

Lead Time to Return

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Abstract

Which came first, the chicken or the egg? This question has challenged the brightest minds, and was probably the motivation behind the development of the Cross Lag Panel design, a statistical methodology utilized to infer causality from correlation data. This paper presents one practical application of the Cross Lag Panel design in business.

Lead time to return is a procurement analysis tool that is based in "just in time" processing. Specifically, correlations between purchases and revenues are used to identify whether acquisitions are reactive, proactive, or just in time. When coupled with independent profitability measures, optimal procurement strategies may be identified.

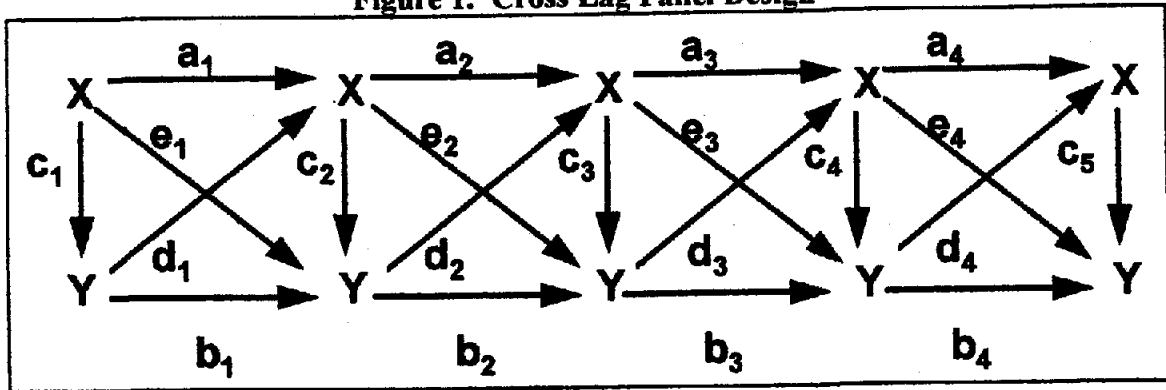
Background

Inferential statistics provide researchers a mechanism to evaluate the effects of experimentally controlled variables on dependent measures. By failing to reject the null hypothesis, the alternate hypothesis (the real focus of the study) is supported. With repeated tests and consistent rejection of competing null hypotheses, causal relationships centering on the alternate hypothesis are formed. This is the essence of scientific investigation.

In many natural settings, it is neither ethical nor possible to experimentally control variables. For example, there is a known relationship between cigarette smoking and lung cancer, but does smoking cause lung cancer or does the propensity to lung cancer cause an irresistible urge to smoke. Similarly, there is a strong positive correlation between ice cream cone sales and rapes in New York City. Does ice cream consumption result in rapes? Do rapes cause an increase in appetite for ice cream? Or is a third factor, such as temperature, affecting both the number of rapes and ice cream sales? Since urges, propensities, and other personal characteristics can not be experimentally manipulated, the causal relationships between them may appear to be elusive.

There is one procedure that may be used to examine causal relationships in correlation data. The Cross Lag Panel Design is a statistical procedure that scrutinizes static, temporal, and lag correlations between two naturally occurring variables to identify such causal relationships. A pictorial representation of the Cross Lag Panel Design is shown in Figure 1.

Figure 1. Cross Lag Panel Design



where:

- a_n = temporal correlation of X with itself (the reliability of X or its stability over time)
- b_n = temporal correlation of Y with itself (the reliability of Y or its stability over time)
- c_n = static correlation of X with Y (correlations as typically measured)
- d_n = lag correlation of Y with X at a later point in time (YX_{+1})
- e_n = lag correlation of X with Y at a later point in time (XY_{+1})

A requirement of employing the Cross Lag Panel Design is that the reliability of both variables is reasonable and that the average static correlation is respectable. Assuming these requirements have been met, the average lag correlations are examined. If one lag correlation is stronger than both:

- ♦ the alternate average lag correlation (e.g., $d > e$ or $e > d$) and
- ♦ the average static correlation (e.g., $d > c$ or $e > c$)

then a causal relationship is supported in the direction of the stronger lag correlation.

A Practical Business Application Using the Cross Lag Panel Design

The primary purpose of this paper is to propose another equally valuable use of the Cross Lag methodology, which has been previously unexplored. Specifically, it is suggested that with slight modifications, the Cross Lag Panel Design can be used to determine Lead Time to Return. Lead Time to Return refers to an organization's acquisition pattern, which may be reactive, proactive, or just in time. Furthermore, the design may be used to identify the optimal acquisition pattern when used in conjunction with external corporate performance criteria, such as ratings, profits, or stock prices.

The proposed application is intended for profit-making organizations that acquire resources and incur expenses as a direct function of workload or demand. When demand increases, the company expands — buys new equipment, hires new workers, or builds new sites — to accommodate the increased production. Companies spend money to make money. But how well are these expenditures timed with the revenues they bring?

Proactive acquisitions are those which occur in advance of increased demand. Management might anticipate an increase in demand, or they might consciously time advertising campaigns to follow increased production capacity. Reactive acquisitions are those which occur after an increase in demand. Management reacts to increased demand and declining ability to meet that demand. Band-Aid measures, such as overtime new production shifts, or delayed shipments, may be employed in the interim while production capacity is increased. Some business may be lost. Just in time acquisitions are those timed as close as possible to increases in demand, thereby avoiding the expenses of unused excess capacity or the pains of insufficient capacity.

Lead Time to Return employs a slight variation in the Cross Lag Panel Design. The causal relationships are known. Companies expend resources to accommodate workload or demand. By focusing on the lag correlations the more interesting question of acquisition timing may be addressed. Figure 2 illustrates the change in focus with Lead Time to Return analysis. Instead of selecting one lag, all possible lags are considered.

Figure 2. Cross Lag Panel Design Expanded for Lead Time to Return Analysis

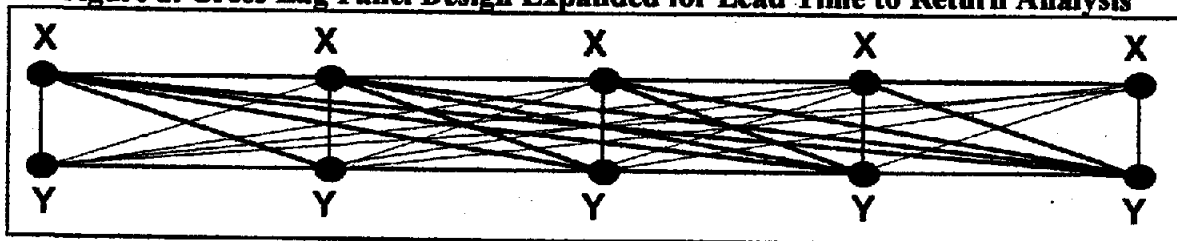


Figure 3 depicts all possible lag correlations for a 16 month data sample. As the number of correlation coefficients for each lag increases, the stability of the results improves.

Figure 3. All Possible Lag Correlations for Monthly Data Spanning 16 Months

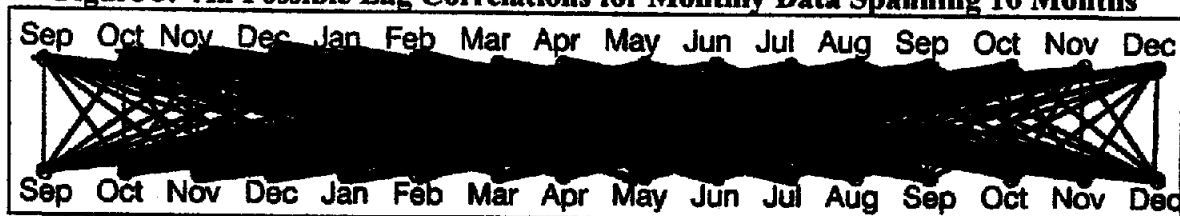


Table 1 shows the number of correlation coefficients for each lag in the above example. As shown in the table, there are a total of 256 correlations. The maximum number of coefficients occurs at lag zero, and decreases as the lag count increases in either direction from that point.

Table 1. Correlation Coefficients for Each Lag with 16 Months of Data																																	
Lag	-16	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0		
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0		
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0		
Jan	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0		
Feb	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0		
Mar	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0		
Apr	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0		
May	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0		
Jun	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0		
Jul	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0		
Aug	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0		
Sep	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0		
Oct	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		
Nov	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Dec	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		

The average correlation for each lag is plotted against the lag number. The distribution should approximate a normal one and the lag corresponding to the overall mean identifies the acquisition pattern. When correlating expenses against revenues, an overall mean at a negative lag denotes a reactive acquisition pattern since revenues at one point in time are most highly associated with expenses at a future point in time. By the same logic, an overall mean at a positive lag signals a proactive acquisition pattern in that revenues at a future point in time are most highly correlated with expenses at a given point in time. Finally, an overall mean at or about lag zero represents a "just in time" acquisition pattern.

A few precautions should be observed. First, the expenses should be directly tied to the revenues measured. This can be confirmed by looking at the static (lag zero) correlations. If they are not reasonably high, it might be better to look at different expenses or revenues. Try to capture the costs of raw inputs to the process, or equipment costs if they change quickly. Also, be sure to isolate the revenues for the process from other revenue sources. For example, do not correlate the cost of maintaining an orange tree against the revenues from bushels of mixed fruit. The correlations surrounding the overall mean should drop off within six or seven lags, but if there are no peaks and valleys, do not be alarmed. Flat portions of the curve at a relatively high correlation may indicate a stable business with relatively unchanging expenses or revenues over the time interval.

Figures 4 through 9 show samples of Lead Time to Return analyses. Although the results generally support the model, they are a little disappointing. Later, it was learned that contracts play an important role in these acquisitions. Perhaps another setting, such as a manufacturer, restaurant, or retailer might provide a better test of the model.

Assuming the results of the first phase of the modified Lead Time to Return analysis are satisfactory, external performance criteria can be correlated with the results to determine optimal acquisition patterns. External performance criteria may include profits, stock prices, corporate bond ratings or the like. Large time samples for a single company or many samples from similar companies will enhance the validity of the results. Correlate the acquisition patterns (lag at the overall mean) with the external performance criteria. The acquisition pattern with the highest positive correlation to the external corporate performance criteria is the optimal one for the group.

Figure 4. Sample 1 -- CPU

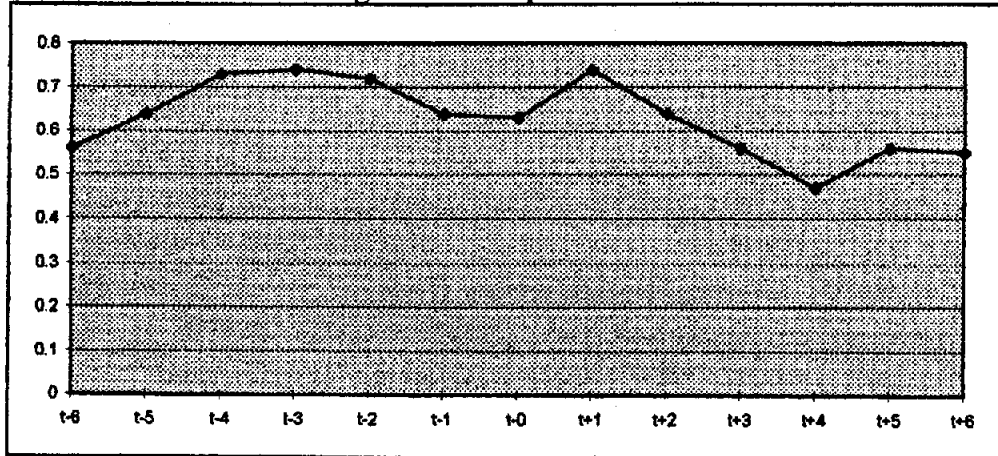


Figure 5. Sample 2 -- CPU

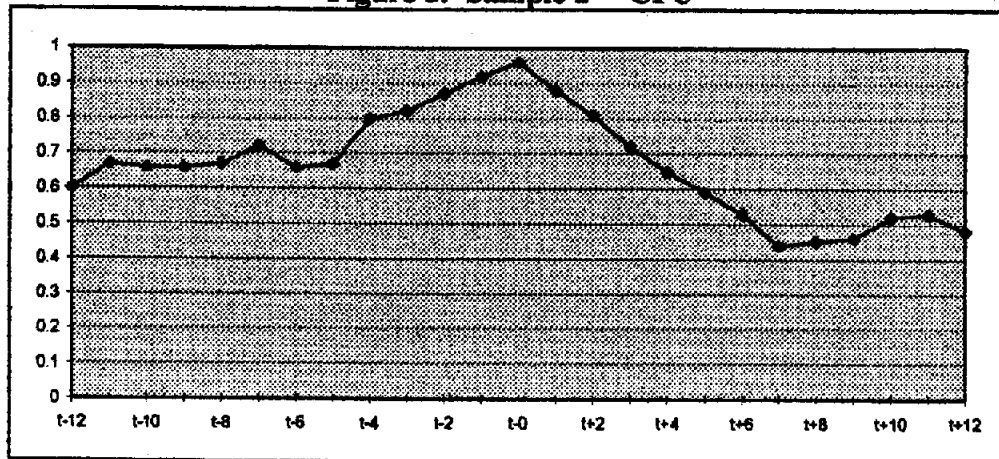


Figure 6. Sample 3 -- CPU

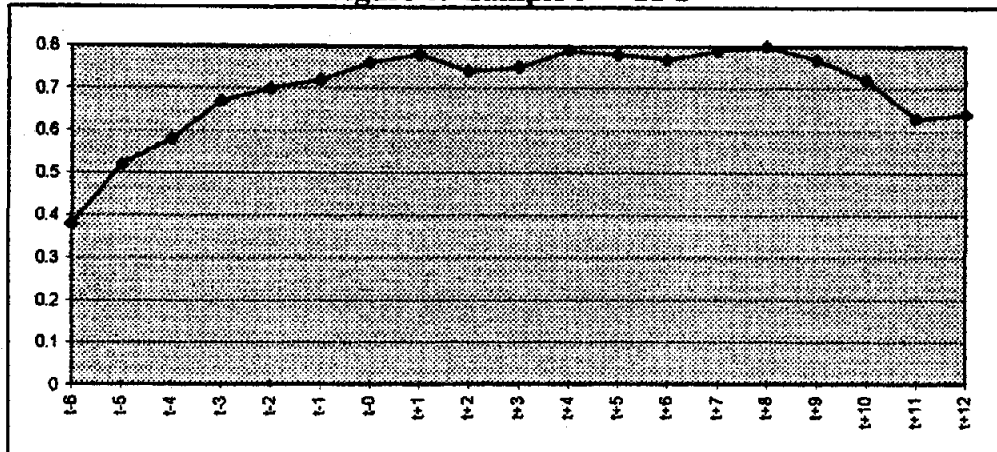


Figure 7. Sample 1 – DASD

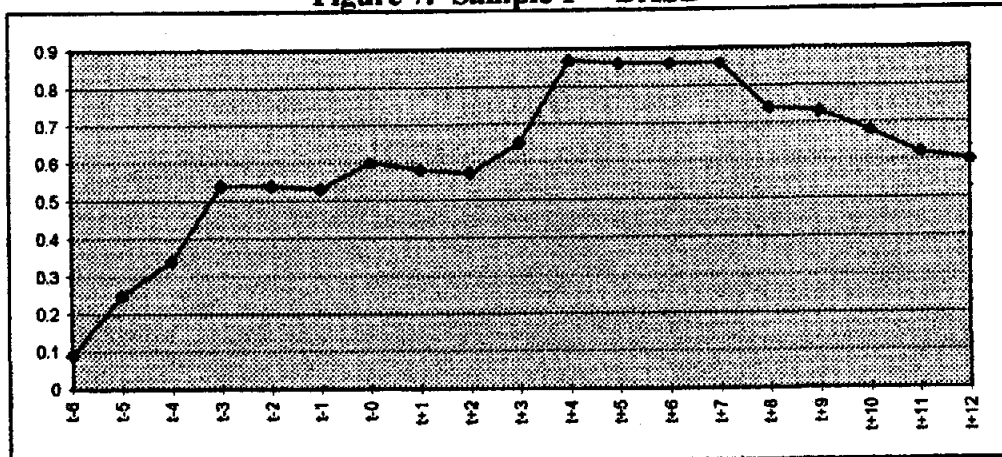


Figure 8. Sample 2 – DASD

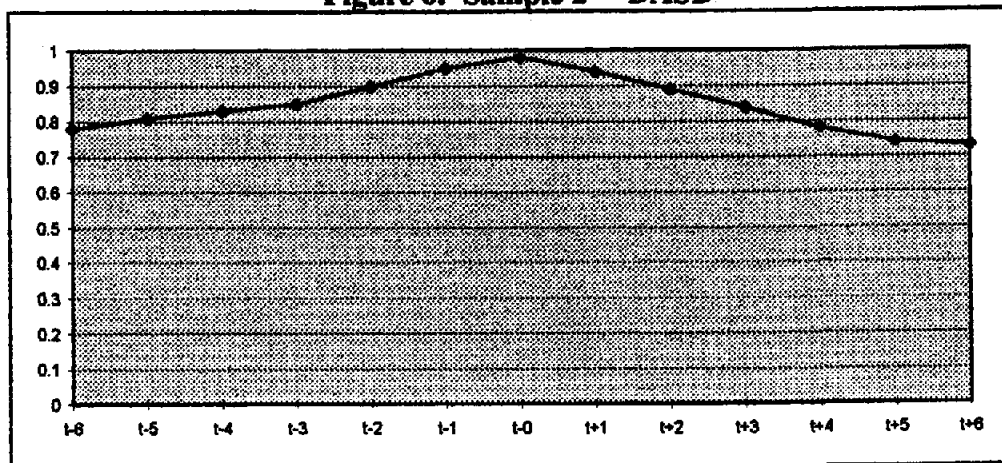


Figure 9. Sample 3 – DASD

