975. The trend and the cycle are charted in Figure 1.

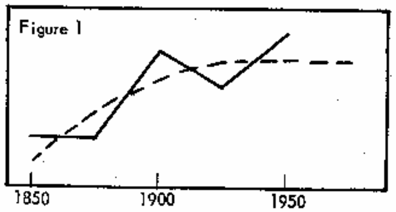

Figure 1

When the cycle is in its upward phase (or leg) it will reinforce the underlying growth and make it *seem* stronger. Conversely, when the cycle is in its downward phase it will tend to offset the underlying growth and make it *seem* weaker. Thus if, in 1900 or 1950 at peaks of the cycle, you were to look at the actual figures that contain both the growth element and the cycle, the trend will seem stronger than it really is. And conversely in 1875, and 1925, at troughs of the cycle, the trend will seem weaker than it really is.

But the trend, like the equator, is an imaginary line. You can not see it when you look at the actual behavior. What you actually see, for the example given, is shown in Figure 2. (In real life the curve will be beclouded by other cycles and by random.) It is from a study of this curve that we must deduce (guess) the underlying trend.

Suppose we are doing our guessing in 1950 when the cycle is at its crest. We might guess the underlying trend to be strongly upward as charted by the broken line in Figure 3.

Suppose, however, we are doing our guessing in

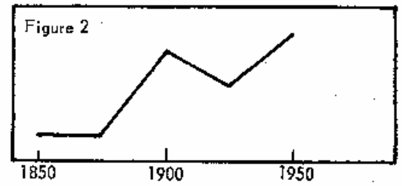

Figure 2

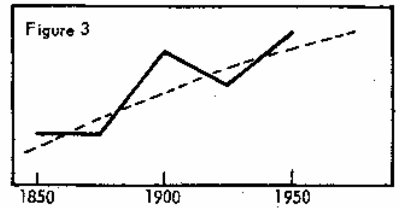

Figure 3

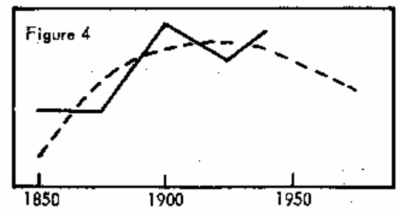

Figure 4

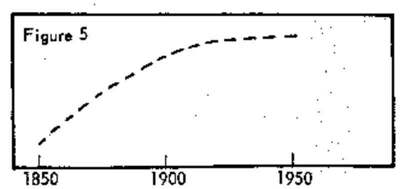

Figure 5

1940 when the upward leg of the 50-year cycle is only a little over half completed. If we did not know about the cycle our projection might well be as in Figure 4.

Obviously, neither projection is correct. As we know (from construction) the true trend is the one shown by the broken line in Figure 1.

If, however, at any place along the line from 1850 forward we had adjusted the composite curve (Fig. 2) for the effect of the 50-year cycle we would have obtained the growth curve as shown by the broken line in Fig. 1 (or by itself as Fig. 5). This curve changes its direction so slowly and so smoothly that it would have been easy in 1950, or indeed in 1940, or any other year, to have projected it a number of years into the future.

What I have said so far is an oversimplification of a very complex matter. It implies that one can be sure of long cycles that have repeated only a few times; that there is a real growth element that can be determined accurately; and that this growth element can be projected for considerable distances into the future. All of these implications are untrue. And yet it is true that, for every forecast, trend *must* be projected, that to project trend we must know, as nearly as possible, what the trend has been, that long cycles make the trend look different from what it really is, and that therefore these long cycles *must* be determined as accurately as possible and adjusted for in order to get a realistic projection of trend.

I have spoken of long cycles. How long is "long?" This term is relative. In 1,000 years of figures it would probably be enough to remove cycles 100 years in length or longer. In 100 years of figures cycles as short as 9 or 10 years in length might create important distortions. What will or will not create an undue distortion depends upon the nature of the trend, the strength of the cycle, and the accuracy with which one needs to make the projection.

ANALYSIS OF RANDOMS

Randoms are those elements of a time series that are completely haphazard and therefore completely unpredictable, except in terms of probability. They exist in addition to cycles and trend.

A knowledge of cycles, strange as it may seem, is of help in determining randoms. A moment's reflection will show why this is so: If we adjust the series of figures for trend *and* for the cycles the remaining values are the randoms. We now have them isolated and can study them at leisure. Suppose that we do so and find that in a particular case, in 5% of the instances the randoms have an absolute value of over 12. In 15% of the instances the randoms lie between 8 and 12, in 30% of the instances the values lie between 4 and 8, and in 50% of the instances the values lie between 0 and 4.

These values are very different from the values that we would get if the cycle (or cycles) had not been removed. With the cycles included, 20% of the values, after the removal of trend, might be 12 or over.

Now that we know the proportions and values of the randoms as such, unbeclouded by the cycles, we can include them in our forecast. We do not know *when* they will come, but we do know how big they will be when they do, and how often the big ones will occur. Thus, in making our forecast we can say, "The product of trend and cycles for year x (or month, week, or day

x) is such and such, but this forecast must be modified by the probability of a plus or minus random of 12 or over in 5% of the times, by a random of ±8 to ±12 15% of the time, etc., according to what our findings in regard to the randoms have shown these probabilities to be.

CYCLE FORECASTING

Most people think of cycles as a means of seeing tomorrow today, as someone once put it. And indeed this is a prime reason for cycle study. Where there is non-chance regularity, there is predictability.

Of course cycles are not the only factors that control the future. As I have indicated above, we must contend with *trend* – the underlying tendency that changes its direction slowly. Then, too, as has been said, there are accidental non-cyclic elements that are always present in the unfolding of any series of events. But, insofar as the cycles govern, a knowledge of them is probably the surest way to see around the corner into tomorrow.

In all of this there are dangers and limitations that must be kept in mind. Let us review them:

First of all, in using a knowledge of cycles to forecast the future, we must be sure that the cycle upon which we are depending is not a regularity that has been "read into" a series of figures by the investigator. Our cycle must be one that results from real forces. It cannot be mere description.

Second, we must be sure that our cycle is not the result of a combination of closely related cycles. A cycle of this sort is non-chance, it is perfectly real, it is statistically significant, and yet it will not continue. This fact can be demonstrated by controlled data.

Consider Figure 6. Here we have three perfectly regular cycles of 4.89 years, 5.50 years, and 6.07 years, diagrammed by Curves A, B, and C. Below them, as Curve A x B x C, is shown their combination or synthesis. Note that the combination from 1854 through 1896 shows a quite regular cycle of about 5.7 years in length. This 5.7-year cycle is not random. It was created, by construction, of non-chance elements. And yet, as we can see by inspection, it does not continue.

I find that many people do not know how cycles can be combined. Such combination is very easy. Each cycle has a value above or below trend for each year or other unit of time. These values can be expressed in plus and minus values or, better, *in percentages*. If the values are in plus and minus form, the values for each year are merely added and subtracted to get a plus or minus resultant for that year. If, as in the example shown in Figure 1, they are in the form of percentages, these percentages are multiplied. Thus, for the year 1854, the values of Curves A, B, & C are 96.5%, 101%, and 96%, respectively; the value of the synthesis for 1854 is therefore .965 x 1.01 x .96, or 93.6 as charted in the lower curve. And so on for each succeeding year.

Third, cycles, even when real, have a disconcerting way of missing a beat or evidencing two waves when the pattern calls for three.

Consider Figure 7. Here we have a chart of wrought iron prices in England from 1290 to 1909 after removal of trend. A 16 2/3-year cycle is clearly evident and unmistakably real. Note crests at A, B, C, D, E, F, G and H. Yet from H to J and from J to L we have, in each instance three waves where the 16 2/3-year pattern calls for two (that is, an 11 1/9-year pattern for six repetitions). Then the 16 2/3-year pattern reasserts itself with crests at L, M, N and O. Then three waves O to Q. Then crests at Q, R, S, T, U (distorted) and V. Then a jumble until AA. Then crests at AA, BB, CC, DD. Then a jumble until GG. Then GG, HH (and a bad random at 1846), II, JJ, and KK.

This skipping of beats, or two waves instead of three, or three waves instead of two, or other aberrations, is characteristic of cycles. After the off beats the old pattern resumes, but this fact is of little comfort to the forecaster who has not been able to know *in advance* that the aberration was going to take place.

I know of only one example where the failure of a cycle comes at predictable times. I refer to the failure of the 9.6-year cycle in the number of international battles. This failure – if you want to call it that – comes regularly at 86.4-year intervals. After nine 9.6-year waves we have seven 12.34-year waves, then nine 9.6-year waves, then seven 12.34-year waves, and so on, time after time. Since 1731 the 9.6-year has kept on coming true in phenomena other than war at those times when, in war, it is supplemented by the 12.34-year cycle. We must therefore conclude that the aberration is due to the nature of war and not to the nature of the 9.6-year cyclic force itself. We are now in the 86.4-year span dominated by the 9.6-year tendency and can look for its continuation until about the year 2030.

Fourth and finally, there is the difficulty that, even when real and consistent, cycles do not operate with precision. Even the well established cycle of the year, with its temperature trough in City x due ideally on February 1st, may miss the coldest day of the year by a month or more. In this instance we know that the causative force is absolutely regular and that the deflections are due to random or other cycles. In other instances, where we do not know the cause, it is not at all clear whether we are dealing with distorted regularity or inherent irregularity tied to an underlying regularity. From the standpoint of forecasting it does not really make too much difference. We know that, whatever the reason, crests and troughs will be irregularly strong and weak, early and late. Forecasts must therefore be made in terms of probabilities: "A crest of the x-year cycle is due ideally mid-1967. The probabilities are 50% that the actual crest will come within 1 year one way or the other of this time; 70% that it will come within 2 years one way or the other of this time; 90% that it will not be more than 3 years early or more than 3 years late." What is said in terms of timing can also be said in terms of strength.

To summarize: In using cycles for forecasting you must be sure (1) that the manifest cycle is not a mere description of random oscillations that happen to come at reasonably regular intervals, (2) that the manifest cycle is not the combinations of real cycles that are closely related to one another in period, (3) that the cycle has not suddenly failed, and (4) that you forecast in terms of probabilities or confidence limits.

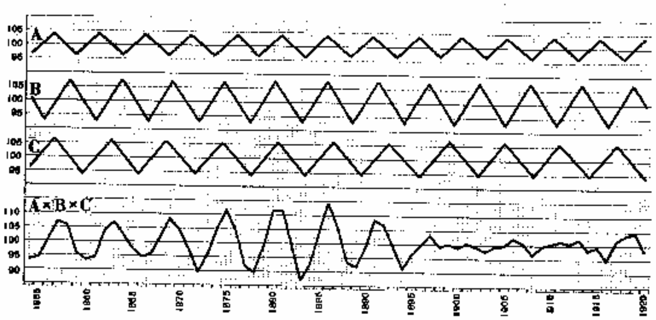

Fig. 6: A. THE 4.89-YEAR CYCLE, B. THE 5.50-YEAR CYCLE, C. THE 6.07-YEAR CYCLE, AND A x B x C, THEIR SYNTHESIS

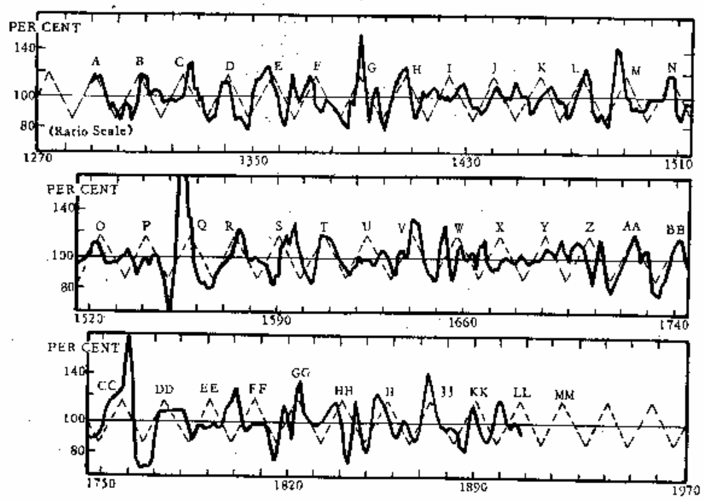

Fig. 7: THE 16 2/3-YEAR CYCLE IN WROUGHT IRON PRICES IN ENGLAND