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THE ASSOCIATION

SEASONALITY IN RETAIL PRICES IN HONG KONG

by

W. F. Maunder *

Although the concept of a seasonal element in prices is not without some ambiguity and estimation in practice cannot be precise, yet there are some reasons why it is useful to have some indication of the possible extent of fluctuations which may be ascribed to such causes. It is, for example, particularly desirable at times like the present, when retail prices are high and have risen sharply in recent months, to know how much movement, if any, may be offset as usual seasonal effects.

The aim of the present study is to examine the Retail Price Index for evidence of seasonality on a component basis, to estimate the extent of seasonal movement where it is found to exist (ie. to obtain seasonal indexes) and to compute a 'deseasonalized' series (i.e. one free of seasonal influence) from the inception of the Index to date.

The Model

It is necessary in the first place to decide exactly what is meant by the seasonal influence which is to be measured and how it enters into the observed series. The original series (P_t) of Retail Price Index numbers is computed for time t as a base weighted average of component indices (I_t's):

$$P_t = \sum e_o I_t \quad \ldots\ldots \quad (1)$$

where the e_o's are the relative expenditures on each component in the base period (March, 1947) and summation is taken over the entire field of commodity groups.

Similarly, any individual component (I_t) may be defined in terms of constituent commodity item as

$$I_t = \sum p_t q_o / p_o q_o \quad \ldots\ldots \quad (2)$$

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where the q_o's are quantities consumed in the base period, the p_t's are prices in period t and summation is taken over all commodity items in the component group.

Hence, among the simple alternatives, there is the choice of investigating seasonal movement either overall in the general series P_t or among its constituent parts; if the latter approach is adopted, there is the further choice of examining the original price series (the p_t's) or the component indices (the I_t's). It might be thought that the overall approach, although by far the least burdensome, is a crude one and that greater sensitivity would be achieved by breaking up the general series. In so far as interest is centered upon obtaining a deseasonalized general series it is doubtful whether any appreciable difference would emerge in the end result between the two methods but it is clear that there is also an intrinsic interest in tracing the seasonal influences at least as far as the main commodity groups. It would appear therefore that the most useful approach is to deal with the component series (I_t's), the conclusion is reinforced in practice by the fact that data on individual commodity prices (P_t's) are not readily available and in any case the gain from using them would hardly repay the extra labour involved. One qualification might be added and that is with regard to the Food group; this component carries more than half the total weight and it is a matter of some regret that greater detail is not published. Clearly here is a case where we would wish to have at least two or three sub-components to analyse separately.

There are several simple ways in which a seasonal element might be involved in a component series I_t but there appears no particular reason for investigating any model other than the usual multiplicative one. The hypothesis is then expressed as

$$I_t = V_t W_t \epsilon_t \quad \ldots\ldots\ldots (3)$$

where v_t is the trend value, w_t the seasonal element and ϵ_t a random effect. The seasonal element w_t is taken to be a cyclical factor with a period of twelve months expressed

as a proportion varying about unity and satisfying the requirements (i) $w_{\tau} = w_t + 12_p$ for p = o, 1, 2, . . and (ii) $\prod_{s=0}^{s=11} w_{s+12p} = 1$. With regard to the residual the most simple assumption is that Log ε_t is normally distributed about zero, independent of t and with constant variance i.e. the variate values are independent random selections from the same normal population. This is not a necessary assumption. however, and in fact all that we require from the point of view of estimation is that ε_t should not show any tendency to oscillate with a period of 12 months i.e. no seasonality should either remain in or be induced into the residual.

The aim for each commodity group is first to test the hypothesis, second to estimate the w_t if appropriate and third obtain a deseasonalized series (I_t'). The definition of I_t' follows obviously from (3) as

$$I_t' = \frac{V_t \, \epsilon_t}{V_o \, \epsilon_o} \quad \ldots\ldots\ldots (4)$$

and hence the definition of the deseasonalized general series (P ' is)

$$P_t' = \sum e_o I_t' \quad \ldots\ldots\ldots (5)$$

Procedure

The trend series u_t is first estimated; strictly a centered moving geometric average is required —

$$V_t = \left\{ \prod_{s=t-5}^{s=t+5} I_{t-6} \; I_{t+6} \; I_s^2 \right\}^{1/24} \quad \ldots (6)$$

which has the advantage of approximately reproducing any long term systematic movement. Consequently, the ratio of

the orginal series to the estimated trend value can be formed as

$$\frac{I_t}{V_t} \sim w_t \epsilon_t \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots (7)$$

and these ratios can be tested for homogeneity when classified on a seasonal basis (i.e. by months) without the comparison being unduly disturbed by any time effect e.g. as from business cycle swings. The method of testing employed is to compare the variance within months with that between months so that it is actually the null hypothesis of no real difference between months which is examined. Failure to reject the null hypothesis implies that $w_t = 1$ for all t, i.e. that there is no seasonal element in the series I_t

It may be observed that there is some degree of approximation involved in regard to the use of analysis of variance with respect to the ratios defined by (7). This is so both because the use of (6) as an estimator of trend involves some dependence between successive terms and because logically the analysis should be in terms of the logarithms of the ratios rather than the ratios themselves. For present purposes no great sensitivity is required and neither of these points need cause concern since they have only a minor effect. In addition, it is to be noted that if there is a systematic element in the residual the testing procedures become less sensitive as an instrument for detecting seasonality.

If the null hypothesis is rejected, the seasonal indices are then estimated as the means of the ratios for each month adjusted to satisfy the unity product condition, (ii) above. Strictly they should be calculated as geometric means: in practice both here and in obtaining (6) it makes only a negligible difference whether an arithmetic or geometric mean is taken and the former has been used for computational convenience.

The next stage is to form the deseasonalized series I_t' which are estimated as

$$I_t' = I_t \frac{w_0}{w_t} \sim V_t \epsilon_t w_0 \sim \frac{V_t \epsilon_t}{V_0 \epsilon_0} \qquad (8)$$

As a final test of the hypothesis (3) it is then possible to form the residuals as

$$I_t / v_t w_t = \epsilon_t \quad \ldots\ldots\ldots\ldots (9)$$

and to examine them for randomness.

The Analysis

The component indices which have been investigated are the following:

Series		Weight
I	Food (including drink)	51.00
II	Rent*	9.00
III	Clothing (including footwear)	7.00
IV	Fuel, light and cleaning:	
	(a) Fuel	4.00
	(b) Electric light*	1.00
	(c) Cleaning	2.50
V	Other Items:	
	(i) Education	3.50
	(ii) Tobacco and Cigarettes*	3.00
	(iii) Doctors & medicines*	2.50
	(iv) Fares*	2.25
	(v) Household equipment	1.75
	(vi) Hair dressing	1.00
	(vii) Newspaper and stationery*	1.50
	(viii) Shoe repairs*	0.50
	(ix) Rates*	0.25
Total		91.25

A preliminary inspection of the series listed above revealed that it was possible to reject eight of them without further enquiry as having no seasonal element; the groups rejected are those marked with an asterisk. In the remaining six cases there was room for doubt and the procedure outlined above was applied. The table below shows the results of the analysis of variance. It should be remarked that the series analysed run from January, 1953 to January, 1959 but 12 terms are lost in fitting the trend so that the

total number of degree of freedom is 60 i.e. one less than the total number of remaining observations. The inception of the Retail, Price Index dates from March, 1947 but up to 1952 data are available at quarterly intervals only so that the series could not be used over this period..

Analysis of variance of ratio to trend ($100\ I_t/v_t$)

Series		Estimate of Variance (a) Between Months (11 D.F.)	(b) Within Months (49 D.F.)	$F = \frac{(a)}{(b)}$
I	Food	60.873	6.052	10.058***
III	Clothing	1.731	1.987	0.871
IV a	Fuel	20.448	5.424	3.770***
IV c	Cleaning	1.009	0.946	1.067
V v	Household equipment	2.945	3.344	0.881
V vi	Hairdressing	70.832	70.547	1.004
V viii	Shoe repairs	0.525	0.692	0.759

*** Significant at the 0.1% level.

The results could hardly be more clear cut; there is no hesitation in concluding that seasonal elements are present in the Food and Fuel components and for no other series.

Seasonal indices (w_t) were accordingly calculated for these two groups and the results are shown below.[a]

[a] As a check on the assertion made in the text that arithmetic means give a close approximation to geometric means for these data, an alternative set of calculations was made for the Food component. The difference in the seasonal index was found in no case to exceed 0.1.

Index of seasonal movement about annual average

Month	Group	
	I Food	IVa Fuel
January	96.7	102.2
February	100.1	102.6
March	98.2	102.2
April	96.5	101.5
May	96.4	99.2
June	98.0	98.7
July	100.8	97.6
August	103.2	97.0
September	107.1	97.8
October	104.9	100.6
November	99.9	99.9
December	98.8	101.0

A noticeable feature about the results is that the seasonal movements in the Food and Fuel components tend to be negatively associated (i.e. the maxima in the one correspond to the minima in the other and vice versa) so that their effects on the General Index cancel out to some extent. In view, however, of the small weight carried by Fuel compared with Food the tendency is of limited significance.

The final test of the basic hypothesis was made by forming the residuals as given by (9) and testing for randomness. If the logarithms of the residuals are independent selections from the same normal population with zero mean then the total number of runs of consecutive terms with like sign should lie, at the 5% significance level for a sequence of 61 terms, between 23 and 38. The actual number of runs turn out to be 25 for the Food group residuals and 13 for the Fuel group residuals. Consequently, it emerges on the showing of this test that, for the former component, the residual element does not exhibit any marked departure from randomness and the hypothesis expressed by (3) is acceptable although the decision tends to be marginal one. For the latter component, there is clear evidence of a systematic influence remaining in the residual in that the average length of run is much longer (i.e. the total number of runs much fewer) than expected if occurring at random. However, for our purpose, the only con-

cern is whether this systematic element is seasonal i.e. whether the seasonal index either under or over estimates the movement. This possibility has been examined by classifying the positive (log) residuals by-quarters and comparing them with the expected distribution on the basis of equal probability. The resulting value of X^2 is 0.89 which is not significant for 3 degrees of freedom. Hence, although the hypothesis (3) is not acceptable without modification in the case of the Fuel component, there is no hesitation in concluding that the seasonal element, which is the limit of our interest, is satisfactorily estimated.

The deseasonalized series are presented below.

Deseasonalized Series of Retail Price Index Numbers

Period	Food	Fuel	General Index	Period	Food	Fuel	General Index
1947 March	100	100	100	1948 March	93	96	94
June	90	96	92	June	86	91	89
Sept.	88	126	93	Sept.	89	106	92
Dec.	83	99	88	Dec.	90	105	92
1949 March	92	102	93	1950 March	105	114	113
June	112	111	105	June	124	106	107
Sept.	102	112	100	Sept.	115	109	103
Dec.	121	111	112	Dec.	110	134	108
1951 March	119	172	117	1952 March	122	151	119
June	124	141	119	June	125	127	119
Sept.	117	135	115	Sept.	120	123	117
Dec.	124	141	120	Dec.	123	111	118
1953 Jan.	122	113	116	1954 Jan.	125	100	117
Feb.	126	103	118	Feb.	135	108	123
March	121	104	115	March	130	109	120
April	127	109	119	April	127	108	118
May	125	105	117	May	124	106	116
June	128	98	119	June	124	106	118
July	128	103	119	July	125	106	118
Aug.	133	105	122	Aug.	124	104	118
Sept.	136	107	123	Sept.	121	106	116
Oct.	133	104	121	Oct.	116	105	114
Nov.	137	98	124	Nov.	116	106	113
Dec.	138	103	125	Dec.	118	105	115

Period	Food	Fuel	General Index	Period	Food	Fuel	General Index
1955 Jan.	123	111	117	1956 Jan.	120	92	115
Feb.	114	105	112	Feb.	117	92	113
March	118	101	114	March	117	92	113
April	117	100	113	April	120	93	115
May	115	100	112	May	123	95	116
June	115	100	112	June	123	95	117
July	118	101	114	July	127	96	118
Aug.	120	94	115	Aug.	127	97	119
Sept.	114	93	111	Sept.	128	95	119
Oct.	114	91	112	Oct.	129	101	120
Nov.	117	94	113	Nov.	130	102	121
Dec.	119	93	115	Dec.	127	101	120
1957 Jan.	130	100	121	1958 Jan.	118	100	114
Feb.	131	100	121	Feb.	120	100	117
March	128	101	120	March	121	100	116
April	128	102	119	April	120	101	115
May	126	102	118	May	122	100	116
June	126	103	118	June	121	100	115
July	125	104	117	July	118	100	113
Aug.	119	104	115	Aug.	119	102	114
Sept.	120	103	115	Sept.	119	101	114
Oct.	125	104	118	Oct.	121	106	116
Nov.	118	102	114	Nov.	123	115	117
Dec.	114	100	112	Dec.	125	113	118
1959 Jan.	140	114	126				
Feb.	140	112	127				
March	147	112	130				
April	145	119	129				

Concluding remarks

An observation of some moment is that the recent rise in the general price level is decidedly real and not to be explained by normal seasonal variations. In fact, after eliminating seasonal influences, it transpires that the General Retail Price Index has reached an all time high level in 1959. The highest figure previously achieved for the deseasonalized general series is 125 in December, 1953. The index is currently running at a few points above this level i.e. 126, 127, 130 and 129 for the first four months of 1959. Here, there

fore, are some interesting data for our economists to work on.

Finally something may be said on the significance of the results from the point of view of the consumer and wage-earner. It might be argued that, in assessing the position of wage earners, the actual month to month impact of seasonal forces can be neglected since the effects will balance themselves out over the course of a year and in this case the deseasonalized series provide the best guide. Hence, both employers and workers might find it more convenient to tie wage agreements to the deseasonalized series than to the uncorrected Index. The logic of the suggestion can best be gauged by considering what the situation would be if the only price changes were those due to seasonal factors: it would seem likely that there would be general agreement on paying wages at a seasonally unadjusted rate in this situation. In practice it is more or less the actual position during periods of so called stable prices.

However, it is important to be clear on the difference between two separate approaches: the concern of the present study has been to examine seasonal variations in prices whereas if the Index is to be adjusted in order to reflect the impact of such fluctuations on consumers the need is for the investigation of seasonal variation in **weights.** The weighting system of a retail price index is made proportional to the expenditure pattern of some given set of consumers the need is for the investigation of seasonal variation in weights. The weighting system of a retail price index is made proportional to the expenditure pattern of some given set of consumers and, in practice, the most popular procedure (as is done in Hong Kong) is to use fixed weights derived from consumption in the base period. In consequence an Index so constructed varies with the changing cost of purchasing the fixed base period 'basket' of goods but in fact the consumer will adjust the content of the basket. Hence, if we require an index to reflect the actual impact of seasonal variations on consumers the logical approach would appear to be to leave in the full range of price fluctuation but to modulate the effect by using a set of varying seasonal weights. Although it does not appear to be specifically stated it seems that the Retail Price Index is in practice adjusted along these lines in a rough and ready way; thus, e.g., in the official ac-

count of its construction it is stated the weight for lettuces was reduced to zero in December, 1949 'as the tonnage available was small, (See reference (a), page 57.)

Reference and sources

(a) **A Report on Post-War Movements in the Cost of Living in Hong Kong, Government Printer, 1950**

(b) Supplement No. 4 to the **Hong Kong Government Gazette, 1948 to date.**

Acknowledgements

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THE EXTREMES OF MONETARY PROPOSALS

by

Amando M. Dalisay *

The present concern over the further deterioration of our international reserves and the consequent inability of the Central Bank to meet all demands for foreign exchange is understandable if only from the point of view of supporting a high level investment program. Any effort to sustain private investment in manufacturing and trade would exert a heavy pressure on our dwindling reserves.

The greater concern, however, is over the fate of our local currency, the peso. Would a loss of the reserves mean the complete loss of the value of the peso? Should we not devalue the peso before the dollar reserves are exhausted?

These questions are uppermost in the minds of our thinking citizens; apparently our economic leaders are very much perturbed by these incessant questions from our people.

The proposals from the business and financial quarters are up to now the extremes of a desirable monetary policy that will support continuing investment at a desirable level and help stabilize the value of our currency. There are several reasons for these extreme positions. One is the apparent ineffectiveness of our economic controls in their failure to bring about economic stability. Assuming, for the moment, that the import and exchange controls designed to protect the external stability of the currency and to promote domestic investment in dollar-saving industries are a middle-of-the road policy, the dissatisfaction over their result has so far compelled some of our economic thinkers to look elsewhere for solutions.

The other reason could be the impatience among many of our local investors over the slowness and arbitrariness with which the foreign exchange allocations are granted by the Central Bank and their apparent inability to meet the ever-increasing demand from new or even old enterprises for the importation of necessary machinery and spare parts. Whether the complaints are due to unsatisfactory policies or to inadequate or faulty implementation do not really matter,

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What matters is that these new industires are clamoring for more and more foreign exchange to meet what they believe are legitimate investment requirements.

Another valid reason for the general dissatisfaction over the controls and their administration is the shift in emphasis from one position to another, assuming that no apparent change in policy is adopted, without any adequate announcements or explanations from the Central Bank and without any definite previous consultations with other policy-making bodies, such as the National Economic Council and other advisory bodies of the government. Such examples, as the changes in emphasis on local raw materials for manufacturing industries, in the criteria for profit remittances, and in the considerations for the screening of importers entitled to exchange allocations, among others, tend to justify the oft-repeated criticisms that the implementation of exchange and import controls is arbitrary and dictatorial. The adoption of the famous Circular No. 71 and the subsequent changes forced upon the Monetary Board in regard to margin requirements and the priorities of industries involved indicate, not only the lack of a careful consideration of the vital economic factors at work, but also the inability to comprehend the proper role of private investment in attaining internal stability.

The Goals of Monetary Policy

The responsibility for the administration of the monetary and banking system of the Philippines is entrusted to the Central Bank of the Philippines under Republic Act No. 265. This responsibility consists in the management of the banking and credit system so as to achieve the following objectives:

(a) To maintain monetary stability in the Philippines;

(b) To preserve the international value of the peso and the convertibility of the peso into other freely convertible currencies; and

(c) To promote a rising level of production, employment and real income in the Philippines.

These goals of monetary policy may be achieved in a developing economy not only by monetary management and the utilization of the ordinary instruments of central banking, but also by the proper coordination of economic activi-

ties particulalry in production and in distribution as well as in government spending and taxation. It will call for, as in our present condition, a much closer coordination of government activities with the economic activities of the private sector of our economy.

While monetary and credit policy is essential in directing the flow of money and credit into desirable fields of investment in the private sector so as to accelerate the pace of economic development, the initiative and resourcefulness of private business are quite indispensable in taking advantage of the opportunities of private investment. At the same time the fiscal measures adopted by the government, particularly in the field of taxation, are by themselves stimulants or deterrents to private business activities. In this regard the level of government spending and the means employed to finance government expenditures are powerful influences in determining the magnitude of private investment.

Because in a capitalistic, democtratic system the level and magnitude of private investment is paramount in determining the increment of income generated in any single period, the activities of the government in production and investment influence to a large extent the amount and direction of private activities in these fields. And in a growing economy like ours, the volume and intensity of government investment act as deterrents or unfavorable influences on private business activities.

The important thing to emphasize is that the goals of monetary policy cannot be attained in an underdeveloped country like ours by monetary and credit measures alone.

The fiscal operations of the government, the implementation of our government policies, and the response of the private sectors to government incentives are quite as important, if not more so.

External vs. Internal Stability

This brings me to the problem of external stability of the currency in contrast to its internal stability. Obviously, the mistake of the Central Bank is in emphasizing the external stability of the peso, with its preoccupation with the dollar reserves and tying up our internal finances and domestic economic activities with the utilization and conservation of

such reserves. Knowing fully well that the country has an export economy dependent for its exchange earnings on a few raw material exports, the Central Bank nevertheless continued to promote continuation of that export economy while at the same time advocating the establishment of dollar-saving, consumer-goods industries. The result was a tightening of finished consumer-goods imports and the liberalizing of exchange allocation to packaging and assembling industries utilizing imported raw materials, while maintaining support for dollar-producing industries.

The records will show a rapid decline since 1951 of luxury and non-essential consumer imports, an apparent stabilization of essential consumer imports, and a marked increase in the importation of machinery, equipment, and raw materials. Up to 1956, the yearly increase in capital goods imports was justified by the increase in the number of new industries established. After this, the annual rise in capital imports slowed down and then declined without any apparent let-up in raw material imports. The total imports of consumer goods and industrial raw materials were higher than the former levels of consumer imports alone. The only difference is that the profits of the regular importers had shifted to the assembly and packaging industries.

The continued decline of the dollar reserves has been justified by the Central Bank as a means of financing capital-goods imports needed by "new and necessary industries" and financing consumer good imports so as to help stabilize internal prices. While trying its best to support the external value of the peso, by meeting all legitimate demands, under the control system, at the existing exchange rate of ₱2.00 to $1.00, it also managed to maintain the internal value of the peso by providing as much dollars as possible for consumer goods imports to supplement internal production. So long as the dollar earnings continued to increase and internal consumer goods production was sustained by raw-material imports, the problem of internal balance did not impede economic development.

But as soon as the dollar earning declined and no further support could be given to importation of raw materials for existing industries, not only was the internal supply-demand situation unbalanced, but the maintenance of a desirable level of investment was also threatened. It was

clearly revealed that the external value of the peso could be sustained only at the expense of the internal value. So long as adequate external resources or dollar reserves were available, the policy of maintaining the external stability of the peso could be pursued, while at the same time trying to support its internal stability. In the long run, especially in the face of limited foreign exchange, the two policies are antagonistic to each other.

I do not know of any country that has pursued the two policies at the same time with success. An undeveloped country with limited exchange resources and faced with a program of accelerated economic development cannot but choose a policy of internal stability. The mistake of the Central Bank is in pursuing a policy of external stability, which can only be sustained at the expense of internal stability.

Proposals on Devaluation

Up to now, however, the Central Bank has not considered any definite proposal toward achieving the internal stability of the peso, or the stabilization of the peso in relation to the value of domestic goods and services it can command in the market. Except for the tightening of bank credit and other measures designed to restrict the money supply, all others measures adopted up to now have been directed at preserving the value of the peso in relation to the dollar, or its external value.

If only for the above reason, the majority of the proposal to date have revolved around one central idea, the devaluation of the peso, or the alteration of the exchange rate of the peso in relation to the dollar. The subsidiary or component measures to devaluation may be considered as secondary proposal, if not actual camouflage for the real intention, that is, to modify the external value of the peso.

The most recent proposal, although not new by any means is that presented by Mr. Arsenio Jison, former president of the Philippine National Bank. The Jison proposal is essentially intended to "set up a dollar price level equal to the value which the national places on it", which means devaluation by the Central Bank, pure and simple. The accompanying proposals to restrict imports and to balance the country's international transactions are obviously the means to maintain the new exchange rate once adopted.

Mr. Jison also suggests that the country "seek the stabilization of the country's dollar expenditures with its receipts by gradually correcting the unrealistic exchange rate and placing foreign prices at a desirable relationship with local prices." How the problem of overvaluation (in the case of imports) or of undervaluation (in the case of exports) can be remedied, and how domestic prices can be aligned with prices in the foreign markets — which are the principal problems of internal stabilization — are not indicated. Mr. Jison also has not shown how his proposal could "halt inflation and maintain a stable value for the peso without working undue hardships on the people . . . "Still more puzzling is his suggestion to provide for a climate where a system of either exchange control or exchange decontrol can work more effectively."

In other words, the same problems of attaining those conditions of stability necessary to safeguard the present exchange rate remains even after devaluation or a new rate is adopted. How can external stability of the peso in relation to the dollar be achieved if the foreign exchange budget cannot remain balanced? How can foreign prices bear a stable relationship with local prices when foreign exchange earnings are not sufficient to meet the demand for imports? And how can foreign earnings increase when the demand for our exports or the prices thereof are beyond our control? These questions have not been answered by Mr. Jison and other proponents of devaluation. But they want us to believe that devaluation will bring about internal price stability and the realignment of domestic prices with prices in the foreign markets, as if all that is necessary is the miracle of devaluation.

The latest convert to devaluation, Mr. Alfonso Calalang, President of the Bankers' Association of the Philippines, declared before a forum of the Philippine Columbian that devaluation is "an operation resorted to in an attempt to restore health and vigor to ailing economies." He believed that "it is the operation of the irrevocable laws of economics that would force it upon us" and cited countries of the world which have already devalued without the dire or abhorrent consequences to their economics. He also cited multiple exchange rates, dollar retention, and the tax on foreign exchange as partial or selective devaluation; actually these are schemes toward depreciation of the currency.

However,Mr. Calalang did not elaborate on how the "irrevocable economic laws" will lead to devaluation. It is not enough it seems to me, to mention the fact that the dollar reserves of the country declined to $130 million this month, or a fall of about $16 million in a period of seven months. He also admitted that before April 1946, he was a hard-money man and was therefore fully supporting Mr. Cuaderno's monetary policies. To back up his stand he advocated the establishment of a currency stabilization fund of several million dollars, together with the strict enforcement of existing controls.

Mr. Calalang did not also indicate how the devaluation of the peso would solve the serious problems of inadequate production, persistence of unemployment at a level which, in other countries, would have produced adverse social repurcussions, low international reserves, overvaluation of the peso, dollar leaks caused by rampant overshipment of exports and circumvention of the no-dollar law, lack of coordination in the fiscal policies of the government and the monetary and credit policies of the Central Bank, and the lack of coordination between the executive and legislative branches in the implementation of the national economic policies.

There are other proposals for devaluation— ranging from graduated premium fees in the sale of foreign exchange to variable retention rates for foreign exchange earnings by different industries. All of these are apparently designed to favor certain economic groups at the expense of the whole economy. None of them would help contribute to the stabilization of the currency.

If devaluation would really solve all these economic ills, then let us do it by all means. But I am sure our policy makers would like to understand the step-by-step process by which after devaluation these problems could be tackled in a systematic and effective manner. I am afraid these problems would still be with us after devaluation unless the essential measures which are now necessary are adopted even before any devaluation is ever attempted.

Proposals for the Removal of Controls

The other extreme of monetary proposals is the complete or gradual removal of economic controls. Those who are against the controls are obviously dissatisfied with the result

attained so far in the implementation of the import and exchange controls. They believe that a complete decontrol at this time would facilitate the economy's return to free enterprise.

On the other hand, those who are advocating gradual control believe that the unsatisfactory balance of payments situation, as well as the imbalance in our foreign trade can not be remedied overnight. Therefore, as the internation trade and payments situation improves some of the controls would have to give way and only those that are absolutely essential have to be retained. These certainly form their conviction that controls are never indicative of a healthy and prosperous economy, and the sooner the controls are removed, the faster would be the development toward a stable economy is realized.

It must be admitted from the outset that economic controls are no more than instruments of national economic policy. In the case of our imports and exchange controls, and the credit controls now prevailing, they have been instituted in order to partly insulate our economy from external influences and partly to facilitate or promote further economic development. That these controls have not satisfied all sectors of the economy, there is common agreement. That the sooner these controls will be removed from our midst, the better would be the free play of economic forces and the free exercise of private business and investment decisions.

Two conditions must be met before the import, exchange and credit controls may be removed from our economy:

1. Our foreign trade situation is balanced and prospect for attaining a balanced international payment situation is quite good;
2. The economy has access to sizable exchange stabilization fund that could meet the demand of all commodity imports as well as invisible payments including remittances of profits abroad.

In the absence of these two conditions, it would be idle talk to advocate the removal of economic controls.

The gradual removal of restrictions on imports or selective import controls will continue to be a desirable aspect for

our foreign trade policy for two reasons, namely: (1) the quantitative and selective import control is an indispensable aspect of development programing for a growing economy like ours, in the face of scarce foreign exchange resources, and (2) this type of control is one means of saving our foreign exchange by avoiding allocations to non-essential and luxury import items. The moment that a sizable production of our consumer-good requirements has been attained, or as soon as our domestic manufacturing industries can stand the competition of imported items, the import restrictions on consumer-goods may be removed. At the same time and as soon as a balanced foreign trade has been attained, the quantitative restrictions could be removed retaining only the exchange and credit controls. In other words, gradual removal of controls is an essential feature of a development program in the process of effective and satisfactory implementation.

Mr. Alfredo Montelibano, President of the Chamber of Agriculture and Natural Resources, is the most vocal among those who are opposed to the continuation of the present economic controls. In a memorandum to the House Committee on decontrol, dated October 17, 1958, he proposed the adoption of gradual foreign exchange decontrol along the following lines:

1. For calendar year 1959, reserve 65 percent, or about $440 million of our total foreign exchange receipts (this is equivalent to total export income) for importation at the official exchange rate of ₱2:$1 of the most essential needs of the 92% of our households with annual incomes of ₱3,000 or less each, for government payments, and for foreign remittances. Whatever balance remains thereafter should be used for the importation of equipment and raw materials not available locally that may be needed by the most essential industries. After 1959, this will be gradually reduced by expansion of what is provided in paragraph 2.

2. In 1959, allow the balance of about $220 million or 35% of our total foreign exchange receipts (equivalent to 50% of export income) to be in a partial free exchange market to be operated by the Central Bank and its agents, pursuant to the provisions of Sections 73, 76 and 79 of the Central Bank Charter itself, R.A. 265. This 50% of export income freed from control should be expanded to 70% in 1960 and 85% in 1961, until on January 1, 1962, exchange control will be completely eliminated.

Mr. Montelibano believed that the first step will help the government keep the cost of living stable among the masses until production could respond to this incentive. He felt that the second step is the best way to restore competition and opportunities for all industries to earn their returns on the basis of their competence and their responsiveness to consumer demand.

In fairness to Mr. Montelibano, it must be said that his opposition to devaluation lies in the fact that it may increase employment and real income in the long run, but it may also initially reduce real income among certain sectors of economy and the initial rise of prices on essential imports may disturb social and political stability. On the other hand, the application of drastic deflationary measures may also mean increased taxation. The proposed reduction of government expenditures, further restriction of credit and investment and increases in interest rates would result, Mr. Montelibano believed, in greater unemployment, reduction of real income among certain sectors especially the unemployed, reduction in investment and output and on the whole, undesirable effects on social and political stability leading to greater social unrest. He, therefore, suggested that a wise combination of these two extreme alternatives would be a more reasonable approach to our urgent economic progress.

Another prominent exponent of decontrol is Mr. Vicente A. Araneta, President of G.A. Machineries, Incorporated, and and other local industrial firms. While Mr. Araneta does not advocate the complete removal of economic controls, particulary import and exchange controls, he recommends a general policy that would promote indutries that will produce the basic necessity for our people as a means of solving such pressing problems as unbalanced foreign trade, growing unemployment and inadequate production. Specifically, he advocates a drastic increase in the list of banned import items to a point where the exchange savings would amount to at least $200 million a year. Recognizing that an increase in exportation cannot be made in the next five years sufficient to balance our foreign trade, he suggested that our commodity imports be cut by at least $50 million annually largely in terms of non-essential and luxury imports and another $150 million to provide employment to 2 million Filipinos a year. Through these means he believes that production for

domestic consumption would reduce our exposure to idleness and increase the employment of our resources.

Mr. Araneta believes that a strict policy on banning of import, that is, whatever is not banned in finished goods would be decontrolled in order to permit their free importation, without passing thru a system of controls. Not satisfied with these, he would still cut the import by $100 million a year by subjecting essential goods such as meat, milk, sardines, etc. to a program of gradual ban in accordance with a pre-determined progressive schedule which will result, in a period of five to six years, to their complete banning. Corollary to his program of banned imports is Mr. Araneta's proposal to increase public and private investment to a level of ₱1.8 billion a year, of which 2/3 is in Philippine currency and 1/3 in foreign exchange. In the absence of any appreciable response from the private sector, such an increase in investment by about ₱400 million from the present level would mean resorting to government investment. Even without considering the merits of such an investment proposal, it can be readily inferred that the present investment levels are highly inflationary. Raising the investment level by about 25% woud be excessively inflationary. Instead of getting out of the control system, such an inflationary measure would require much more strict control of credit, money supply, and government expenditures than are now necessary.

While it may be admitted that the **raison d'etre** for the present controls is their usefulness in supporting an investment level commensurate to the increase in population and to our aspiration for a higher standard of living, these controls are not sacrosanct nor permanent fixtures of the economy. Without monetary and fiscal controls the present level of investment, as well as the proposed higher levels would pump into the income stream more money than can reasonably be absorbed by the increase in output of goods and services. The resulting run-away inflationary income and prices would be harmful, rather than contributory to our economic development. The accelerated investment proposals would, therefore, result in greater inflation which could deter further development.

On the other hand, the management of the control machinery should be undertaken with greater efficency by minimizing the cost of intermediaries, the temptations to

graft and corruption and the unnecessary delays in the processing of dollar allocations and the grant of peso loans to essential industries. What is needed is not so much the removal of controls but the improvements in their administration. In the case of foreign exchange allocation under a special committee of the Monetary Board, our experience during the last two years would indicate that with the development of a sound priority system and a systematic approach to allocations by industrial groups, the allocation of foreign exchange may now be delegated to private and government banks.

It is also possible that with the improvement of control administration, the necessity for quantitative restrictions may be dropped in a year or two, retaining only our exchange control and the piority system for credit assistance to essential enterprises. As our internal production increases, and that marketing, distribution and processing become more effective under the management of local entrepreneurs, the realization of a balanced foreign trade is not difficult to foresee.

The programming of our foreign exchange needs on the basis of a balanced fiscal budget and the minimum requirements of a reasonable development program could lead, under effective management, to a more or less balanced international payments situation. When this time comes, only then could our economic controls be safely eliminated. In the meantime, we must strengthen our control machinery and apply the control system more effectively.

The Middle-Way to Stability.

Perhaps Chairman Jose Locsin of the National Economic Council has presented what appears to me the middle-way approach to economic stability. He emphasized the necessity for effecting desirable changes in the monetary and foreign exchange policies now prevailing, when he proposed before this honorable committee the following policy modifications:

1. Re-channeling of investments from real estate and other non-productive activities to the productive sectors, including agriculture, manufacturing and mining.

2. The adoption of a foreign investment policy designed to promote and encourage joint Filipino-foreign ventures with ratios of participation in accordance with existing policies.

3. The adoption of a policy allowing desirable productive enterprises to negotiate with the suppliers of capital goods and raw materials on a deferred payment basis.

4. The adoption of any or a combination of the following schemes to increase foreign exchange earnings:

a. A 30% foreign exchange tax for all types of imported exchange such items as drugs and basic foodstuffs.

b. A dollar retention scheme of from 15 to 20% of the foreign exchange earnings from exports to the U.S. markets and 20 to 25% on exports to other world markets.

c. A multiple rate system for various types of exported and imported items.

d. A mutiple reserve system with respect to the Japanese yen, the German mark, the Swiss franc, the pound sterling and other strong foreign currencies.

e. Repeal of the no-dollar import law.

f. Modification of the dollar remittance formula.

The keystone of the Locsin proposal is the support for productive enterprises utilizing local raw materials and natural resources and the promotion of joint Filipino-foreign ventures. The other measures are merely supplementary to this central idea.

The combination of the other supplementary proposals, are serious attempts to indicate the direction of the policy implementation in the face of the realities of foreign markets and the necessity for negotiation with these markets with one aim in view, that is, to facilitate the importation of necessary capital goods and to stimulate dollar earning from exports. There are, however, two points in these supplementary measures which may defeat the middle-way approach. One is the 30% import privilege tax which when applied to capital goods imports for essential industries, would inevitably increase the capital and operating costs of the new developing enterprises. In the case of agriculture, this would hinder the mechanization of plantation farming and the establishment of agricultural processing plants.

The other objectionable feature is the retention scheme for foreign exchange earnings of producers of export products. No sector of the economy may be allowed to retain a portion of its exchange earnings without raising the same demands from other sectors. It is a desirable aspect of foreign

exchange policy for the central monetary authority to retain all exchange earnings and then apportion them to the various sectors based on their legitimate needs. This is the real basis of the present allocation of dollars.

The central objective of any middle-way approach is to stimulate internal production to meet the needs of basic consumption and, if possible, to leave a surplus for capital building or capital formation. If we can increase production in all sectors of our economy, including the desirable industries, the real value of local currency will rise because a peso will be able to command more goods and services in exchange. The surplus of production over and above our internal requirements would find their way into the internationl markets through tariff negotiations and other schemes short of barter. The foreign earnings of these exports would pay for absolutely essential capital-goods and raw-materials imports.

To attain the goals of the above approach it would be necessary to balance the operating expenditure of the government and at the same time restrict the flow of money to less essential and non-productive enterprises. These are the anti-inflationary measures. To provide for a leeway for continuous development, the government must encourage private investment in essential industries in agriculture and manufacturing industries for local consumption, with emphasis on the utilization of local raw materials, and to stimulate joint ventures in order to overcome some of the foreign exchange difficulties.

The government will also have to restrict public or government investment in overhead capital intended to improve the climate for private investment. Any inflationary gap may then be filled by taxation measures and the mobilization of private savings so as to siphon off any excess in private purchasing power. These are therefore positive efforts to attain higher levels of production, employment and income without bringing about excessive inflationary tendencies or a runaway inflation and without any devaluation of the currency.

The secret formula for such a middle-way approach lies in sound management of our production, of the fiscal affairs of the government, of the administration of the Central Bank and the banking system and the effective coordination of public and private economic activities.

THE USE OF RANGE IN STATISTICAL ANALYSIS

by

P. B. Patnaik *

I. Introductory

The use of range in place of the usual root-mean-square estimate of standard deviation has become important in several fields, particulary, in industrial quality control. However, owing to the complicated nature of the distribution of range in normal samples and the non-availability of suitable tables, its use in statistical tests was very limited until a successful approximation to the distribution of mean range was obtained by Patnaik in 1950. Earlier, E. Lord (1947) had employed mean range instead of the root-mean-square estimate of σ to derive a modified t-test and he gave the percentage points of the statistic obtained by quadrature. The approximate distribution of mean range simplified the procedure of this test by reducing it to a t-test with fractional degrees of freedom. Range methods were applied to analysis of variance tests for a one-way classification by Patnaik (1950) and for randomized blocks by Hartley (1950). Extension to a few other double classification designs was made by David (1951). The power functions of some of the range tests were examined by Lord (1950) and David (1953) who found them to compare very favorably with those of the corresponding standard tests based on the t-and F-distributions. On account of the simplicity and ease of application of these tests a brief account is given in the early part of this paper.

Analogous to the use of range as an estimate of σ it is possible to consider the use of ranges in bi-variate normal samples for estimating the covariance and coefficients of regression and correlation. Some of the results in this direction are given in this paper. Simple tests of significance of regression and correlation coefficients are also developed.

In sample surveys it is of considerable advantage to get a quick estimate of the precision of the results. In strati-

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fied and multistage sample designs, the procedure is sometimes so elaborate that variances at the final and intermediate stages are not usually attempted in large-scale surveys. The use of range methods promises to provide quick and simple measures of the precision of the estimates. Some of these possibilities are also briefly considered here.

2. Distribution of mean range

Denote by $x_1, x_2, \ldots, x_n$ a random sample of n observations arranged in ascending order of magnitude, drawn from a normal population with mean M and standard deviation σ. Let w_n denote the range in this sample, i.e. $w_n = x_n - x_1$ Since w_n does not depend on M, we may for convenience take M to be zero. The distribution of w_n is given by

$$F(w_n) = n\int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi}\sigma} e^{\frac{-x_1^2}{2\sigma^2}} \left\{ \int_{x_1}^{x_1+w_n} \frac{1}{\sqrt{2\pi}\sigma} e^{\frac{-x^2}{2\sigma^2}} dx \right\}^{n-1} dn_1. \quad (1)$$

The values of the probability integral $F(w_n)$ for $\sigma = 1$ are obtained by quadrature from a formula by Hartley (1942) and given up to $n = 20$ in Biometrika Tables for Statisticians I (Pearson and Hartley, 1954). The first two moments d_n and V_n as also the B_1's and B_2's are also tabulated for $n = 0$-20, 30 and 60.

We have for the distribution in (1),

$$E(w_n) = d_n \sigma \; ; \qquad Var(w_n) = V_n \sigma^2. \quad (2)$$

Thus $\frac{w_n}{d_n}$ is an unbiased estimator of σ. From the values of V_n and d_n it can be seen that this range estimator is nearly as reliable as the s.d. estimator up $n = 10$, the ratio of standard errors for this sample size being 0.926; the relative accuracy however drops off for larger n.

In view of the low efficiency of the range estimator for large samples and also its departure from normality (—it is closest to normal for $n = 8$ to 10), it was proposed that the observations in a sample be randomly divided into groups of 8 to 10 and a weighted mean of the several group ranges taken. The simplest case, and one which can be quite common, is that for which the groups or sub-samples are of the same size. If there are m such independent groups with n observation in each, the mean of the m ranges will be denoted by $\bar{w}_{m,n}$ Corresponding to (2), we have

$$E(\bar{w}_{m,n}) = d_n\sigma\,; \quad Var(\bar{w}_{m,n}) = \frac{V_n\sigma^2}{m}\,. \qquad (3)$$

It was shown by Patnaik (1950) that a X-distribution would give a reasonably accurate representation of the distribution of $\bar{w}_{m,n}$. From various checks, it was verified that $\bar{w}_{m,n}/\sigma$ is closely distributed as $cX/\sqrt{v}$, where c is a scale factor and v the degrees of freedom of the corresponding χ^2. Since s/σ is distributed as $X/\sqrt{v}$, we see that $\bar{w}_{m,n}$ has the distribution of cs. A table of values of c and v in term of m and n is given in Biometrika Tables I.

It is possible that the m samples on which $\bar{w}_{m,n}$ is based might arise independently instead of being the result of subdivision of a single sample. In this case the different samples might be of unequal sizes and it will be necessary to take a weighted instead of a single mean of the ranges. An unbiased minimum variance estimator of σ can be obtained in the form

$$\bar{W} = \sum_{i=1}^{m} a_i w_i\,, \qquad (4)$$

where w_i is the range in the i th. sample of size n_i There-

fore, taking d_i and V_i as the mean and variance of samples of size n_i from a normal population of s.d. unity, we have

$$E(\bar{w}) = \sum a_i d_i \sigma = \sigma \qquad (5)$$

and

$$Var(\bar{w}) = \sum a_i^2 V_i \sigma^2 \qquad (6)$$

Minimizing (6) subject to the condition (5), we get

$$ai = \frac{(di/Vi)}{\sum \frac{(di)^2}{Vi}}$$

Hence the required estimator is

$$\bar{w} = \frac{\sum (w_i d_i / V_i)}{\sum (d_i^2 / V_i)} \qquad (7)$$

and its variance is

$$\frac{\sigma^2}{\sum (d_i^2 / V_i)}$$

This $\bar{w}$ corresponds to $\bar{w}_{m,n} / d_n$ of the equal sample case.

The distribution of $\bar{w}$ can be approximated by that of $cX/\sqrt{v}$ or cs where c and v have values dependent on m and the n's.

3. Tests based on range

The modified t-test

If $\bar{x}$ is the mean of a normal sample of N observations, then the standard test of significance of the difference of $\bar{x}$ from a specified u is based on the statistic

$$t = \frac{|\bar{x} - u| \sqrt{N}}{s}.$$

Employing a range estimate of σ instead of s, we have the ratio

$$u = \frac{|\bar{x} - \mu| \sqrt{N}}{\bar{w}/d_n}, \qquad (8)$$

where $\bar{w}$ is the mean of ranges in the m groups of size n into which the sample of N is randomly divided. It is known that the sample mean is independent of the range in the sample and, therefore, of the mean range. Lord (1947) has studied the distribution of u and has developed the u-test which is analogous to the t-test. Adopting the approximation to the distribution of $\bar{w}$ discussed in the last section, we find that u in (8) is distributed as

$$\frac{d_n |\bar{x} - \mu| \sqrt{N}}{cs} = \frac{d_n}{c} t,$$

where t has v degrees of freedom v and c being contants based on m and n. Hence the test procedure consists in evaluating the statistic

$$\frac{cu}{d_n} = \frac{c|\bar{x} - \mu| \sqrt{N}}{\bar{w}}$$

and refer it to the t probability scale for v degrees of freedom.

To test the significanse of the difference of two sample means, we likewise obtain a modification of the standard two-sample t-test by using a range estimate for the common σ. If the samples are of sizes N_1 and N_2 and they are divided randomly into m_1 and m_2 subsamples of the same size n then the single mean of the $k = m_1 + m_2$ ranges is

taken instead of the pooled root-mean-square estimate. The statistic

$$\frac{c\,|\bar{x}_1 - \bar{x}_2|}{\bar{w}_{k,n}\sqrt{\left(\frac{1}{N_1}+\frac{1}{N_2}\right)}}$$

follows approximately a t-distribution with v degrees of freedom. Moore (1957) has considered the case of two samples of sizes n_1 and n_2 and the status of the range test using the statistic

$$\frac{|\bar{x}_1 - \bar{x}_2|}{(w_1 + w_2)} \quad . \tag{9}$$

He has shown that it the sample sizes are around 8 to 10, although slightly unequal, $\frac{w_1 + w_2}{2}$ can be well represented by a X-distribution and he has given a table of percentage points of the distribution of (9). Since the main objection to use of range as an estimator of σ is its higher variance than the s.d. estimate, it should be desirable to combine w_1 and w_2 so as to give an estimate having minimum variance. Following the result given in Section 2, we shall employ the following estimate of σ :

$$= \frac{[\text{illegible}] \quad [\text{illegible}]_2 / V_2}{d_1^2/V_1 + d_2^2/V_2} \;;$$

where the suffixes refer to the two samples. This may be used in the place of $\bar{w}_{m,n}$ in (8); the scale factor c and the equivalent degrees of freedom v of the approximate t-distribution will depend on n_1 and n_2

Analysis of variance test

Suppose W_N is the range in a sample of N observations

from a normal population with s.d. σ and let there be m further independent samples of sized n drawn from the same population and let the mean range be noted by w. The ratio $W_N / \bar{w}$ has been shown (Patnaik 1950) to follow approximately the distribution of a Studentized range, that is, the ratio of a range to an independent root-mean-square estimate of σ. Since tables for the distribution of the Studentized range $W_N / \bar{w}$ are available, tests based on the distribution of the range ratio $W_N / \bar{w}$ could be easily conducted.

In a one-way classification where there are m groups with n observations in each, the ratio of the range of the group means ($\bar{X}_{max} - \bar{X}_{min}$) to the mean range within groups $\bar{w}_{m,n}$ could provide a test criterion for testing the significance of the differences between the group means. Using the approximation to $\bar{w}_{m,n}$ we see that

$$q' = c\sqrt{n}\left(\frac{\bar{X}_{max} - \bar{X}_{min}}{\bar{W}_{m,n}}\right)$$

is distributed as a Studentized range, since the ranges in the numerator and denominator are independent. This test procedure avoids the necessity of computing the sums of squares needed in the standard F-test and can be followed easily by anyone. Even when there are unequal numbers in the groups, David (1951) has shown that the test could be applied in the same manner taking, however, $\bar{n}$ the mean of the group frequencies in place of n.

In a randomized blocks design with m blocks and n treatments, to estimate the error standard deviation, σ, we first form the differences of dividual observations from their respective treatment means and then take the range of these treatment residuals in each block. The average of these ranges for the blocks (w) is $\bar{w}$ and the range of the treatment means is W_n. As the w_i's are correlated, the

variance of $\bar{w}$ is not V_n / m, where V_n is the variance of single w_b. Hartley (1950) has worked out the correlations and obtained the correct expression for the variance of $\bar{w}$. As before, the distribution of the range ratio $W_n/\bar{w}$ was represented by that of Studentized range, the scale factor c and equivalent degrees of freedom v being slightly different from the un-correlated case of a one-way classification. The test of significance of differences between treatment means consists in referring $\frac{c\sqrt{v}\, W_n}{\bar{w}}$ to the tables of Studentized range.

David (1951) has extended the range methods to double classification with cell replication and also with two-factor treatment combinations and the split plot design. It may be mentioned that a ratio of two independent mean ranges was used for testing interactions.

4. Range in bi-variate samples

The usefulness of range as an estimator of σ suggests the extension of range methods to bi-variate normal samples. We shall show how very simple expressions could be given in terms of the ranges of correlated variables for measuring the covariance, coefficients of regression and coefficient of correlation and how they could be used for deriving certain tests of significance.

Let $(x_1\ y_1), \ldots (x_n\ y_n)$ be n pairs of independent observations from a bi-variate normal population defined by $f(x\ y)$. Let the second order moments be $\sigma_x^2, \sigma_y^2, \rho\, \sigma_x\, \sigma_y$ and the regression coefficients be $B_1\ B_2$. As we will be employing differences of pairs of x's or y's we may take the means M_n and M_y to be zero. Suppose amongest the x's, x_n is the largest and x_1 the smallest. Denote the range $x_n - x_1$ by w_n and the difference of the associa-

ted y's that is $y_n - y_1$ by u_y Similarly if y_i and y_j are the largest and smallest y's, denote the range $y_i - y_j$ by w_y and the difference $x_i - x_j$ by u_n. It will be noted that while w_x and w_y are ranges which can take only positive values, u_x and u_y are not ranges and they can take any values from $-\infty$ to ∞ We shall refer to them as "associated differences".

We have seen (Section 2) that σ_x and σ_y can be well estimated by w_x and w_y. We propose the following expression to measure covariance of x, y:

$$\frac{1}{2}\left(w_x u_y + w_y u_x\right) \qquad (10)$$

and we shall show that this can be used to estimate the covariance in the population. Using this expression for the covariance and w_x^2 and w_y^2 for the variances in the Pearson coefficient of correlation, we have the following range expression for r:

$$r = \frac{\frac{1}{2}\left(w_x u_y + w_y u_x\right)}{w_x w_y} = \frac{1}{2}\left(\frac{u_y}{w_y} + \frac{u_x}{w_y}\right) \qquad (11)$$

For the regression coefficients we shall have

$$b_1 = \frac{u_y}{w_x} \quad ; \quad b_2 = \frac{u_x}{w_y} \qquad (12)$$

Although these do not satisfy the standard relation $b_1 b_2 = r^2$ where r is as defined in (11), it will be seen that they are unbiased estimated of B_1, B_2.

We shall now obtain the mean values and variances of u_y u_y / w_x and $u_y w_x$ Since X_1 X_n are the extreme observations in the simple $(x_1 y_1), \ldots (x_n y_n)$, the joint distribution of $x_1, y_1, \ldots x_n, y_n$ is given by

$$p(x_1, y_1, \ldots x_n, y_n)\, dx_1 dy_1 \ldots dx_n dy_n$$
$$= n(n-1)\left\{\int_{x_1}^{x_n}\int_{-\infty}^{\infty} f(x,y)\, dy\, dx\right\}^{n-2} f(x_1, y_1) f(x_n, y_n)\, dx_1 dy_1 dx_n dy_n$$
$$= n(n-1)\left\{\int_{x_1}^{x_n} f(x)\, dx\right\}^{n-2} f(x_1, y_1) f(x_n, y_n)\, dx_1 dy_1 dx_n dy_n, \quad (13)$$

where $f(x) = \int_{-\infty}^{\infty} f(x,y)\, dy$ is the probability density function of x. From (13) we have for the mean value of u_y

$$E(u_y) = n(n-1)\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left[F(x_n) - F(x_1)\right]^{n-2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x_1, y_1) \times$$
$$f(x_n, y_n)\ (y_n - y_1)\, dy_1 dy_n dx_1 dx_n . \quad (14)$$

Now
$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x_1, y_1) f(x_n, y_n)(y_n - y_1)\, dy_1 dy_n$$
$$= f(x_1) f(x_n) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(y_n | x_n) f(y_1 | x_1)\ (y_n - y_1)\, dy_1 dy_n . \quad (15)$$

Since $f(y/x)$ defines the conditional distribution of y for a given x it has mean $B_1 x$ and variance $\sigma_y^2 (1 - P^2)$. Hence the right side of (15) simplifies to

$$f(x_1)\, f(x_n)\, \beta_1 (x_n - x_1) .$$

Therefore from (14),

$$E(u_y) = n(n-1)\beta_1 \int_{-\infty}^{\infty}\int_{x_1}^{x_n}\left[F(x_n) - F(x_1)\right]^{n-2} f(x_1) f(x_n) \times$$
$$(x_n - x_1)\, dx_1 dx_n = \beta_1 E(w_x) \quad (16)$$

To find the variance of u, we obtain, following a method similar to the above,

$$E(u_y^2) = 2\sigma_y^2 (1-\rho^2) + \beta_1^2 E(w_x^2) \qquad (17)$$

Therefore

$$V(u_y) = 2\sigma_y^2 (1-\rho^2) + \beta_1^2 V(w_x^2) \qquad (18)$$

The moments of $\frac{u_y}{w_x}$ and $u_y w_x$ are similarly obtained from the joint distribution (13). The values are

$$E\left(\frac{u_y}{w_x}\right) = \beta_1, \; V\left(\frac{u_y}{w_x}\right) = 2\sigma_y^2 (1-\rho^2) E\left(\frac{1}{w_x^2}\right);$$

$$E(u_y w_x) = \beta_1 E(w_x^2);$$

$$V(u_y w_x) = 2\sigma_y^2 (1-\rho^2) E(w_x^2) + \beta_1 V(w_x^2). \qquad (19)$$

Results similar to those in (16), (18), (19) can be derived for the expectations and variances of u_x, u_x / w_y and $u_x w_y$.

As in the earlier sections, we shall denote the mean and variance of range from a normal population with $\sigma = 1$ by d and V, dropping the subscript n. Then it will be seen that

$$E\left\{\frac{u_y w_x + u_x w_y}{2}\right\} = \frac{1}{2}\left\{\beta_1 \sigma_x^2 (V+d^2) + \beta_2 \sigma_y^2 (V+d^2)\right\}$$

$$= \rho \sigma_x \sigma_y (V+d^2).$$

Hence $\dfrac{(u_y / w_x + u_x / w_y)}{2(V+d^2)}$ is an unbiased estimator of the population covariance.

From (19) we find that u_y / w_x is an unbiased estimator of B_1. Similarly u_x / w_y will be an unbiased estimator of B_2.

With regard to the proposed correlation coefficient

$$r = \frac{w_x u_y + w_x u_x}{2 w_x w_y},$$

we may use

$$\frac{d^2 (w_x u_y + w_y u_x)}{2 (V + d^2) w_x w_y} = \frac{w_x u_y + w_y u_x}{2 \left(1 + \frac{V}{d^2}\right) w_x w_y} \qquad (20)$$

as an estimator of P since $w_x u_y + w_y u_x / 2 (V + d^2)$ is an estimator of P $\sigma_x \sigma_y$ and w_x / d and w_y / d are estimators of $\bar{x}$ and σ_y An alternative estimator which is simpler than (20) can be taken as

$$\frac{1}{2} \left(\frac{u_y}{w_y} + \frac{u_x}{w_x} \right) \qquad (21)$$

$E(u_y) = \rho \sigma_y d$, $E(\sigma_y) = \sigma_y d$ and $E(u_x) = \rho \sigma_x d$, $E(w_x) = \sigma_x d$.

This differs from (20) by the factor $\left(1 + \frac{V}{d^2}\right)$ in the denominator which is nearly unity. It is clear that neither (20) nor (21) is an unbiased estimator of P. Experimental sampling conducted in the U. P. Statistical Center showed that the extent of the bias in (21), is generally small.

As in uni-variate samples, the mean ranges in bi-variate samples are distributed more closely to the normal than the ranges in single samples. It is therefore desirable to divide a large bivariate sample into random groups of 8 to 10 each and use the mean ranges $\bar{w}_x$, $\bar{w}_y$ and the mean "associated differences" $\bar{u}_y$ $\bar{u}_x$ in the estimating functions given at (11) and (12).

To test the significance of b_1 when $B_1 = 0$, we shall consider the statistic

$$b_1 \cdot \frac{\bar{w}_x}{\bar{w}_y} = \frac{\bar{u}_y}{\bar{w}_x}$$

the distribution of which will be free from σ_x or σ_y. It can be easily shown that in a normal sample, the difference of any two observations is uncorrelated with the range. For,

$$E[(y_i - y_j) w_y] = E(y_i w_y) - E(y_j w_y);$$

since there is no restriction on i or j (—they can take values from 1 to n), y_i and y_j have the same status in relation to w_y and therefore $E(y_i w_y) = E(y_j w_y)$. Hence $E(u_y w_y) = 0$ and it follows that $E(\bar{u}_y \bar{w}_y) = 0$. Now $\bar{u}_y$ is a normal deviate and $\bar{w}_y$ has a distribution close to the normal as could be verified for the tabled B_1, B_2 of $\bar{w}$. Hence we may take $\bar{u}_y$ and $\bar{w}_y$ to be independent. Now adopting the more accurate representation of w_y by a X, we find that

$$\frac{c u_y \sqrt{m}}{\bar{w}_y \sqrt{2m}} = \frac{c u_y}{\sqrt{2}\, \bar{w}_y}$$

is distributed approximately as a t with v degrees of freedom. The c and v are the same constants based on m and n considered in section 2. This provides a very simple test for the significance of b_1.

The t-approximation to $(\bar{u}_y / \bar{w}_y)$ is not accurate at the tails as this statistic can have values only between — 1 and 1. A Type II distribution appears to be more appropriate and a better test may result from the use of this approximation.

Turning To

$$r = \frac{1}{2}\left(\frac{\bar{d}_y}{\bar{w}_y} + \frac{\bar{d}_x}{\bar{w}_x}\right);$$

it will be noted that when $P = 0$. E(r) is also zero. This statistic will follow approximately the distribution of $1/2\ (t + t)$ i.e. t and the test for significance of r is thus identical with the test developed above for b_1.

5. Use of range in sample surveys

It is known that when two independent estimates of a population characteristic are available from two sub-samples of the same size, preferably of an inter-penetrating type, the difference between the estimates could provide a method of judging the accuracy or reliability of each estimate. Here we are really using the range between the two estimates as a measure of the precision of the results. Range methods could be developed to provide similar quick estimates of the precision of the means or proportions obtained through sample surveys. Range estimates will be much easier to compute and they are likely to be nearly as efficient as the root-mean-square estimates. Three simple designs will be considered here in all of which sampling is by replacement.

Simple random sampling

If from a population of N units, a simple random sample of n units is drawn with replacement, we divide this sample into m sub-samples of n_1 units each, n_1 being about 8 to 10. This can be done quite easily by numbering the units serially as they are drawn and taking the first n_1 as one group, the next n_1 as another group and so on. (If one or two groups have one unit more or less than the others, this is found to have very little effect on the estimate of variance.) Take the range of x in each of the m groups and find the mean range $\bar{w}$. The quantity $\bar{w}/d_{n_1}$ will estimate the population standard deviation and therefore an estimate of the standard error

of the sample mean will be

$$\frac{\bar{w}}{d_{n_1}\sqrt{n}},$$

where d_{n_1} has the same meaning as before.

Stratified random sampling

Suppose there are m strata and n_h is the size of the simple random sample drawn with replacement from N_h units in the h th stratum. Let w_h denote the range of x in the h th stratum, An estimate of the population standard deviation in this stratum is given by w_h/d_{n_h} ; therefore an estimate of the standard error of n_h is $w_h/(d_{n_h}\sqrt{n_h})$. To find the standard error of $\bar{x}$, we may replace in the variance function

$$V(\bar{x}) = \frac{1}{N^2}\sum_{h=1}^{m}\frac{N_h^2\sigma_h^2}{n_h}$$

the range estimates w_h/d_{n_h} for σ_h and obtain

$$V(\bar{x}) = \frac{1}{N^2}\sum_{h=1}^{m}\frac{N_h^2 w_h^2}{d_{n_h}^2 \cdot n_h} \qquad (22)$$

The expression in (22) is however not an unbiased estimate of $V(\bar{x})$. Since $E(w_h^2) = \sigma_h^2(V_{n_h} + d_{n_h}^2)$ we may obtain an unbiased estimate $V(\bar{x})$ in the form

$$V(\bar{x}) = \frac{1}{N^2}\sum_{h=1}^{m}\frac{N_h^2 w_h^2}{(V_{n_h} + d_{n_h}^2)n_h}. \qquad (23)$$

Better estimates could be obtained by using mean ranges in (22) or (23); these would be obtained by dividing the sample in each stratum into random sub-samples.

Two stage sampling

Let us consider a sample with m first stage units and n second stage within each first stage unit. Since sampling is to be done with replacement, the variance of the sample mean $\bar{x}$ is given by

$$V(\bar{x}) = \frac{\sigma_u^2}{n} + \frac{\sigma^2 w}{nm} , \qquad (24)$$

where σ_u^2 is the population variance between the first stage units and σ_w^2 that within the first stage units. As in the analysis of data with one-way classification (see Section 3), we can estimate σ_u^2 by taking the range w_m of the means of the m first stage units and σ_w^2 by taking the mean of the ranges amongest the observations in the second stage units within each first stage unit ($\overline{w}_{m,n}$). Thus the range estimate of $V(\bar{x})$ would be

$$v(\bar{x}) = W_m^2 / n d_m^2 + \overline{w}_{m,n}^2 / nm d_n^2 . \qquad (25)$$

An unbiased estimate of $V(\bar{x})$ can be obtained as in stratified random sampling by adjusting the divisors d_m^2 and d_n^2 in (25).

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". . . the availability of data in any country is an index of how developed, how systematic, how disciplined the country is — the more highly organized it is, the more statistics it has. If "dearth of statistics" also mean that we would like statistics which become more accurate and more reliable, then surely all, especially statisticians, should endeavor to attain that perfection."

Economic Affairs
by Manila Jaycees Economic Affairs Committee, Manila Times, Nov. 21, 1956

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