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作業資源彈性與作業成本行爲

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摘要

瞭解成本行爲有助企業經理人員估計所做決策的影響。根據成本在攸關範圍內對產量變動所做的反應，大多數管會教科用書將成本歸分爲變動成本及固定成本。該成本歸類方式有迅速提供關於成本與產量間關係的優點，然而卻無法反映作業成本(Acticity costs)乃取決於作業資源(Activity resources)的投入量而非其實際用量之事實。

本研究以作業資源投入量及其實際消耗量，推導作業成本的模型並闡述在何種條件下作業成本比較可能隨產量作比率的變動。特別地，本研究以作業資源的彈性來評估作業成本與產量之間的關係。運用個案分析，本研究指出，當企業經理人員擁有較大的彈性能經常依據實際產量來調整對作業資源的投入量時，作業成本將較具變動性。

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INVITED EDITORIAL

Flexibility of Activity Resources and Behavior of Activity Costs

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Abstract

Understanding cost behavior is essential for managers to estimate the impact of their decisions. Most management accounting textbooks classify costs into variable costs and fixed costs based on their behavior in response to changes in the level of production volume within the relevant range. Such a classification of costs as variable or fixed has the advantage of providing a quick perspective of the relation between costs and production volume. But, it fails to reflect the fact that activity costs are determined by the resources committed to the activity rather than the actual usage or consumption of these resources required to support actual production.

This paper explicitly models activity costs in terms of commitment and consumption of activity resources and describes conditions under which activity costs are more likely to vary in proportion to the production volume. In particular, the paper evaluates the relationship between activity costs and production volume in terms of a firm's flexibility in adjusting the resources committed to the activity. With reference to a case analysis, this paper shows that activity costs appear more variable if managers have greater flexibility to frequently adjust the committed activity resource capacity levels in response to the demand placed on them.

1. Introduction

Understanding cost behavior is essential for managers to estimate the impact of their decisions. Most management accounting textbooks classify costs as variable or fixed based on their behavior in response to changes in production volume within the relevant range (Garrison 1991; Hansen and Mowen 1992; Horngren and Foster 1991; Kaplan and Atkinson 1989). Variable costs are defined as costs that vary in proportion to changes in production volume. Direct material costs are presented as an example of variable costs because direct materials are consumed in proportion to actual production volume. Fixed costs are defined as costs that remain the same in total for a given time period regardless of the actual production volume. Rent and insurance for plant facility are considered to be fixed costs because they do not change even when the actual production level is less than the budgeted production level.

Such a classification of costs as variable or fixed has the advantage of providing a quick perspective of the relation between activity costs and production volume within the relevant range. But, it fails to reflect the fact that activity costs are determined by the resources committed to the activity, production volume influences only the usage or consumption of activity resources, and the consumption level may not be the same as the capacity of resources committed to the activity. For instance, direct labor cost is usually classified as a variable cost (Hansen and Mowen 1992, p. 49; Garrison 1991, p. 40). However, the committed direct labor resources often cannot be changed readily in response to short run fluctuations in production level because of the commitment implied by a firm's decision to employ a certain number of monthly or weekly workers. This inflexibility results in idle time for workers in some time periods when the demand for labor resources placed by the actual production level is less than the committed labor resource capacity, and overtime in others when the demand placed on labor resources exceeds the committed labor resource capacity. Therefore, in such cases, direct labor cost does not vary in proportion to production volume.

A principal problem with the traditional treatment of variable and fixed costs is that it does not provide us a formal basis to evaluate when some costs are more likely to be variable rather than fixed, or vice versa. It is intuitive that activity costs are variable in the long run because managers have greater flexibility to adjust the resource capacity level over the long haul to meet the demand placed on the activity resources. But, there is no formal basis to examine the link between flexibility and cost variability. The thesis of this paper is that a more precise way to understand the behavior of costs is to examine the relationship between committed resource capacity and actual consumption of resources.

Variable costs represent resources whose consumption can be adjusted to match the demand placed on them. They are supplied as needed (Cooper and Kaplan 1992, p. 4). Thus, the costs incurred for such activity resources vary directly with the actual production that creates the demand for these activities. In contrast, fixed costs represent the resources that are committed in advance of usage and cannot be varied with their actual use. Their costs depend, therefore, entirely on the initial capacity of activity resources made available. However, for most activities, resources are not supplied as needed, resource capacities need to be committed in advance of usage, but these capacities can be adjusted with differing degree of flexibility in response to information on expected demand for the activity resources. Should such activity costs be classified as variable or fixed?

In this paper, we model the behavior of activity costs in terms of commitment and consumption of activity resources (Cooper and Kaplan 1992). We build on Banker and Hughes' (1994) stochastic cost model and specify a piecewise linear and convex functional form for the activity costs. We describe conditions under which activity costs are more likely to vary in proportion to the production volume. In particular, we evaluate the relationship between activity costs and production volume in terms of a firm's flexibility in adjusting the resources committed to the activity. With reference to a case analysis, we show that the common assumption that all direct costs are variable is incorrect. We also illustrate with the case analysis that activity costs appear more variable if managers have greater flexibility to adjust the committed activity resource capacity levels in response to the anticipated demand for the activity.

The remainder of this paper is organized as follows. Section 2 sets forth our basic activity cost model. Section 3 describes activity cost and production data in the context of a specific case to highlight the relation between activity costs, activity resource commitment, and activity resource consumption. Section 4 relates activity cost variability with flexibility in adjusting activity resource capacity levels. Finally, section 5 concludes the paper.

2. Stochastic activity cost model

Following Banker and Hughes (1994), we consider a firm which employs multiple support activities $i=1,..I$ to manufacture multiple products $j=1,..J$. Each activity i has a driver which provides the measurement scale to assess the capacity and consumption of resources for activity i. Facing uncertain demand, the firm sets activity resource capacity levels x_i after observing imperfect demand signals $\psi \equiv (\psi_1, \ldots \psi_j, \ldots \psi_J)$ for the J products, but before the actual realization of demand. Without imposing any additional assumption about the optimization behavior that leads to the expected demand, we write:

(1) $q_j = \overline{q}_j(\psi_j) + \eta_j,\ j=1,..J,$

where $\overline{q}_j(\psi_j)$ is the expected demand for product j after the firm observes signals ψ_j and η_j is a random variable representing the unobserved uncertainty in market demand with $E(\eta_j)=0$ and Var $(\psi_j) < \infty$ for all $j=1,..J$. We assume as in Banker and Hughes (1994) that actual production levels equal the realized demand. Figure 1 depicts the time line of events.

t=1	t=2	t=3
Observe imperfect expected demand signals, $\overline{q}_j(\psi_j)$	Choose optimal capacity levels $x_i^*(\psi)$	Demand q_j is realized and filled.

Figure 1. Time Line of Events

Consumption of activity resources is modelled as a linear function (Noreen 1991; Banker and Hughes 1994). Each product consumes a s-tandard amount of activity resources. Let μ_{ij} denote the number of u-nits of activity resource z_i demanded to support the production of one unit of product j. Therefore, the *total* number of units of activity re-source z_i actually required for the production of q_j units of the j=1,...J products is:

$$(2) \qquad z_i = \sum_{j=1}^{J} \mu_{ij} q_j + \epsilon_i,$$

where ϵ_i reflects the measurement and/or specification error associ-ated with this linear representation of activity resource consumption. The random variables ϵ_i are assumed to be independent of q_j and ψ_i with $E(\epsilon i)=0$ for i=1,...I.

If the consumption z_i is less than the capacity x_i of activity re-sources, the unused balance of $(x_i - z_i)$ units of activity resources re-mains idle. On the other hand, if the activity usage z_i, required to sup-port the actual production of q_j units for the j=1,...J products, exceeds the capacity x_i, then the firm must acquire the additional required quan-tity $(z_i - x_i)$ of activity resources in the spot market, or at short notice, paying a higher price than that paid to commit to the capacity x_i.

We define the activity cost function $c_i(x_i,z_i)$ for each activity i as follows:

$$(3) \qquad c_i = w_i z_i + m_i x_i + \theta_i m_i y_i + \delta_i,$$

where w_i = variable cost per unit of activity cost driver z_i,

m_i = normal cost per unit of activity resource capacity x_i,

x_i = initial level of committed capacity for activity i,

$\theta_i m_i$ = cost per each additional unit exceeding capacity x_i, $\theta_i > 1$,

y_i = number of units exceeding capacity

$= (z_i - x_i)\ D(z_i > x_i)$,

where $D(z_i > x_i) = 1$ if $z_i > x_i$

$= 0$ otherwise,

and δ_i is a disturbance term independent of ψ, with $E(\delta_i) = 0$.

Our activity cost function in (3) is convex and comprises two linear pieces, with costs remaining constant before available activity resource capacity is fully utilized, but increasing steeply after it is fully utilized (Cooper and Kaplan 1992; Banker and Hughes 1994). The first term on the right hand side of (3) represents variable costs of activity resources whose consumption can be adjusted to exactly match the production requirements. The second term represents the normal costs associated with committed resources whose consumption cannot be adjusted to match production, but remain fixed once commitments have been made. The third term on the right hand side of (3) is the penalty for the actual resource usage exceeding initial capacity level. The second and the third terms combined together imply that (*i*) if the actual demand for activity *i* is less than the initial level of committed capacity then the unused capacity is idle and the fixed cost of activity *i* remains at $m_i x_i$, and (ii) if the actual demand for activity *i* exceeds the initial level of committed capacity then additional cost of $\theta_i m_i$ is incurred for each additional unit of activity resource *i* consumed. Note that θ_i is greater than 1 because it represents penalty for short term acquisition of additional resources, such as premium paid to workers working overtime.

Figure 2 depicts the expected activity cost function. From Figure 2, we see that the expected cost of activity i is the sum of the fixed cost ($m_i x_i$) of committed activity resources and the variable cost ($w_i z_i$) which varies in proportion to the actual consumption of the cost driver z_i when the actual usage is no more than the available capacity x_i. However, when the actual usage z_i is more than the available capacity x_i, the expected activity cost equals the sum of the fixed cost ($m_i x_i$), the variable cost ($w_i z_i$), and the extra cost ($\theta_i m_i(z_i - x_i) = \theta_i m_i y_i$) incurred for additional usage exceeding the capacity.

Let x and z represent vectors of activity resource capacities $(x_1, \ldots x_I)$ and activity resource consumption $(z_1, \ldots z_I)$, respectively. The firm chooses the level of activity resource capacities x, after observing the information signals ψ but before the realization of actual demand. Expected activity costs for any given level of activity resource capacities x, but conditional on the signals ψ are:

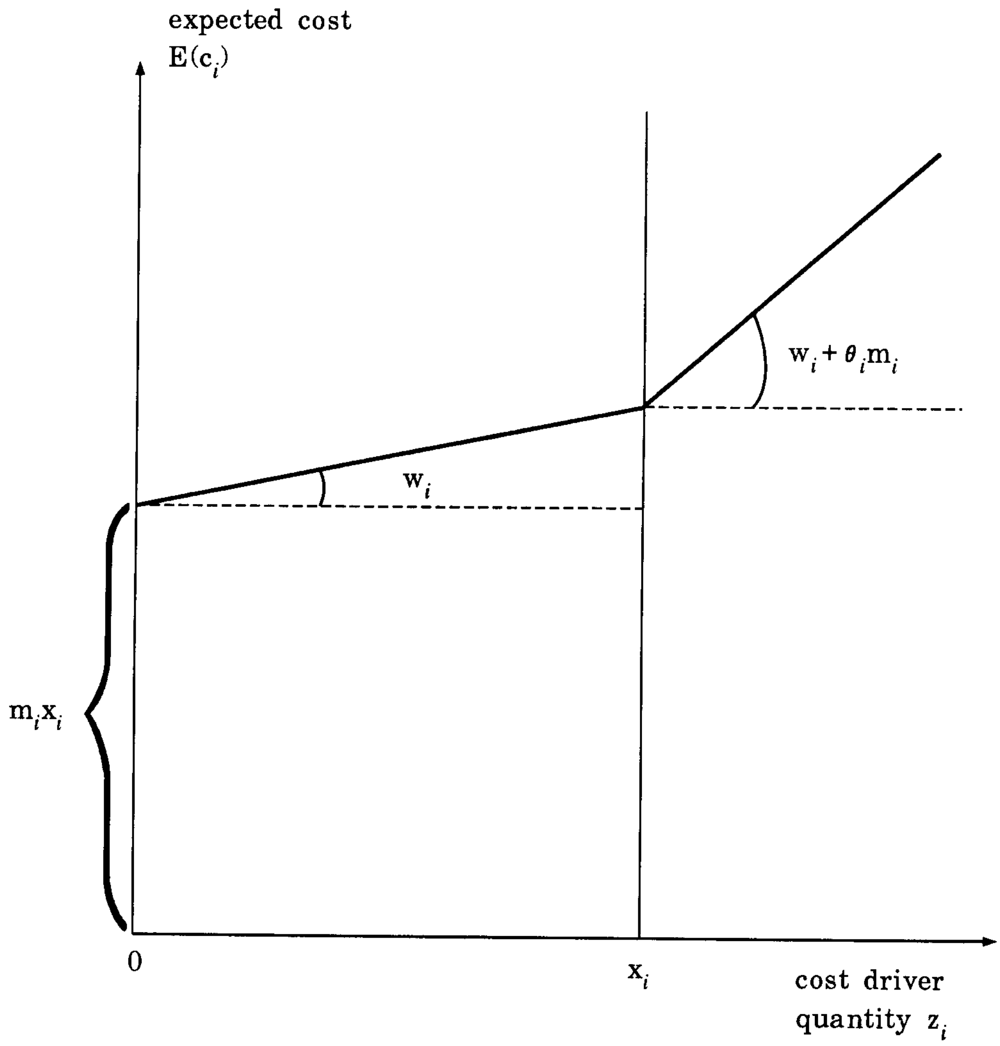
$$(4) \quad E[c(x, z(\psi) \mid \psi)] = E[\sum_{i=1}^{I} c_i(x_i, \ z_i(\psi) \mid \psi)]$$

$$= E[\sum_{i=1}^{I} (w_i z_i(\psi) + m_i x_i + \theta_i m_i y_i(\psi) + \delta_i) \mid \psi]$$

$$= E[\sum_{i=1}^{I} w_i z_i(\psi) + \theta_i m_i y_i(\psi) \mid \psi] + \sum_{i=1}^{I} m_i x_i$$

Let $\overline{z}_i(\psi) = \sum_{j=1}^{J} \mu_{ij}(\overline{q}_j(\psi))$, and $h_i = \sum_{j=1}^{J} \mu_{ij}\eta_j + \epsilon_i$, so that $\overline{z}_i(\psi) = \overline{z}_i(\psi) + h_i$, and $E(h_i) = E(h_i \mid \psi) = 0$. The probability density function of h_i is derived as a convolution of the probability density functions of all η_j and ϵ_i. Let $f_i(h_i)$ denote the marginal probability density function of h_i and $F_i(h_i)$ the corresponding cumulative density function. Note that the distribution of h_i in our formulation is independent of the observation of signals ψ because both η_j and ϵ_i are independent of ψ. Therefore,

Figure 2. Expected Activity Cost Function



$$(5)\quad E[c(x,z(\psi)\mid\psi] = \sum_{i=1}^{I}[w_i\overline{z}_i(\psi)+m_ix_i+\theta_im_i\int_{x_i-\overline{z}_i}^{\infty}(\overline{z}_i(\psi)+h_i-x_i)f_i(h_i)dh_i]$$

$$=\sum_{i=1}^{I}[w_i\overline{z}_i+m_ix_i+\theta_im_i(\overline{z}_i(\psi)-x_i)\int_{x_i-\overline{z}_i}^{\infty}f_i(h_i)dh_i$$

$$+\theta_im_i\int_{x_i-\overline{z}_i}^{\infty}h_if_i(h_i)dh_i],$$

Differentiating (5) with respect to x_i yields the following first-order conditions characterizing the optimal capacity levels x_i^*:

$$(6)\quad \frac{\partial E(c)}{\partial x_i}$$

$$=m_i-\theta_im_i\int_{x_i-\overline{z}_i}^{\infty}f_i(h_i)dh_i-\theta_im_i(\overline{z}_i-x_i)f_i(x_i-\overline{z}_i)$$

$$-\theta_im_i(x_i-\overline{z}_i)f_i(x_i-\overline{z}_i)=m_i-\theta_im_i(1-F_i(x_i-\overline{z}_i))=0.$$

Rearranging the terms in (6) yields the following optimal capacity levels:

$$(7)\quad x_i^*(\psi)=\sum_{j=1}^{J}\mu_{ij}(\overline{q}_j(\psi_j))+G_i=\overline{z}_i(\psi)+G_i,$$

where $\overline{z}_i(\psi)$ is the expected cost driver usage, $G_i=F_i^{-1}\left(\frac{\theta_i-1}{\theta_i}\right)$ and $F_i^{-1}(.)$ is the inverse of the cumulative density function F_i of h_i independent of ψ.

Substituting the optimal capacity levels $x^*\equiv(x_i^*,\ldots x_I^*)$ in (7) into (5), and using the condition in (6), yields the following:

$$(8)\quad E[c(x^*(\psi),z(\psi)] = \sum_{i=1}^{I}[w_i\overline{z}_i(\psi)+m_i(\overline{z}_i(\psi)+G_i)$$

$$+\theta_im_i(\overline{z}_i(\psi)-\overline{z}_i(\psi)-G_i)\int_{x_i^*-\overline{z}_i}^{\infty}f_i(h_i)dh_i$$

$$+\theta_im_i\int_{x_i^*-\overline{z}_i}^{\infty}h_if_i(h_i)dh_i]$$

$$=\sum_{i=1}^{I}[(w_i+m_i)\overline{z}_i+\theta_i m_i\int_{x_i^*-\overline{z}_i}^{\infty} h_i f_i(h_i)dh_i]$$

$$=\sum_{i=1}^{I}[(w_i+m_i)\sum_{j=1}^{J}\mu_{ij}(\overline{q}_j(\psi_j))+\theta_i m_i\int_{G_i}^{\infty} h_i f(h_i)dh_i].$$

Note that the expected activity cost in (8) has two components. The first set of terms can be thought of as the variable cost component as each term $[w_i+m_i]\sum_j \mu_{ij}(\overline{q}_j(\psi_j))$ changes in proportion to the expected production volumes $\overline{q}_j(\psi_j)=E(q_j|\psi_j)$. The second set of terms is independent of the expected production levels $\overline{q}_j(\psi_j)$. All of the latter terms are also positive because $E(h_i)=0$.

3. Commitment versus consumption

Firms must commit to providing various production and support activity resources in advance of usage of those resources. Costs associated with committed activity resources are fixed costs unless the availability of such resources can be adjusted in response to changes in the actual demand for these resources. That is, if the managers have the flexibility to adjust the level of committed resources, without incurring additional costs, to match the actual consumption of these resources, then costs of such resources become variable because these costs will vary proportionally with the actual usage. Therefore, a more precise way to understand cost behavior is to examine the relation between commitment and consumption of resources. In this section, we explain the behavior of activity costs in terms of commitment and consumption of resources in the context of the following case analysis.

Consider the cranberry processing plant operated by the Algoma Cranberry Company (ACC, disguised name and industry). The plant processes fresh cranberries and yields frozen cranberries. Figure 3 describes the frozen cranberry production process at the ACC plant.

$$=\sum_{i=1}[(w_i+m_i)\overline{z}_i+\theta_i m_i\int_{x_i^*-\overline{z}_i}^{\infty}h_i f_i(h_i)dh_i]$$

$$=\sum_{i=1}^{I}[(w_i+m_i)\sum_{j=1}^{J}\mu_{ij}(\overline{q}_j(\psi_j))+\theta_i m_i\int_{G_i}^{\infty}h_i f(h_i)dh_i].$$

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Commitment versus consumption

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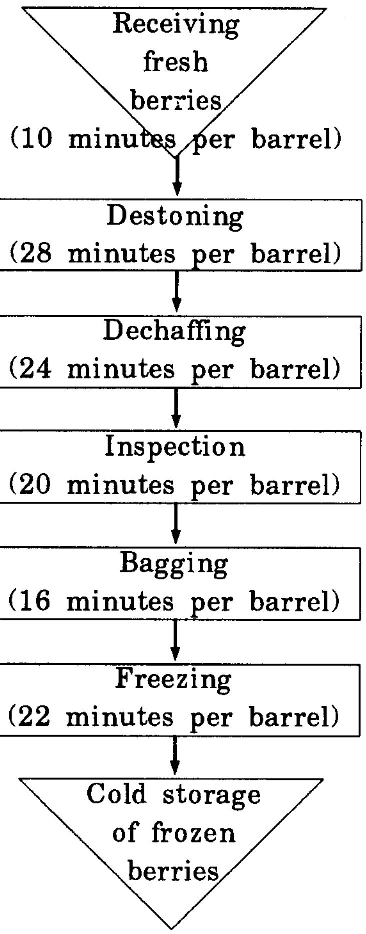
Figure 3

Frozen Cranberry Production Process at the ACC Plant



Berry growers deliver fresh cranberries to the ACC plant. Upon receiving fresh berries, production labor performs the following processing activities: (1) destoning: separation of small stones that might be mixed in with the berries; (2) dechaffing: removal of stems and leaves that might still be attached to the berries; (3) inspecting: inspection of each berry prior to bagging; (4) bagging: preparation of berries for freezing and storage, (5) freezing: freezing of bagged berries for cold storage.

To ensure the freshness of the berries bagged and frozen at the ACC plant, all berries must be processed on the same day as the day they are received. The plant operates all 7 days in a week during the harvest season starting in early September and ending in early December.

The company hires 168 production workers working 40 hours per week during the harvest season. Thus, a total of 6,720 (=168 * 40) hours of production labor are available each week. In addition, workers are also employed overtime to ensure that all fresh berries received at the plant are processed on the same day they are delivered to the plant. The average weekly wages, including fringe benefits, are $300 per worker. Overtime cost is $11.25 per hour. These production labor costs are direct labor costs because they can be traced directly to the product (frozen cranberries) produced each day.

The daily demand for production labor at the ACC plant depends on the number of barrels of cranberries received each day. It requires, on average, a total of 120 minutes (=10+28+24+20+16+22) of production labor to destone, dechaff, inspect, bag and freeze a barrel of cranberries. Therefore, the capacity made available by employing one worker on an 8-hour shift is equivalent to processing 4 (=8 * 60/120) barrels of cranberries per day.

Suppose that the ACC plant is constrained to a uniform level of production labor working on its production line. That is, the working days of the 168 workers are scheduled such that on each of the 7 days in a week the plant operates, there are 120 (=(168 * 40)/(7 * 8)) workers working an 8-hour shift. Because the number of barrels of cranberries received fluctuates day by day, some workers are asked to work overtime, if necessary, to meet the actual daily demand for production labor. However, if the number of barrels received on a day is less than the available daily capacity, then some workers are idle for some time.

Table 1 summarizes the daily direct labor costs depending on the number of barrels of cranberries received on a particular day given the employment of 120 workers on each day of the week. The number of production labor hours is the cost driver for the processing activities at the ACC plant. By employing 120 workers to work on each day, ACC is committed to paying a total of $7,200 (=$120 * 300/5) in daily wages for the 960 (=8 * 120) available hours of production labor, which provides a capacity to process 480 barrels on each day in a week. Additional resources are required if the actual demand for production labor on any day exceeds 960 hours (or equivalently, 480 barrels). However, if the demand for production labor on any day is less than 960 hours, then the unused available capacity of production labor remains idle.

Because workers at ACC are hired for the entire harvest season to work 40 hours a week (8 hours a day for 5 days a week), the regular wages paid each day to them represent costs of committed resources. These costs are fixed at this level unless the daily demand exceeds the committed capacity. Overtime cost including overtime premium, is incurred when the required consumption of production labor exceeds the available capacity on a day. Therefore, we can write the daily labor cost equation for the cranberry processing activities as:

$$c = \$7{,}200 \text{ if } z \leq 960, \text{ and}$$
$$c = \$7{,}200 + \$11.25 * (z - 960) \text{ if } z > 960,$$

where z denotes the actual demand for production labor (in hours) on a particular day.

Table 1
Algoma Cranberry Company: Daily Direct Production Labor Costs

Number of Barrels	360	390	420	450	480	510	540	570	600
Number of Workers	120	120	120	120	120	120	120	120	120
Demand for Labor (Hours)	720	780	840	900	960	1,020	1,080	1,140	1,200
Available Production Labor Hours	960	960	960	960	960	960	960	960	960
Idle Labor Hours	240	180	120	60	0	0	0	0	0
Overtime Labor Hours	0	0	0	0	0	60	120	180	240
Total Regular Wages	$7,200	$7,200	$7,200	$7,200	$7,200	$7,200	$7,200	$7,200	$7,200
Overtime Cost	$0	$0	$0	$0	$0	$675	$1,350	$2,025	$2,700
Total Direct Labor Cost	$7,200	$7,200	$7,200	$7,200	$7,200	$7,875	$8,550	$9,225	$9,900
Direct Labor Cost per Barrel	$20.00	$18.46	$17.14	$16.00	$15.00	$15.44	$15.83	$16.18	$16.50

Figure 4 graphs the total direct labor costs against different numbers of barrels of cranberry received on a day in accordance with the data described in Table 1. The total labor costs remain unchanged at $ 7,200 until all available resource capacity (960 labor hours adequate for 480 barrels) is fully used, and then increase at the rate of $22.50 (=11.25 * 120/60) per barrel of cranberries received on a day as overtime premium is paid to workers working overtime to meet the additional demand for production labor. Contrary to the common assumption that all direct costs are variable, we see that direct labor costs are fixed until the committed capacity is exceeded because the labor costs associated with the committed but unused labor time cannot be eliminated. Direct labor costs are not fixed costs because overtime premium must be paid when the initial level of committed capacity of 960 labor hours is not adequate to meet the actual demand for production labor resources.

Figure 4

Algoma Cranberry Company: Total Costs Versus Number of Barrels

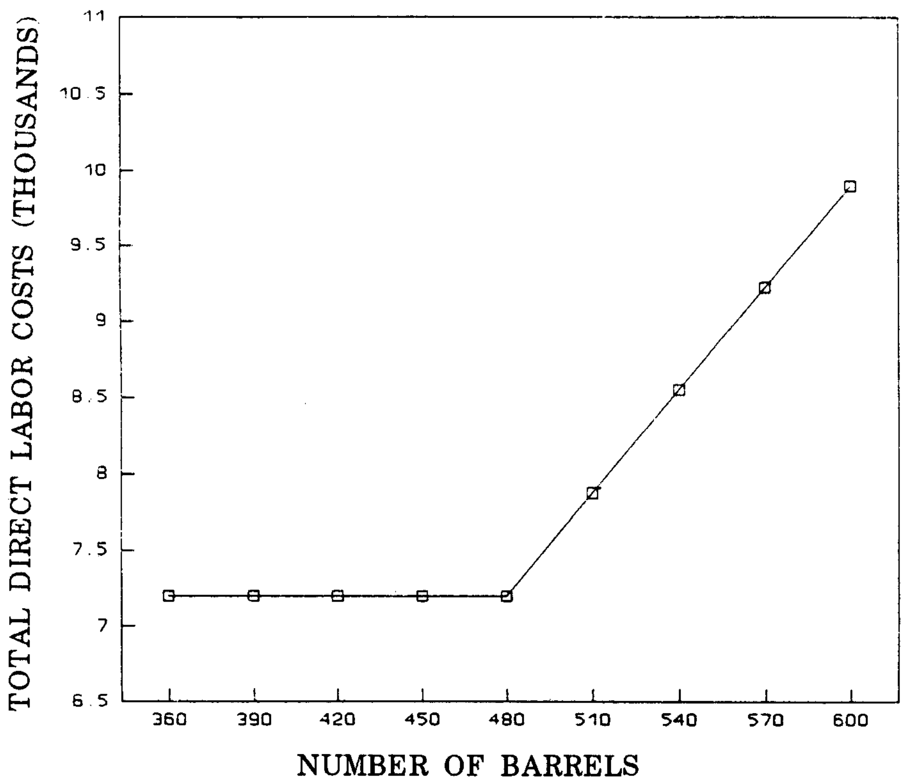
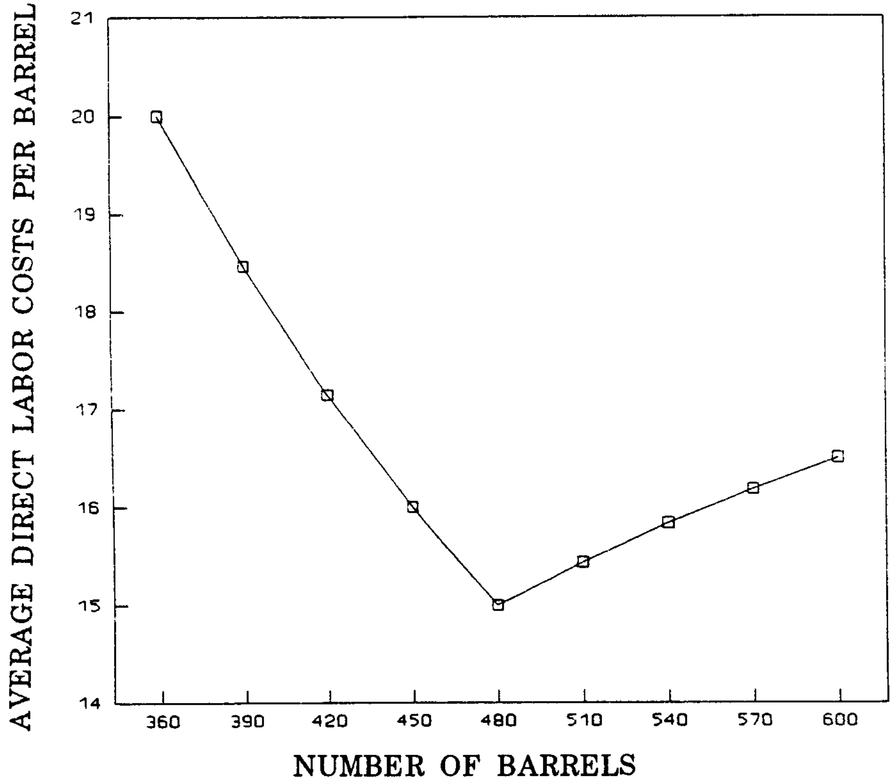


Figure 5 displays the direct production labor costs per barrel plotted against the number of barrels of cranberry received on a day. We see that the average or unit labor cost is not constant, but depends on the number of barrels received. The average cost is lowest ($15 per barrel) when the demand for direct labor exactly matches the available capacity. We refer to this as the normal unit cost of the activity as it represents the unit cost when exactly the right quantity of activity resources are acquired (i.e. there are no idle resources) at the normal price (i.e. there are no premiums paid for acquiring resources exceeding initial capacity.)

Figure 5
Algoma Cranberry Company: Unit Costs Versus Number of Barrels



When actual demand is less than the available capacity, the actual unit cost is higher than the normal unit cost because of idle time. Actual unit cost is also higher than the normal unit cost when demand exceeds available capacity because overtime premium must be paid in this case.

4. Flexibility in activity resource commitment

Recall from the activity cost function defined in (3) that actual activity costs comprise three components: variable costs, normal costs of committed resources, and additional costs associated with inadequate capacity. Therefore, in general, activity costs do not vary linearly with their cost driver levels. The question of interest then is to identify conditions under which they appear to be more variable with respect to their usage levels as measured by their cost drivers.

Intuitively, activity costs are likely to vary more with changes in activity resource usage levels if managers have greater flexibility in setting activity capacity levels in response to the demand placed for activity resources. Flexibility is defined as the ability managers have in adjusting their committed activity resource capacity based on the anticipated market demand. The ultimate form of flexibility arises when activity resources are supplied only as required. In such cases activity costs are perfectly variable. Materials are consumed only as needed, and the unused balance is inventoried for future use. Therefore, direct material costs are variable. When workers are paid on a piece-rate basis for units produced, direct labor costs also incurred only as required, and they vary in proportion to production volume. But, if workers are paid on a daily, weekly, monthly or some other time basis, then direct labor costs measured daily will not vary directly with the corresponding production volume because of idle time and/or overtime. However, these costs will be more likely to vary with production volume if managers have greater flexibility in setting the level of direct labor capacity to meet the expected demand for direct labor.

Let's return to the case of the Algoma Cranberry Company's (ACC's) cranberry processing plant described in the previous section. Managers at the ACC plant have the flexibility to temporarily adjust the number of workers depending on the anticipated demand for activity resources on each day. Demand for production labor is usually high on weekends because some berry growers are able to get help from their children in picking cranberries from the field. The number of barrels processed on weekends (Saturdays and Sunday) averages 520, while the number of barrels of cranberry processed on weekdays varies between

430 and 520. Therefore, ACC hires 124 workers to work on Mondays, 120 to work on Tuesdays, 116 workers to work on Wednesdays, 112 to work on Thursdays and Fridays, and 128 to work on Saturdays and Sundays. Actual daily direct labor costs pertaining to the processing activities for the first four weeks of September 1993 at the ACC plant are shown in Table 2. Costs that would have been incurred had the plant been restricted to employing the same fixed number of 120 workers on each day are also shown in Table 2.

The daily direct labor cost comprises both the fixed cost of the committed resources and the additional cost for the overtime hours. The labor cost equation is as described before except that we now have different equations depending on the number of workers (n) hired on each individual day:

$c = \$7.50 * 8n$, if $z \leq 8n$; and

$c = \$7.50 * 8n + \$11.25 * (z - 8n)$, if $z > 8n$;

where n is the number of workers hired and z denotes the actual demand for production labor (in hours) on a particular day.

The actual daily labor costs at the ACC plant for the first four weeks of September 1993 are plotted in Figure 6 against the actual number of barrels received on a day. We can observe from Figure 6 that the direct labor costs appear to vary more or less in proportion to the number of barrels received on a day. This is in contrast to the labor cost curve in Figure 4, which describes the relation between labor costs and number of barrels when the number of workers is kept fixed at 120. (The correlation coefficient is 0.9966 in Figure 6 compared to 0.8911 in Figure 4.) This increase in variability of direct labor costs with production volume in Figure 6 relative to Figure 4 results from the flexibility that managers have to adjust the amount of resources made available based on the expected demand for the activity resources.

Table 2
Algoma Cranberry Company: Dsily Direct Production Labor Costs
First Four Weeks of September 1993

Day	Date	Actual Number of Workers	Actual Number of Barrels	Actual Idle Time (hours)	Actual Overtime (hours)	Actual Direct Labor Costs	Actual Average Cost per Barrel	Total Labor Costs if 120 Workers Hired	Average Labor Costs if 120 Workers Hired
WED	9/1	116	468	0	8	$7,050.00	$15.06	$7,200.00	$15.38
THU	9/2	112	450	0	4	6,765.00	15.03	7,200.00	16.00
FRI	9/3	112	458	0	20	6,945.00	15.16	7,200.00	15.72
SAT	9/4	128	520	0	16	7,860.00	15.12	8,100.00	15.58
SUN	9/5	128	516	0	8	7,770.00	15.06	8,010.00	15.52
MON	9/6	124	495	2	0	7,440.00	15.03	7,537.50	15.23
TUE	9/7	120	488	0	16	7,380.00	15.12	7,380.00	15.12
WED	9/8	116	476	0	24	7,230.00	15.19	7,200.00	15.13
THU	9/9	112	446	4	0	6,720.00	15.07	7,200.00	16.14
FRI	9/10	112	460	0	24	6,990.00	15.20	7,200.00	15.65
SAT	9/11	128	527	0	30	8,017.50	15.21	8,257.50	15.67
SUN	9/12	128	532	0	40	8,130.00	15.28	8,370.00	15.73
MON	9/13	124	505	0	18	7,642.50	15.13	7,762.50	15.37
TUE	9/14	120	491	0	22	7,447.50	15.17	7,447.50	15.17
WED	9/15	116	472	0	16	7,140.00	15.13	7,200.00	15.25
THU	9/16	112	456	0	16	6,900.00	15.13	7,200.00	15.79
FRI	9/17	112	443	10	0	6,720.00	15.17	7,200.00	16.25
SAT	9/18	128	508	8	0	7,680.00	15.12	7,830.00	15.41
SUN	9/19	128	514	0	4	7,725.00	15.03	7,965.00	15.50
MON	9/20	124	500	0	8	7,530.00	15.06	7,650.00	15.30
TUE	9/21	120	483	0	6	7,267.50	15.05	7,267.50	15.05
WED	9/22	116	480	0	32	7,320.00	15.25	7,200.00	15.00
THU	9/23	112	452	0	8	6,810.00	15.07	7,200.00	15.93
FRI	9/24	112	462	0	28	7,035.00	15.23	7,200.00	15.58
SAT	9/25	128	523	0	22	7,927.50	15.16	8,167.50	15.62
					Total:	$183,442.50	$15.13	$188.145.00	$15.52

Figure 6
Algoma Cranberry Company: Total Costs Versus Number of Barrels

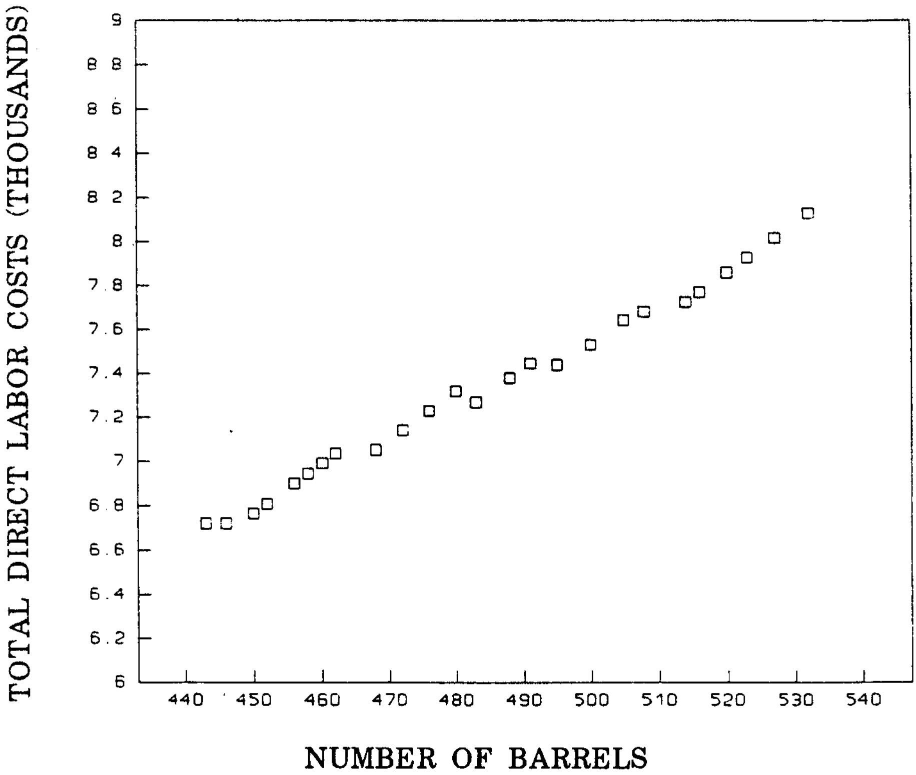
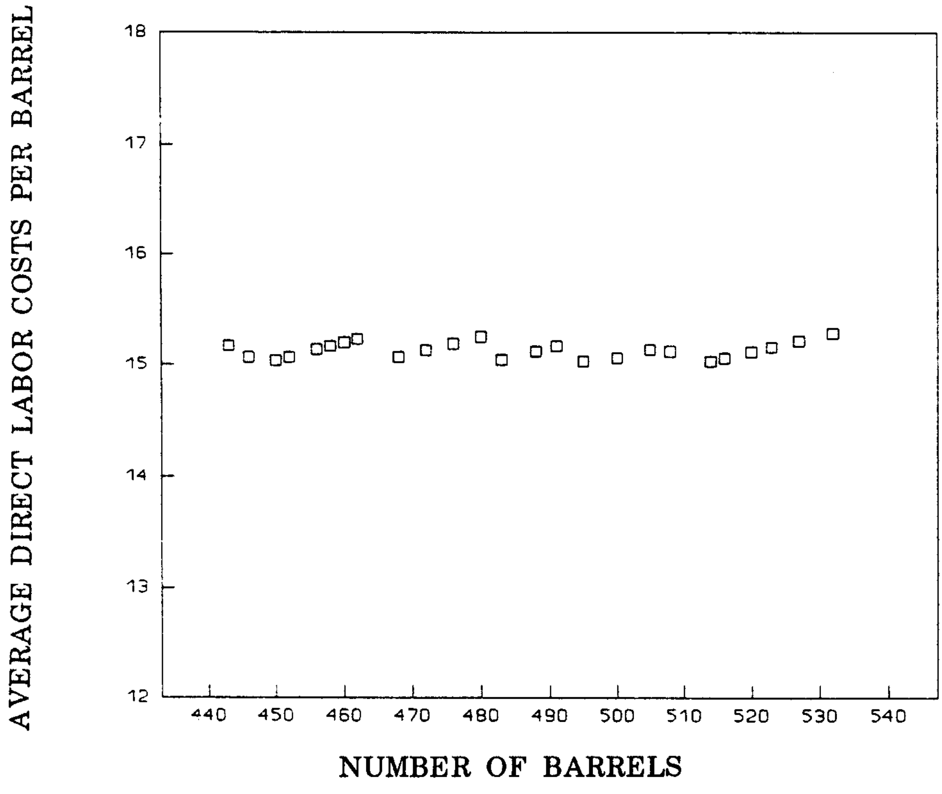


Figure 7 displays the average labor cost plotted against the number of barrels of cranberry received on a day. Unlike the corresponding graph in Figure 5, the average costs in Figure 7 are aligned around a horizontal straight line. This is consistent with the notion that the variable cost rate is independent of the activity level. Therefore, when managers have the flexibility to adjust activity resource capacity frequently in response to the anticipated demand, the activity costs are more likely to vary with activity cost driver levels. Note, however, that the average actual unit costs are still more than the normal unit cost of production labor because of the costs associated with idle capacity for some days and the costs incurred for additional usage that exceeds the initial level of committed resource capacities for other days.

Figure 7

Algoma Cranberry Company: Unit Costs Versus Number of Barrels



Managers at the ACC plant were interested in evaluating the expected value of the flexibility provided by hiring a different number of workers by day of week depending on the expected demand on each day. The expected value of this flexible hiring policy is evaluated by comparing the expected direct labor cost under this policy with the corresponding expected cost with the fixed hiring policy when ACC hires 120 workers to work on each day in a week. The empirical probability distribution of the number of barrels delivered to the ACC plant during the harvest season is approximated by the uniform distribution over the interval [480,520] for Mondays, over [465,505] for Tuesdays, over [450, 490] for Wednesdays, over [430,470] for Thursdays and Fridays, and over [500,540] for Saturdays and Sundays. Thus, the expected number (mean) of barrels delivered varies daily from 500 (=(480+520)/2) on Mondays, to 485 on Tuesdays, 470 on Wednesdays, 450 on Thursdays and Fridays and 520 on Saturdays and Sundays.

The expected daily demand for production labor resource (in hours) is 2m (=(120/60) * m), where m is the expected number of barrels delivered on a day. The expected daily labor cost is 8n * $7.50+$11.25 * max {2m-8n, 0}, where n is the number of workers hired on a particular day. For instance, the expected labor cost on Monday is $7,650 (= 120 * 8 * $7.50+$11.25 * (2 * 500 − 120 * 8)) if 120 workers are hired. In contrast, the expected labor cost is $7,530 (=124 * 8 * $7.50 +$11.25 * (2 * 500 − 124 * 8)) if 124 workers are hired under a more flexible hiring policy. Therefore, the expected value of the flexibility in hiring on Mondays is $120 (=$7,650 − $7,530). Similar computations reveal that the expected average direct labor cost per barrel on Mondays is $15.30 when 120 workers are employed, but only $15.06 if 124 workers are employed under a flexible hiring policy. The expected value of flexibility on Mondays, therefore, is $0.24 per barrel. The computation of the expected value of flexibility for the rest of the week is very similar. We present the expected direct labor cost for each day in a week in Table 3.

Table 3
Algoma Cranberry Company: Expected Direct Labor Costs Under Alternative Hiring Policies

Day	Expected Number of Barrels	Number of Flexible Workers by Day of Week		Fixed Number (120) of Workers by Day of Week	
		Expected Direct Labor Costs	Expected Average Cost per Barrel	Expected Direct Labor Costs	Expected Average Costs per Barrel
Monday	500	$7,530.00	$15.06	$7,650.00	$15.30
Tuesday	485	7,312.50	15.08	7,312.50	15.08
Wednesday	470	7,095.00	15.10	7,200.00	16.32
Thursday	450	6,765.00	15.03	7,200.00	16.00
Friday	450	6,765.00	15.03	7,200.00	16.00
Saturday	520	7,860.00	15.12	8,100.00	15.58
Sunday	520	7,860.00	15.12	8,100.00	15.58
Total		$51,187.50	$15.07	$52,762.50	$15.55

Adding these numbers together for all seven days in a week, we observe from Table 3 that the expected weekly direct labor cost is $52, 762.50 when the number of workers hired is kept fixed at 120 on each day, but only $51,187.50 when a more flexible hiring policy is pursued. Therefore, the expected value of this flexibility in the use of labor resources at the ACC plant is $1,575.00 (=$52,762.50 − $51,187.50) per week representing about 3% (=$1,575.00 / $51,187.50) of the expected direct labor cost. Table 3 also indicates that the expected average direct labor cost per barrel is $15.55 under the fixed hiring policy and $15.07 under the flexible hiring policy. Thus, expected value of flexibility is $ 0.48 (=$15.55 − $15.07) per barrel of cranberry processed.

5. Concluding remarks

Understanding the behavior of activity costs is essential for planning, control, and product costing and pricing decisions. In this paper, we model cost behavior in terms of activity resource commitment and consumption. Starting with a linear representation of activity resource consumption, and a piecewise linear and convex representation of activity costs that depends on committed capacities, we consider when the actually realized activity costs appear to vary with actual production levels. We argue that cost variability depends not only on the relevant range, but also on factors such as flexibility in deploying the level of resources committed to activities. When resource capacities committed to some activities can be set flexibly so that the capacities match more closely the expected demand placed for those activity resources, then the cost of such activities is more likely to be variable with production volume. Resources like direct labor cannot usually be adjusted readily in the very short run and are fixed over that horizon, but if managers have the flexibility to deploy different number of workers depending on expected demand each day then the daily costs of direct labor appear variable.

Our analysis of the Algoma Cranberry Company processing plant data indicates that direct labor costs are more likely to vary with the actual usage when managers have the flexibility in adjusting the number of daily workers in response to anticipated demand for production labor. In other words, costs of activity resources become more variable when managers have the flexibility to frequently adjust the committed resource levels to match more closely the actual demand placed on them.

The behavior of many other manufacturing costs is similar, with different degrees of commitment required for different types of costs. For instance, if setup is a relatively low skilled task then managers can adjust the number of the low skilled setup workers and hence the total setup cost with considerable ease. However, if the setup task is complex requiring highly skilled workers who cannot be recruited or trained easily, then it is much more difficult for managers to deploy different numbers of such highly skilled setup workers depending on the anticipated demand for their work. Finally, pursuing this comparison of different activities to an extreme, note that mangers have much less flexibility in changing plant facility resources and thus adjusting the overhead costs associated with rent and insurance. Thus, costs related to unskilled machine setups are relatively more variable, costs related to high skilled setups are relatively less variable, and rent and insurance costs are relatively more fixed with respect to the production level.

In conclusion, we note that this research can be extended in several ways. On the theoretical front, future research can evaluate how cost variability is affected by other factors, such as flexibility in adjusting the demand for (rather than the supply of) activity resources, and by the aggregation of activity data over different time frames. On the empirical front, data on commitment, consumption and costs of different activities can be analyzed to evaluate whether and how flexibility in activity resource deployment affects cost variability.

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