# SOME APPLICATIONS OF FORECASTING

**Prof. Thomas B. Fomby**
**Department of Economics**
**Southern Methodist University**
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To demonstrate the usefulness of forecasting methods this note discusses four applications of forecasting in the world of business and personal investments: **Supply Chain Management**, **Inventory Control**, **Budgeting in Government**, and **Personal Investments**.

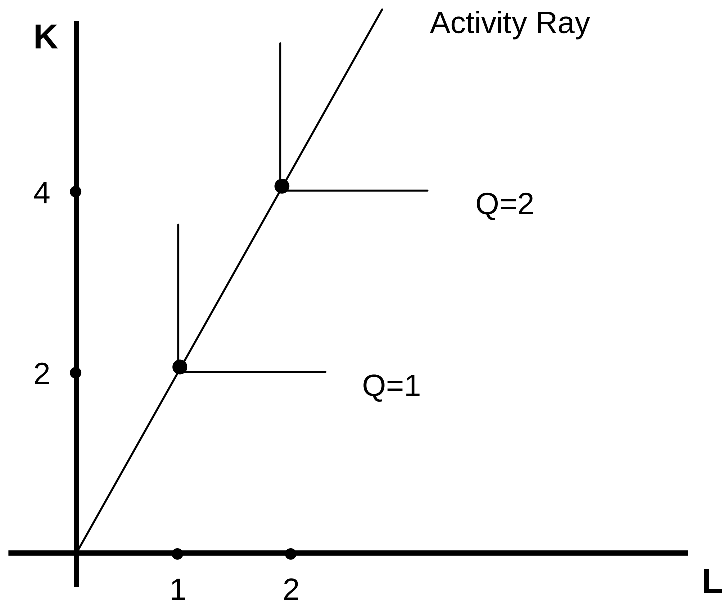
## I. Supply Chain Management

The supply chain manager of a manufacturing company is in charge of making sure that the necessary productive resources (capital, labor, component parts and the like) are always available for producing the required output demanded of the company by its customers. So the supply chain manager must determine a good forecast of the demand for the manufacturing company's output and from that estimate determine the necessary resources to produce the forecasted amount of output. One way to view this need for supply chain forecasts is to envision the manufacturing company producing output according to a **Fixed Proportions production function**. Let Q denote the units of output produced by the manufacturing company and capital (K) and labor (L) being the input to the companies production process. A Fixed Proportions production function is of the form

$$Q = \min\left[\frac{K}{K_1}, \quad \frac{L}{L_1}\right] \tag{1}$$

where $(K_1, L_1)$ is the fixed proportion of capital and labor required **to produce one unit of output**. For illustration, let $(K_1, L_1) = (2,1)$. Then the Fixed Proportion production function with the implied "activity ray" and isoquants is depicted in the figure below:

## Fixed Proportion Production Function




$(K_1, L_1) = (2, 1)$

The activity ray has a slope of two and represents the minimal combinations of capital and labor (in a two-to-one ratio) that will produce the various levels of output. The perpendicular isoquants for Q = 1 and Q = 2 are drawn in the figure and depict the fixed proportions relationship implied by the formulation (1). Assume you want to produce Q = 2, then you should use the input vector $2 \cdot (2,1) = (4,2)$ that is K = 4 and L = 2. Using the combination K = 5 and L = 2 will still produce 2 units of output because of the fixed proportion requirement. Notice that the Fixed Proportions production function exhibits **constant returns to scale**. If you double the inputs (in proportion of course), you double the output. For example, if

$$Q^* = \min\left[\frac{K^*}{K_1}, \quad \frac{L^*}{L_1}\right] \tag{2}$$

then

$$Q^{**} = 2Q^* = \min\left[\frac{2K^*}{K_1}, \quad \frac{2L^*}{L_1}\right]. \tag{3}$$

Therefore, in this simple case (which may be approximately true for many companies' production processes in the short run), we see that a forecast of the demand for output Q, say, $\hat{Q}$, will immediately give rise to forecasts of K and L, say $\hat{K}$ and $\hat{L}$, such that

$$\hat{Q} = \min\left[\frac{\hat{K}}{K_1}, \quad \frac{\hat{L}}{L_1}\right] \tag{4}$$

where $\hat{K}$ and $\hat{L}$ are minimally sufficient to produce $\hat{Q}$.

This situation is then ideal for the supply chain manager. She first forecasts the demand for the manufacturer's product $\hat{Q}$ and then, using the Fixed Production function's relationship (4), she backs out the input forecasts $\hat{K}$ and $\hat{L}$ required to produce the forecasted output. Thus, she manages the "supply chain". The greater the accuracy of her forecasts of Q, K, and L, the greater the profit of the company.

Of course, this discussion can be extended to multiple inputs $I_1, I_2, \cdots, I_K$ and the k-dimensional Fixed Proportions production function

$$Q = \min\left[\frac{I_1}{I_{1(1)}}, \quad \frac{I_2}{I_{2(1)}}, \quad \cdots \quad \frac{I_K}{I_{K(1)}}\right] \tag{5}$$

where $(I_{1(1)}, I_{2(1)}, \cdots, I_{K(1)})$ denotes the input proportion of the k inputs that gives rise to one unit of output. Again, given a forecast of Q, corresponding forecasts of the k inputs can be produced. Such is the supply chain problem in its crudest form.

## II. Inventory Control

If instead of managing production, you are an owner of a retail store, you are likely interested in managing your inventory efficiently as part of your plans to maximize your profits. During the month you wish to have plenty of your product lines on hand for customers to consider and buy but, on the other hand, you don't want to have too much inventory on hand because you then would have too much of your money (capital) tied up in idle inventory that otherwise could be drawing interest in a bank account somewhere. This is called the **inventory control problem** and you are an **inventory controller**.

Suppose that for your company you determine that your optimal inventory of your m products, $y_1^*, y_2^*, \cdots, y_m^*$, given demand for the m products of $y_1, y_2, \cdots, y_m$ is determined by the following optimal inventory-to-sales ratios:

$$ISR_1^{(opt)} = \frac{y_1^*}{y_1}, \; ISR_2^{(opt)} = \frac{y_2^*}{y_2}, \cdots, \; ISR_m^{(opt)} = \frac{y_m^*}{y_m} \quad . \tag{6}$$

Then given that you perceive your product demand for the next sales period to be

$$\hat{y}_1, \hat{y}_2, \cdots, \hat{y}_m \quad , \tag{7}$$

Your estimated optimal inventory for your m products, say

$$\hat{y}_1^*, \hat{y}_2^*, \cdots, \hat{y}_m^* \quad , \tag{8}$$

can be determined from the optimal sales ratios as in

$$ISR_1^{(opt)} = \frac{\hat{y}_1^*}{\hat{y}_1} \text{ or } \hat{y}_1^* = ISR_1^{(opt)} \cdot \hat{y}_1$$

$$ISR_2^{(opt)} = \frac{\hat{y}_2^*}{\hat{y}_2} \text{ or } \hat{y}_2^* = ISR_1^{(opt)} \cdot \hat{y}_2 \tag{9}$$

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$$ISR_m^{(opt)} = \frac{\hat{y}_m^*}{\hat{y}_m} \text{ or } \hat{y}_m^* = ISR_m^{(opt)} \cdot \hat{y}_m \quad .$$

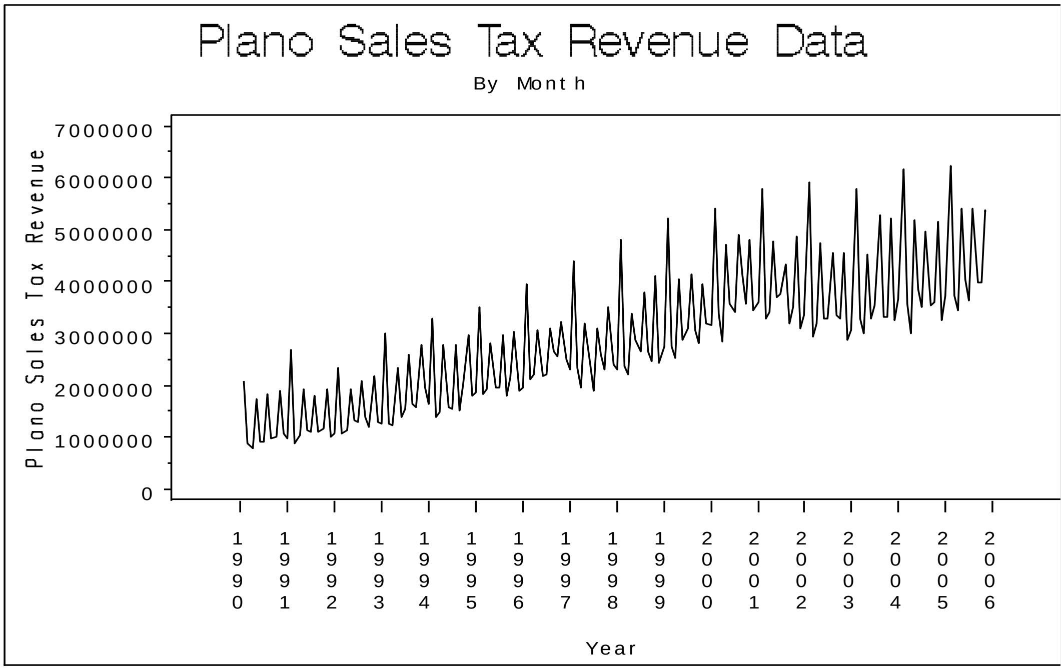
That is, we have established an optimal inventory level for the next sales period for our m products, namely, $\hat{y}_1^*, \hat{y}_2^*, \cdots, \hat{y}_m^*$, based on our product-line forecasts, $\hat{y}_1, \hat{y}_2, \cdots, \hat{y}_m$. Obviously, the more accurate our product line forecasts are, the more efficient our inventory levels well be thus increasing the bottom line profit of the company.

Of course, one might say, "How are the optimal inventory-to-sales ratios, $ISR_i^{(opt)}$, determined?" One way to determine these ratios is by a trial and error system which sees what inventory-to-sales ratios for each of the product lines leads to a minimum of left-over unsold product at the end of the sales period.

## III. The City Manager Problem

But forecasting is not only useful in manufacturing operations (the Fixed Proportions production problem) and optimal inventory control in retail stores (inventory-to-sales ratio problem) but also for public sector jobs like those of city managers managing the budgets of cities.

Consider the **City Manager problem**. The fiscal budgets of city governments are often determined by the amount of tax revenue that the city government hopes to garner in the coming year. Consider the following graph of Plano's sales tax revenues from February 1990 to November 2005.




How is one to forecast the total of sales tax revenue expected for Plano in the following year? One a forecast of the next-year's revenues is produced, the city manager then moves to establish the budgets of the various departments of the city government possibly using a proportional assignment of additional venues implied by the forecasts. Again, the more accurate the forecast of the City's next year revenues, the more accurate the budget setting process will be and thus the less the possible misallocation of resources in the City government over the coming year.

**IV. Personal Investments: The Bond Market**

Now let's consider a personal investment problem. As we know from beginning finance courses, the prices of bonds vary inversely with the level of interest rates. In fact the price of a bond that pays $R dollars per year in perpetuity at a rate of the annual interest rate r is priced at

$$P = \frac{\$R}{r} \quad . \tag{10}$$

Consider the following plot of annual averages of 3 month t-bill rates from 1933 through 2007 obtained from the 2008 Economic Report of the President. If one can identify the peaks of the interest rate cycles and invest long in bonds and, when troughs of interest rate cycles come about, invest short in interest sensitive assets that don't do well in rising interest rate regimes, then one's investment performance will likely improve as a result.

**Annual 3-Mo. T-bill Rates**
**1933 – 2007**