Lags in Training Response to Changes in Economic Activity: An Exploratory Inquiry for Five Industries

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This study investigates the length of time it takes training budgets in five industries to respond to changes in the demand for their services/activity and for their speed of response to changes in productive activity. The results indicate that for the industries studied, the length of lag between change in demand and median adjustment to that change is from six to nine months. This bespeaks serious challenges to America's competitiveness in the world economy.

Keywords: Training, Change, Strategic Human Resource Development

When thinking of the role of training in a conceptual framework, one of the major difficulties facing corporations in American society may be described as "keeping up." Daily we are bombarded with news reports of how companies are losing out to competition from here and abroad with announcements ranging from plant closings to shutting down entirely. Ford Motor Company is a recent example where 14,000 people are to be laid off permanently and at least eight plants are to be closed by 2009 (*Business Week*, 11 September 2006, p. 14; *Forbes*, 3 July 2006, p. 7).

It should be obvious that an area where "keeping up" is of primary importance is training. In order for American business to retain—or possibly increase—its competitive posture, training must be conducted in a fashion to make our workers among the best in the world. The well-known effort in the quality movement, nominally initiated by W. Edwards Deming and Joseph M. Juran, certainly reflects this posture. Moreover, the Six Sigma programs (operated at firms like GE), where workers are trained to move toward Black Belts in Quality instead of Karate, are still another example of America's efforts to make workers both more effective *and* quality conscious employees.

A Conceptual Framework

The issue of aligning training with its need in time is a crucial question for a number of reasons. As we have moved to a "just in time" business environment, the generation of industrial output involves making certain that the capital equipment and raw materials are available as needed. The same must be said for the human capital involved in the production as insufficiently—or belatedly--trained workers will not be able to use plant and equipment efficiently. Similarly, without a timely trained workforce the organization will not provide in an adequate way the inputs it generates for subsequent steps down the supply chain. Additionally, training which does not meet the organization's requirements when needed is often more costly and wasteful.

To summarize these issues, the relative speed of response with training to its need forms a measure of competitive advantage for the firm. The more a rapidly a firm can respond when the need arises the greater its level of competitive advantage in the market place. While not fitting into a specific theoretical model, the idea of speed of response fits within a conceptual framework in which organizations operate to maximize competitive advantage in a dynamic marketplace.

We offer a heretofore unexplored issue in American training: how quickly does industry respond with training efforts when the need arises as business turns upward. Put differently, when a business experiences an increase in the demand for the goods and/or services it produces, how long does it take before the business responds with the necessary training program(s) which will enhance its competitiveness? While we have found no evidence of an inquiry into this issue, we will offer a technique below which allows initial answers to these concerns from some five U.S. Census defined industries.

Measuring Lags in Training—A Technique

There are a host of reasons why training may lag behind economic activity in the firm and industry. A firm may be unsure as to whether an increase in demand will "stick," delaying its training efforts until it is sure. A firm may hold back on training because it has insufficient capital in place and must delay until new technology arrives. A firm may be planning on/working toward expanding in other markets and be caught off guard when demand surges for an output it no longer believed to be an active participant in the market. A firm…..

While the above list could be extended, what is known about such "delaying causes" in the lags between output increases and response to them is that the wait generally follows a geometric lag (Koyck, 1954)….particularly when measured on an aggregated basis. What this means is that those factors which move a firm to delay its investment in the training decision tend to have their greatest impact in the initial period and then trail off in successive periods. This trailing off is largely due to the other effects (some of which are mentioned above) which are working in the instant period(s) and the interactions of all effects from all time periods. While there may be some variation in the lag patterns of individual firms—and lag structures such as the Almon or adaptive expectation lags or the stock adjustment approach might be used--these tend to wash out when industry-wide data are assessed. What this means is that, while the geometric decline of Koyck (1954) provides the best assessment at the level of data utilized here, other approaches may work with individual firm data. The upshot of this approach, however, is that while it is true that the geometric declining effect conceptually is appropriate it also is infinite in length, we would like to be able to limit its impact to a measurable period of time and will do so for this analysis.

What this implies is that we need to consider the impact of any change in the level of economic activity on training as being measured by an equation of the following form:

$$(1) \qquad T_t = \square + \beta_0 O_t + \beta_1 O_{t-1} + \beta_2 O_{t-2} + \ldots + \beta_n O_{t-n} + \square_t$$

which simply says that the training in time t (T_t) is a function of the Output in time t (O_t) and Output in each of the previous time periods (e.g., t-1, t-2,…, t-n).

We then identify a weight, termed λ such that $0 < \lambda < 1$ which captures the geometric nature of the decline in the following form and allows us to use/assess a constant/stable coefficient:

$$(2) \qquad T_t = \square + \beta_0 O_t + \beta_0 \lambda O_{t-1} + \beta_0 \lambda^2 O_{t-2} + \ldots + \beta \lambda^n O_{t-n} + \square_t$$

The remaining difficulty with this equation/approach is that it is still one with an infinite time horizon which means that it is unobservable / unmeasurable in reality. The transformation by Koyck (1954), however, allows us deal with these infinite observations. We start with the equation/relationship noted above lagged one time period:

$$(3) \qquad T_{t-1} = \square + \beta_0 O_{t-1} + \beta_0 \lambda O_{t-2} + \beta_0 \lambda^2 O_{t-3} + \ldots + \beta_{n-1} \lambda^{n-1} O_{\tau-n-1} + \square_{t-1}$$

We multiply our third equation by λ and obtain:

$$(4) \qquad \lambda T_{t-1} = \lambda\square + \lambda\beta_0 O_{t-1} + \beta_0 \lambda^2 O_{t-2} + \beta_0 \lambda^3 O_{t-3} + \ldots + \beta_{n-1} \lambda^{n-1} O_{t-n-1} + \lambda\square_{t-1}$$

We now subtract (4) from (2) with the result:

$$(5) \qquad T_t - \lambda T_{t-1} = \square(1-\lambda) + \beta_0 O_t + (\square_t - \square_{t-1})$$

which becomes through reduction:

$$(6) \qquad T_t = \square(1-\lambda) + \beta_0 O_t + \lambda T_{t-1} + v_t \qquad \text{where } v_t = (\square_t - \square_{t-1})$$

The above, which is called the *Koyck Transformation* (1954), leads to an equation which is measurable in current values of Output and previous values of Training, and allows for an empirical assessment of the lags associated with response to changes in demand….we now turn to such an assessment.

Measuring Lags in Training—An Exploratory Assessment

In applying this technique empirically to questions of training, there are types/levels of analysis we can pursue. The first involves what might be termed the U.S. Census Bureau's approximation to sales, Gross Domestic Product (Originating in an Industry) or GDPO. This measure reports what has been sold by an industry for a specific period (e.g., year, quarter) as a contribution to the Gross Domestic Product (GDP) of the entire country. For an individual industry this is the closest proxy available for sales.

The second Census Bureau measure is Value Added which is a proxy for the production activity in an industry. This measure is more specifically related to the direct economic/productive activity in an industry. This is because changes in demand, as measured by Gross Domestic Product, can be responded to through inventory adjustments, trans/cross shipments and other means while changes in production/value added do require productive activity which will need the efficient and capable efforts of trained employees.

For this study, training data on an industry basis were taken from the annual surveys reported in the magazine *Training*. Each year this magazine provides measures on training on an industry basis; for the instant study we were able to use data from the years 1989 - 1998 for some five Census defined industries. Data complications/availability limited the study and thus make it exploratory. That is, while we know there are data from this source covering more industries and a longer time period, they were not available to us in a way which made them usable for this study.

The second source of data is the quinquennial economic censuses completed by the Bureau of the Census, U.S. Department of Commerce, every five years (e.g., 1987, 1992) as well as industry data on real and current dollar Gross Domestic Output from the Bureau of Economic Analysis of the U.S. Commerce Department and published annually. These sources provide, for firms of 100 or more employees, data on Sales/Gross Domestic Product and Production/Value Added.

For each of five Census industries, two regressions were run using the Koyck transformation of equation 6 above. One estimation utilized the sales data as the independent variable and the other used the production data as the independent variable; in each case training budgets from *Training* magazine constituted the dependent variable. The results of these five pairs of regressions are reported in Table 1.

Table 1. *Computed $ß_0$, λ, and r^2 From Regressions Estimating Training Lag on Five Industries; After Koyck Transformations*

Industry	Sales / Gross Domestic Product			Production / Value Added		
	$ß_0$	λ	r^2	$ß_0$	λ	r^2
Manufacturing	208.2	0.342	0.466	202.2	0.311	0.462
Finance, Insurance and Real Estate	543.1	0.419	0.832	305.8	0.417	0.842
Transportation	-768.4	0.493	0.562	-1277.8	0.271	0.605
Business Services	-114.9	0.135	0.126	-86.2	0.159	0.135
Educational Services	15870.1	0.321	0.418	6266.2	0.348	0.449

Note. Computed Coefficients for Industry Regressions, 1989 – 1998.

These results provide some interesting insight into industrial behavior with respect to responses by these industries to changes in the output measures used. Consider first the $ß_0$ values estimated. One clear result is that three of the industries adjust training expenditures in parallel with output changes—Manufacturing; Finance, Insurance and Real Estate; and Educational Services. What is perhaps more interesting is that two of the industries—Transportation and Business Services—show negative responses (i.e., negative $ß_0$) to output changes. Put differently, this means that they end up cutting back/slowing down on the rate of growth of training expenditures when the see economic expansion and increase the rate when business slows down. While these latter results may

seem counterintuitive, they may be necessitated by characteristics of these industries which are beyond the scope of this investigation.

The coefficients for λ are what would be expected, larger with respect to sales/gross domestic product and smaller with respect to value added. The implications of this will be evident from the discussion which follows. But first a slight digression.

We know from Gujarati (2003) that

(7) $$\text{Median Lag} = -(\text{Log } 2/\text{Log } \lambda)$$

which means that we can derive the median length of adjustment period for each of our industries in response to changes in sales and production. Put differently, it is possible to determine through the use of equation 7 how long it takes each of the five industries investigated to get half-way to complete adjustment to the motivating change. We note that because the estimating relationship involves conceptually an infinite number of time periods and is geometric in nature it would not be possible to make statements about when total adjustment occurs. But the medians hold valuable insights and are reported in Table 2 by solving equation 7 using the λ from each of the estimated equations of Table 1. Estimates of other periods of time are available but, since they are in a relative sense parallel to the estimates reported here, they are reported.

Table 2. *Median Length of Response in Training Activity to Two Measures of Industry Output--Sales and Value Added--in Five Industries; Using Koyck Transformation Regression Results and Calculated Using Equation 7*

Industry	Median Length of Response Time, In Months, Due to Change	
	Sales / Gross Domestic Product	Production / Value Added
Manufacturing	7.7 months	7.3 months
Finance, Insurance, Real Estate	9.6 months	9.5 months
Transportation	11.7 months	6.4 months
Business Services	4.5 months	4.2 months
Educational Services	7.9 months	7.3 months

Note. Number of months calculated from fractions of years derived by use of Equation 7. Thus, an estimated lag of 0.642 years would be translated into 7.7 months. Source: Computed from Regression Results for Industry Regressions

First of all from Table 2 we see that the industries take longer to respond to changes in sales than they do to changes in production (a result of the larger λ estimates for sales than those for production noted above). This is logical as was discussed earlier; it is possible to respond to changes in sales in a variety of ways before it is necessary to ramp up production. When one becomes seriously involved in generating more output it will demand more training.

The second issue raised by Table 2 is the length of time it takes these individual industries to respond or "catch up" with their training activities. The shortest median adjustment period was over four months for Business Services; the longest was Transportation which took almost a year to be half way to adjusting to a change in sales. Note that most industries took from seven to nine months to adjust their training just half way in response to market and production factors. What is interesting is that the "length" of lag is directly related to the stability of training in an industry. Thus, Business Services has the most stable training expenditures of this group; Transportation the most

variable. Put differently, Business Services expenditures on training are more "anticipatory" while those of Transportation are more "reactive."

Summary, Limitations, Implications, and Conclusions

This study has used the Koyck Transformation to investigate the length of time it takes for "industries" to respond to changes in the demand for their output. While the study is only a first approximation, it has demonstrated that median lags between the input and the change in training activity generally involve a six to nine month delay. Certainly this is a lag which means the industry is behind the power curve for a substantial period of time and, in some cases, may mean that it never catches up let alone "keeps up."

Several factors must be considered here. These industries are at substantially aggregated levels; thus manufacturing would include (among others) automobiles, textiles, computers, beverages, and ship building. Each of these more focused industries would reflect lags as well……although they are likely to be even wider in range than is reported here as these numbers represent an "average" in some sense. This implies that the lags may be incredibly long in some cases—perhaps extending for two or more years—while for others the lag may be a month or less. Work here, depending on availability of more "micro" data would be desirable.

Obviously, this study is an introductory one and needs to be expanded in many ways. More data--both for additional years and more industries--would be a valuable step and is a project currently under way. Hopefully it will be possible to obtain sufficient data for a study of three decades rather than one……more time will increase the power of the results. Moreover, with more data it may be possible to assess other lags than the geometric lag of the Koyck formulation although statistical results do indicate it is a very good fit for this purpose.

Another approach to this investigation would involve the use of more robust statistical techniques. The use of ordinary least squares herein runs the risk of statistical bias in estimating the relationships due to the presence of a lagged dependent variable. Further investigation will involve the use of non-linear and maximum likelihood techniques to ascertain different aspects of the relationships studied.

As a field that is closely concerned with employee training, the findings of this study are of significant importance strategically. The findings further HRD's mission to become a strategic business partner. Understanding industry dynamics and adequately interpreting these trends will help HRD to play a significant role in strategically preparing the human capital the organization will need. HRD must not just be an advocate for training; it must advance the strategic importance of training in anticipating business dynamics and work to get training out in front of the business needs. After all, organizations that lead the way through the rough and tumble of markets are those that have the necessary human capital and an organizational culture that fosters organizational learning. This study thus provides a good example of how HRD research can inform the practice and provide strategic guidance and direction in the halls of power within the organization. If firms/industries lag in their response to the market as is illustrated in these results, HRD can perform the important strategic functions of pointing this out and providing the necessary insight to correct the situation.

In sum, we note this exploratory investigation is intended to open a door on an issue of competitive advantage at the firm, industry, and economy level--how long does it take to respond with the appropriate and necessary training in order to remain competitive in the world economy. Results from this inquiry, which deal with but five industries for a decade of time, are only preliminary answers to the questions raised. But the importance of response is crucial in a world where competition faces the firm from a host of directions. It is hoped that more investigation and more dialogue will expand the use of these results and the others which come forth from the process.

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