

ECONOMIES OF SCALE IN RED CROSS BLOOD

Centers: A Re-evaluation

M. Jane Garvey, M.S.

Management Science Department
Loyola University
Chicago, IL 60611

Marc J. Goodfriend, M.A.

Management Science Department
Loyola University
Chicago, IL 60611

William P. Pierskalla, Ph.D.

Leonard Davis Institute of Health Economics
University of Pennsylvania
Philadelphia, PA 19104

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Abstract

This paper presents a statistical analysis of the hypothesis that there are economies of scale in obtaining blood. Based on two years of Red Cross collection data we show that economies of scale do exist except possibly at very high volumes of activity. This conclusion contradicts an earlier Transfusion article by Jacobs and Rawson (7). The collection and recruitment components are also examined separately and show this same pattern of U-shaped economies of scale. In both combined costs and recruiting costs alone, a greater percentage of the variation in data is explained than by the earlier analysis.

In recent years several areas of the country have either regionalized their blood collection systems, notably New York and Los Angeles, or have investigated the possibility, e.g. Chicago. The stated purpose has frequently included statements about "improving service at lower cost." In that light, the conclusions in a Transfusion article by Jacobs and Rawson (7) that economies of scale in recruitment and collection costs do not exist over all scales of activity seem at least counter-intuitive if not completely shocking. The question of scale economies or diseconomies seem to be of such importance to the blood banking community and the shortcomings of the Jacobs and Rawson model seem to be so severe that we decided to reexamine the collection and recruitment cost issue. Through the use of a more complex model, a change in the method of analysis, and the use of more data, we show that scale economies do appear to exist at volumes of activity up to 150-200,000 units annually and diseconomies of operation appear at higher volume. In this more complex analysis we also explain a greater percentage of the variation in costs.

In the way of a brief background, Jacobs and Rawson examined the 1974-75 American Red Cross data (4) by applying the tool of linear regression analysis. By putting the statistically "best" linear equation to the ARC recruiting and collecting average cost per unit data for that one fiscal year they found the following regression equation:

$$\text{AVCOMCO} = 3.3 + .012 \text{ BLOODC} + .77 \text{ AVHREA} + .001 \text{ MOBIL}$$

where AVCOMCO is the average recruitment and collection cost per unit, BLOODC is the number of units collected, AVHREA is the average hourly wage earnings in each region, and MOBIL is the percentage of drawing done by mobile units. They used the manufacturing wage rates from the Bureau of Labor Statistics SMSA data (10) to compare costs at the ARC Blood Centers across the U.S. We notice that due to the linear nature of this equation

it is only possible to show either diseconomies of scale (the coefficient of BLOODC positive, as above) throughout the entire range of volume, economies of scale (a negative coefficient), or no effect due to scale. However economists have frequently found within the operations of many firms that the required inputs (labor and capital particularly) per unit of output may be relatively high at both low levels of output and high levels of output and relatively lower at intermediate levels of output. These findings result in the traditional "U"-shaped average cost per unit curve which exhibits economies of scale at a decreasing rate until a minimum is reached at which point diseconomies of scale commence (see ref. (6) and Figure 1). This economic phenomenon occurs because as volumes initially increase there may be increased efficiency due to more effective use of capital equipment and technology, quantity discounts, increased specialization, and division of labor. As volume continues to increase, the required labor increases or new equipment is needed due to additional management requirements, overcrowding of facilities, or in the case of blood bank recruiting, perhaps even saturation of the "donor market". In order to allow for the possibility of such a U-shaped curve the regression analysis must be done using a quadratic equation instead of the linear equation of (7).

In our approach, the inputs to production are approximated by an equivalent labor input derived by taking average recruitment and collection cost and dividing first by volume to find the per unit average cost and then by an appropriate wage rate to produce a comparably equivalent number of hours at each Center. To do this conversion, a wage rate is needed which reflects the blend of labor inputs purchased by a blood bank. While the Bureau of Labor Statistics wage data (10) used in (7) offers the advantage of being available for SMSA's containing most reporting blood banks, it forces one to reconcile the blood banks' labor mixture with a manufacturing

wage rate. Fortunately, the American Hospital Association publishes both total fulltime equivalent hospital employees and total wages paid aggregated by SMSA (1, 2, 3) allowing us to compute a hospital average wage rate. It is believed that the hospital wage rate is close to the blood bank wage rate since they compete in the same market for nurses and technicians. To reconcile the calendar year AHA data and the fiscal year ARC data, we average the two calendar years containing the fiscal year.

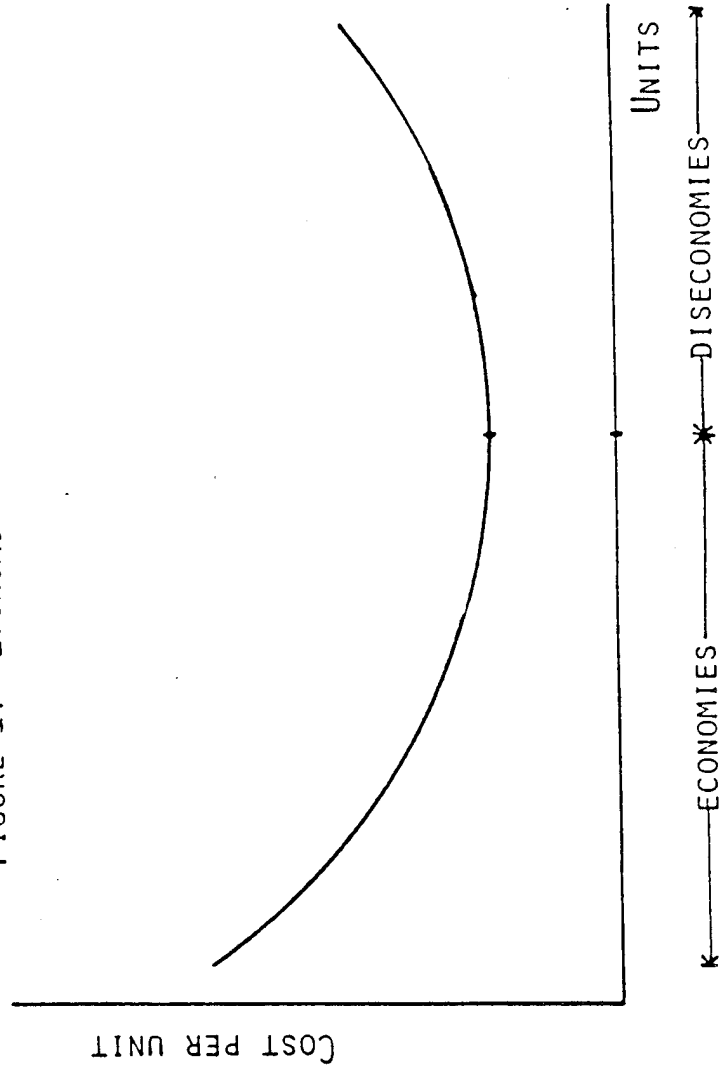
In addition to making these changes the data base was expanded to include both the fiscal year 1974-75 ARC data (4) used by Jacobs and Rawson and the ARC published data for fiscal year 1975-76 (5). Having done this, a quite different picture emerges. Figure 2 is a scattergram of the equivalent hours of labor required for each unit against volume of operation. Despite the scatter caused by other uncontrolled variables, an interesting and expected result is observed. At first the average cost per unit (in hours) decreases then later it increases. This shape suggests that a "U"-shaped quadratic is more appropriate than the linear relationship assumed in (7). The resulting regression equation is:

$$\begin{array}{l} \text{Adjusted average cost} \\ \text{per unit in hours} \end{array} = 3.0164 - .1569 \text{ Volume} + .0045 (\text{Volume})^2$$

where volumes are given in tens of thousands of units and all coefficients are significant at the .001 level. This fit provides an r^2 of .45; that is, 45% of the variance in cost is explained by the model compared to 35% in the model presented in (7).

The remaining variance may be explained by other factors. For example, our knowledge of recruiting and collecting tells us that geographic dispersion of the drawing sites, regional variations in difficulty of recruiting, fraction of drawings done by mobile units, competition in the region for donors, demographic characteristics of the population, and fraction of units drawn by pheresis may all be important. In an attempt to control for some

FIGURE 1: ECONOMIES/DISECONOMIES OF SCALE



ADJUSTED AVERAGE RECRUITMENT AND COLLECTION HOURS PER UNIT

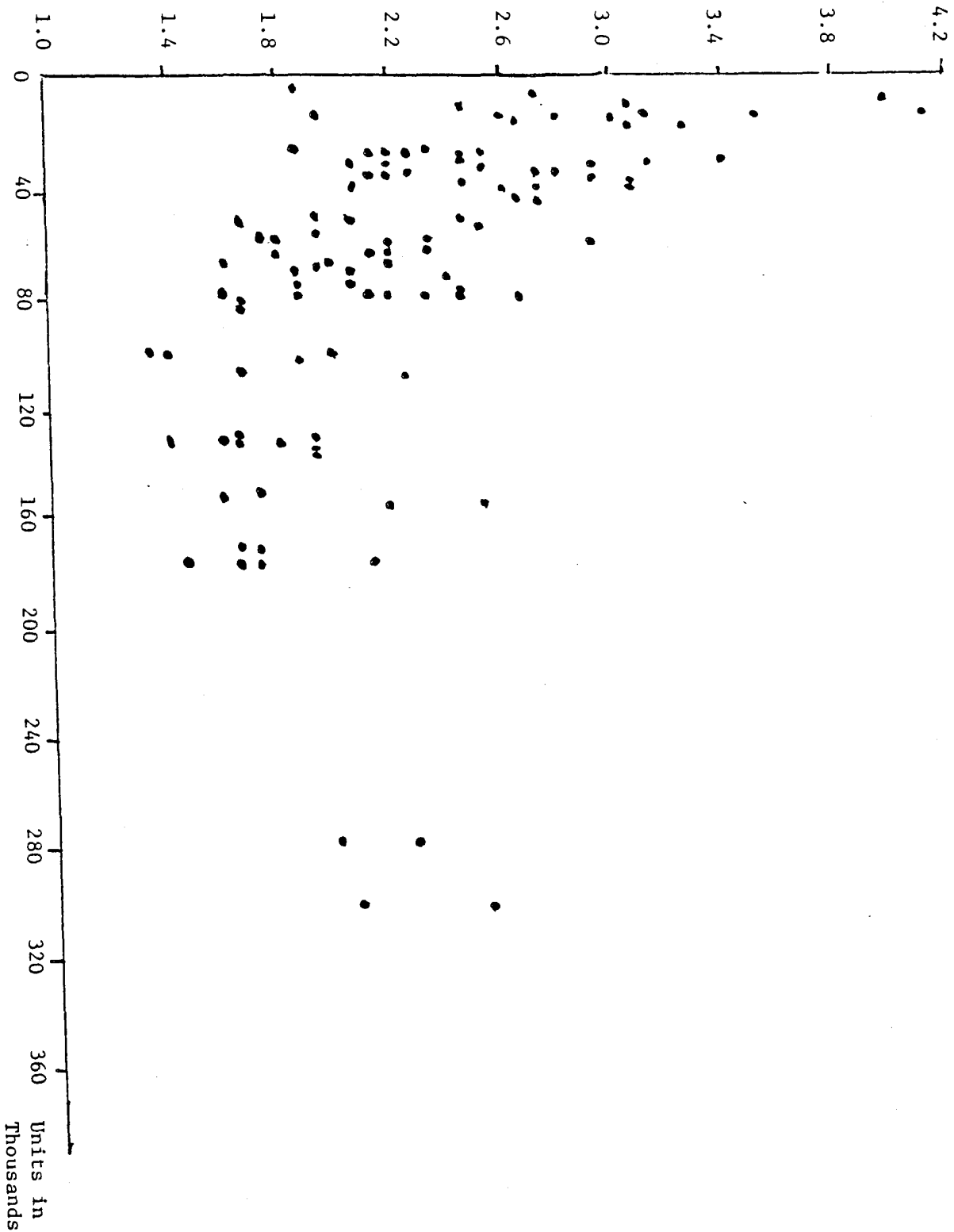


FIGURE 2: Adjusted* Average Cost per Unit in Hours for Collection and Recruitment for all ARC Blood Centers in the U.S. taken from [4] and [5].

of these factors, the square mileage area of the SMSA was used as a proxy for geographic dispersion and drawings per capita as a proxy for difficulty. From the ARC data, the percent of drawings on mobiles and percent of units drawn by pheresis was included. In the regression, it was observed that only SMSA area and mobile drawings are statistically significant, resulting in the following equation (with levels of significance shown parenthetically):

$$\begin{aligned} \text{Adjusted average cost} \\ \text{per unit in hours} &= 2.261 - .1626 \text{ Volume} + .0047 \text{ Volume}^2 \\ &\quad (.001^-) \quad (.001^-) \quad (.001^-) \\ &+ .104 \text{ (SMSA in thousands of square miles)} \\ &\quad (.001^-) \\ &+ .594 \text{ (\% of drawings done by mobiles)} \\ &\quad (.04) \end{aligned}$$

and the resulting r^2 is 0.60.

This model again indicates that the data exhibit "U"-shaped costs and that as the geographic area and/or percentage of mobile drawings increase, the adjusted average cost per unit also increases. For larger areas and more mobile drawings the travel time of recruiters and phlebotomy teams goes up so it is not unexpected that costs (in hours) would rise in conjunction with the increases in these variations.

Although the recruitment and collection functions overlap at the blood centers, this same analysis was performed for collection costs separately and recruitment costs separately in order to see whether more definitive results could be found. The resulting regression equations are:

$$\begin{aligned} \text{Adjusted average collection} \\ \text{costs per unit in hours} &= 1.580 - .093 \text{ Volume} + .0028 \text{ (Volume)}^2 \\ &\quad (.001^-) \quad (.001^-) \quad (.001^-) \\ &+ .047 \text{ (SMSA)} + .553 \text{ (\% at mobiles)} \\ &\quad (.003) \quad (.02) \end{aligned}$$

$$r^2 = .37$$

$$\begin{aligned} \text{Adjusted average recruitment} \\ \text{cost per unit in hours} &= .713 - .0683 \text{ Volume} + .0018 (\text{Volume})^2 \\ & \quad (.001^-) \quad (.001^-) \quad (.001^-) \\ & + .0564 (\text{SMSA}) \quad r^2 = .56 \\ & \quad (.001^-) \end{aligned}$$

Again it is seen that the data display "U"-shaped costs and increasing costs with increasing geographic areas and/or percentage of drawings on mobiles.

The obvious question is why is it that despite doubling the data base and using a more complex model only 37-60% of the variation is explained by the regression equations given above? We suspect that the remaining variation may be explained by such other variables as organizational structure, managerial style, regional, demographic and ethnic variations in attitude toward blood donation, and variations in interpretation of the categories in the standardized reporting procedure. Even the regression equations presented in our analysis should be viewed with a degree of caution. The upward trend shown at large volumes is influenced by a small number of centers which operate at these high volumes. In order to increase the confidence in these conclusions at high volumes, more data would be needed. Therefore we hope that the ARC will resume the publication of financial data which was suspended in 1977. We would also like to caution the reader not to conclude from the results above that a blood center of 170,000 units is the optimal size. If there is an optimal size, its determination must include the qualitative factors above, more data, and the integration of all of the other blood bank functions, e.g. distribution, processing, inventory control and administration (see [11]).

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