AN EVALUATION OF ALTERNATIVE INDICATORS OF COMMODITY INSTABILITY

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July 1981 81-19

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Abstract

Data on ten U.S. field crops for the period 1950 to 1977 are used to determine whether alternative single variable measures provide the same assessment of relative variability. The results demonstrate that the measurement and analysis of instability may be highly dependent on the choice of indicator.

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Several different empirical measures or indicators of variation have been used in the literature on commodity instability. In a number of studies indicators have been used to determine the relative variability of commodity prices or value, and the results employed to evaluate or guide stabilization policies (Coppock; UN; UNCTAD). In most cases, the choice of indicator is treated as incidental, if it is addressed at all. This presents no problem if all indicators provide the same assessment of relative variability. However, if the conclusions drawn are sensitive to the measure used, then selection is an important consideration.

In this paper, a number of single variable measures previously employed to analyze commodity instability are discussed, and the degree to which they provide the same assessment of relative variability is evaluated. The analysis is conducted using acreage, yield, output, price and revenue data for ten U.S. field crops over the period 1950 to 1977.

The Concept of Instability and Its Measurement

An unambiguous definition of instability would provide the ideal starting point for the selection of an appropriate empirical indicator.

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Paper presented at the Annual Meetings of the American Agricultural Economics Association in Clemson, South Carolina, July 27-29, 1981.

Unfortunately, the concept of instability is nebulous because the perception of what constitutes unstable behavior is largely subjective. It is crucially dependent on who is evaluating the "instability" and what problems he/she views it to present. For example, from a producer's perspective only downward fluctuations in commodity prices may be viewed as a problem because of their effects on revenues, whereas from a consumer's perspective upward fluctuations may be the focus of concern because of their effects on expenditures. From a policymaker's perspective, upward and downward fluctuations in prices resulting from systematic changes in such factors as consumer income may be viewed to be acceptable, since these act as signals for resource allocation. However, fluctuations which are created by stochastic factors such as weather conditions may be viewed with concern.

Since much of the discussion on instability is directed towards the analysis of government stabilization policies, the perceptions of policymakers are particularly important. A given degree of variation in the price of a major commodity (however defined) may not be viewed in the same light as that for a minor commodity. Furthermore, in the case of a single commodity a given degree of variation in price may not be viewed in the same way as the same degree of variation in revenue.

This brief discussion indicates that the definition of instability is complex. It is clear that variability and instability cannot necessarily be equated and that the measurement of instability requires that an implicit or explicit judgment be made as to what constitutes "acceptable" versus "unacceptable" variability. In many cases, for example, some type of trend is removed from the data before instability is measured, possibly on the grounds that such trend is predictable and does not therefore constitute instability. This clearly reflects some judgment on acceptable variability (that due to trend) and unacceptable variability (deviations from trend). Only rarely is the rationale behind the particular specification of trend adopted explicitly considered (e.g., Massell). Gardner, for example, has stressed the need to provide a rationale for the exclusion of trend and for the types of fluctuations to be treated as instability.

Analysis of Alternative Measures

The single variable measures considered in this paper have all been used in previous empirical studies of instability (Offutt). They include percentage range and average period-to-period change measures, moving averages, a logarithmic index developed by Coppock, and several versions of the coefficient of variation. Their formulae and major characteristics are outlined in table 1.

The measures in table 1 were applied to acreage, yield, output, price and revenue data on ten U.S. field crops (barley, corn, cotton, oats, rice, rye, sorghum, soybeans, sugarbeets, and wheat) over the period 1950 to 1977. For each instability indicator, two kinds of rankings were compiled. On a cross-commodity basis, commodities were ranked in descending order of the level of instability exhibited in each of revenue, yield, output, acreage, and price. On an intra-commodity basis, the five variables (revenue, etc.) for each of the commodities were ranked in the same way. In this manner, 15 sets of rankings were obtained for each indicator.

The main objective of the application was to discover whether or not the measures provide a consistent assessment of instability. This can be determined by comparing the rankings obtained in each of the two schemes. As a summary measure of the degree of agreement, Spearman correlation coefficients were computed for all relevant pairings. This nonparametric coefficient provides an index of the degree of similarity between two rankings of the same list of items. Its value ranges from positive unity, indicating complete agreement, to negative unity, indicating complete disagreement. Averaging the values of the Spearman coefficient across rankings (intra- and cross-commodity) and across pairs facilitates a general comparison of behavior among and between measures.

In general, the first group of measures (PR, APC, MA, and CPI, see table 1 for the key to abbreviations) agree well among themselves in both ranking schemes, with an average Spearmen coefficient of 0.75. The coefficients of variation had only a few cases of disagreement among themselves, due mainly to the differences in treatment of outliers. However, the agreement between the first group of measures and the coefficients of variation was fairly low, an average correlation of 0.35 by the Spearman coefficient. The discrepancy seems attributable to the influence of trend in a number of data series. Trend appeared to outweigh any other data characteristic when evaluated by the coefficients of variation. Variables with the strongest trend were ranked most unstable by the coefficients. The other measures seemed more sensitive to outliers and sawtooth-like data features, so jagged series were identified as most unstable by them, practically regardless of the presence of trend. Thus, the coefficients of variation identified as most unstable those data series with smooth but strong trend as opposed to nontrending series with significant negative serial correlation.

Individual measures had some idiosyncratic features which deserve mention. The PR measure recorded its lowest values for series with fairly constant percentage trend, such as yield, and was influenced strongly upward by outliers such as occurred toward the end of most price series (during 1973-1974). The average percentage change measures moderate the influence of these outliers and so agreed most closely with PR for smoother series. Although the moving average (fit with three and five period lengths) accounts for trend, it agrees fairly well with the PR and APC measures. The similarity is due to the flexibility of this average, which uses subsets of the data in determining trend values, such that it is influenced more strongly by outliers than, say, linear regression. This sensitivity to extreme values accounts for its agreement even with non-detrended measures.

The Coppock Index is supposed to yield a close approximation of the period-to-period percentage change adjusted for (linear) trend. Yet, curiously it agrees quite well with the average percentage change measures, which do not account for trend. Furthermore, the agreement is best (0.92 Spearman value) for the cross-commodity ranking of yield, the variable that generally displayed the most trend. That adjustment for trend has no apparent effect on the rankings is an anomalous result. The sensitivity of CI to the particular period chosen, which has been pointed out by Knudsen and Parnes, was demonstrated. The expectations part of the measure, m, depends only on the first and last observations; changes in the period often had dramatic effects on the ranking of a variable. For example, when the 1977 observation was dropped and CI recomputed, cotton fell from the third to the tenth most unstable in a cross-commodity ranking of output. This sensitivity makes CI a rather unreliable measure.

Coefficients of variation are frequently calculated using the residuals derived from trend lines, rather than deviations around the arithmetic mean. Therefore, all 50 data series were subjected to both linear and exponential detrending by least squares regression. Based on examination of the coefficients of multiple correlation (R^2's) for these equations, "best" estimates of the coefficient of variation CV(S) were chosen. If both R^2's were less than 0.6, the non-detrended coefficient was selected; if one or both were greater than 0.6, the higher of the linear or exponential was chosen. In this fashion, a best estimate list of coefficients of variation was developed. This list was then compared with coefficients from the non-detrended data. The Spearman coefficient between the two lists was only about 0.20. Here again, the lack of agreement can largely be attributed to the influence of trend in the mean. Those series which the non-detrended coefficient of variation (CV(S)) identified as being most unstable very often fell in ranking once trend was removed, as the systematic change in mean inflated the value of the non-detrended coefficient.

A comparison of the PR, APC, and MA measures with the best estimate CV(S) shows, on the average, very little concurrence between rankings. Table 2 reports the Spearman coefficients for this exercise. Note the disparity across commodities and by measures. The lesson appears to be that a judicious accounting for trend can produce rankings radically different from those obtained when trend is ignored. The results of this application should eliminate any remaining skepticism as to the dependence of the characterization of instability on the choice of empirical technique.

Implications

As evidenced above, the treatment of trend is perhaps the paramount issue in the application of single variable measures. Whether or not trend is regarded as instability depends on the context of the analysis; however, recognition of trend should always be made inasmuch as it influences a measure's empirical evaluation of data series. Commonly, some coefficient of variation is applied to the residuals of a series net of trend. Residuals from the moving average should not be used for this purpose because they tend to be serially correlated as do those from differencing. The coefficients provide unbiased estimates of variability only for random series. For this reason, it is most often the residuals from linear regressions which are used, on the assumption that they are random once deterministic trend has been removed.

Should regression residuals not be random, as indicated perhaps by the Durbin-Watson statistic, stochastic process models can be employed to account for the remaining oscillatory movements if data series are sufficiently long. Integrated autoregressive moving average (ARIMA) models, as discussed by Box and Jenkins, can account for the deterministic and oscillatory parts of a time series and leave a random residual for which a coefficient of variation can be calculated. However, the identification and estimation of these models can be difficult and time-consuming, so the use of the residuals from linear regression can be considered an acceptable approximation to randomness for most purposes.

The dissimilarity in the rankings demonstrates that it is unlikely that all single variable measures will provide the same assessment of relative instability. Therefore, results will be dependent on the particular measure chosen. Since the determination of what type of behavior constitutes instability is subjective, it is not possible to advocate unequivocally the use of any one measure. However, some general guidance can be given in making the selection.

The first step should always be to plot the data under investigation; this will reveal the presence of trend or outliers which, as indicated above, can markedly affect a measure's performance. An understanding of each measure's characteristics can then be used to determine which one might be most appropriate. While it is probably advisable in any case to compute several of the single variable measures for purposes of comparison, some can be eliminated from consideration. Because of its limitations in identifying the effects of trend, the percentage range measure seems too simple to be of much use. The Coppock Index, due to its sensitivity to the period of the data series, might also be excluded, especially since techniques such as regression can also account for trend with much less computational burden.

The average percentage change and moving average measures may have applicability in some situations. The former may be useful, for example, when some idea of the average yearly change in a variable is of importance, as opposed to an index of relative dispersion from a mean value, as obtained from the coefficient of variation. The coefficients may be more useful for relative comparisons rather than absolute measurements. The flexibility of the moving average and its use of only a subset of the data in the calculation of trend values may have appeal, particularly if one is attempting to represent a policymaker's expectations. These measures can be computed in a straightforward fashion and provide a useful comparison to the coefficients of variation.

The use of the coefficients of variation on detrended data is probably suitable for most purposes. A coefficient of variation can be applied to the residuals of the regression to yield a measure of instability. While the coefficient which uses the sum of squared residuals is probably most easily obtainable, that which uses absolute deviations may be preferable. This is because such a form can distinguish widely dispersed data from that which is more compact. The sum of squared residuals will not be as sensitive to the absolute value of the distance of the data points from the fitted line; this feature may be of significance in a study of instability in which absolute as well as relative distances are important.

Table 1. Measures of Instability.

Measure	Formula	Major Characteristics
Percentage Range (PR)	$PR = W_M - W_m$ where $W_M = MAX(W_2, \ldots, W_{n-1})$; $W_m = MIN(W_2, \ldots, W_{n-1})$; $W_t = \frac{\lvert V_t - V_{t-1}\rvert}{V_{t-1}} \times 100 \quad t=1, \ldots, n$	No account made for presence of trend; strongly affected by outliers.
Average Percentage Change 1 (APC1)	$APC1 = \frac{\sum_{t=2}^{n} \left\lvert \frac{V_t - V_{t-1}}{V_{t-1}} \right\rvert}{n - 1} \times 100$	Measures average period-to-period change; absolute value in numerator moderates influence of outliers; asymmetrical treatment of increases, which can be greater than 100%, and decreases, which cannot be.
APC2	$APC2 = \frac{\sum_{t=2}^{n} \left[\frac{V_t - V_{t-1}}{V_{t-1}} \right]^2}{n - 1} \times 100$	Measures average period-to-period change; squaring accentuates influence of outliers; same asymmetry as APC1; larger value the more concentrated are the fluctuations in a short span of years.
APC3	$APC3 = \frac{\sum_{t=2}^{n} \left[\frac{V_t - V_{t-1}}{MAX(V_t, V_{t-1})} \right]^2}{n - 1} \times 100$	Measures average period-to-period change; squaring accentuates influence of outliers; use of $MAX(V_t, V_{t-1})$ in denominator corrects asymmetry in ACP1 and 2.
Moving Average (MA)	$MA = \frac{\sum_{t=r+1}^{n-r} \left\lvert \frac{V_t - V_{t*}}{V_{t*}} \right\rvert}{n + 1 - m}$ where $V_{t*} = \frac{\sum_{t-r}^{t+r}}{n}$; $r = (m - 1)/2$; m = pd. of MA	Coincides with trend increasing by constant amount each period, lies below if increasing by decreasing amounts, and above if by increasing amounts; uses only subset of data to determine trend value, fits data closely; generates oscillatory movement in residual; minimizes cyclic fluctuation, allows specification of length of average, can be symmetric, as shown, or backward looking.

Table 1. (Cont.)

Measure	Formula	Major Characteristics
Coppock Index (CI)	$CI = \text{antilog}\left[\frac{1}{n-1}\sum_{t=1}^{n-1}\left[\log\left[\frac{X_{t+1}}{X_t}\right] - m\right]^2\right]^{1/2}$ $m = \frac{1}{n-1}\sum_{t=1}^{n-1}\log\left[\frac{X_{t+1}}{X_t}\right]$ X_t = log of data's first difference	Linear trend removed by taking first differences; taking logs of first differences moderates influence of outliers in squaring; interpreted as approximation of average period-to-period percentage variation net of trend; m depends only on first and last points in differenced series.
Coefficients of Variation (CV)	$CV(S) = \frac{\left[\frac{\sum_{t=1}^{n}(V_t - \overline{V})^2}{n}\right]^{1/2}}{\overline{V}}$ $\overline{V}$ = mean of V_t	Unit free measure of relative dispersion from variable's mean; no account for trend in mean; results in overstatement of variability relative to nontrending series; no constant range; squaring accentuates outlier effect.
	$CV(D) = \frac{\left[\sum_{t=1}^{n}\frac{\lvert V_t - \overline{V}\rvert}{n}\right]^{1/2}}{\overline{V}}$	Absolute value formulation modifies effects of outliers; more sensitive to difference between dispersed and more compact data series than CV(S); otherwise similar.
Standardized Coefficients of Variation (SCV)	$SCV(S) = \frac{CV(S)}{n-1}$	Division by maximum value of CV(S) gives constant range between zero and one; independent of length of series, facilitates comparison among variables.
	$SCV(D) = \frac{CV(D)}{2(1 - 1/n)}$	Division by maximum value of CV(D) gives constant range between zero and one, independent of length of series, facilitates comparison among variables.

Note: Coefficients of variation are frequently calculated using deviations from trend. In this $\overline{V}$ in the numerator is replaced by $\hat{V}_t$, the predicted value of V derived from the trend line.

Table 2. Spearman Correlation Coefficients: Best Estimate CV(S) Rankings Compared to PR, APC, and MA Measures.*

	PR	APC1	APC2	APC3	MA3	MA5	CI
Revenue	0.36	-0.05	0.31	-0.08	-0.07	-0.02	0.08
Acreage	0.90	0.88	0.92	0.84	0.90	-0.26	0.94
Output	0.44	0.72	0.72	0.68	-0.09	-0.13	0.90
Price	0.36	0.61	0.58	0.45	-0.45	-0.22	0.58
Yield	0.40	0.75	0.70	0.68	0.59	0.84	0.68

* For ten pairs, a correlation of |0.63| or higher is significant at the 5% level (two-tailed test) and one of |0.78| or higher is significant at the 1% level.

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