Economic Incentives in Academic Departments

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ECONOMIC INCENTIVES IN ACADEMIC DEPARTMENTS

By

L. Dwight Israelsen
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Both economic and noneconomic factors may provide work incentives for faculty in academic departments. Economic factors include salary, additional compensation, promotion, security (tenure), and mobility; while noneconomic factors include prestige, peer pressure, environment, and ethical norms. The primary purpose of the following analysis is to examine the impact on work incentives of alternative methods of allocating direct compensation (salary) within the traditional academic organizational structure of departments and colleges. The model employed includes a department output function, a college output function, a faculty reward function, a department reward function, and a college reward function. It is assumed that department output is a function of total work done in the department, that college output is the sum of the outputs of departments within the college, and that the college reward is some function of the college output. Alternative specifications of reward allocation schemes from college to departments and from department of faculty are used to determine the faculty reward function.

Traditionally, the process of salary compensation in academic institutions involves the use of compensation pools which are allocated to colleges and, in turn, are allocated to departments and/or faculty. In the present context, it is assumed that the college receives a reward fund, which it allocates to its department sin accordance with a "department reward function." Upon receiving the allocation from the college, each department then allocates to its department sin accordance with a "department reward function." Upon receiving the allocation from the college, each department then allocates...
its funds among its faculty according to a "faculty reward function." Given the specification of department and faculty reward functions, it is possible to identify the "marginal income" or work incentive a faculty member can expect from each additional unit of work effort. The fact that academic institutions are commonly faced with the problem of allocating given funds among existing faculty, rather than treating faculty as if they were workers in a competitive market to be hired at the going wage, leads to allocation rules which are very similar to those used in producer cooperatives. Hence, the producer cooperative literature provides a departure point for our allocation models. In particular, two specifications for reward functions--"communal" and "collective"--are used alternatively for department and faculty reward functions (see Israelsen [1980]). A collective reward function is one in which the share of total college (department) income going to the department (faculty member) is proportional to the output (or labor input) of the department (faculty member) as a fraction of the total for the college (department). A communal function is one in which all departments share in total income of the college according to size of the department, or in which each faculty member receives an equal share of departmental income, or according to some other allocation rule not directly related to work performed or output produced. Since reward is allocated at two stages, the use of communal and collective rules as alternatives at each stage leads to four possible cases: communal-communal, communal (faculty)-collective (department), collective (faculty)-communal (department), and collective-collective. The formal model and analysis follow.
Model

Assumptions:

1. For simplicity, each department produces output with labor only;
2. All faculty members have equal abilities;
3. Rank, seniority, and tenure are not considered in compensation decisions;
4. All values of output and reward are measured in real terms.

Symbols:

\[ n = \text{number of faculty in department "a"} \]
\[ A = \text{number of faculty-weighted departments in college} \]
\[ l_i = \text{units of work effort contributed by i}^{\text{th}} \text{ faculty member} \]
\[ L = \text{total units of work effort contributed in department "a," } L = \sum_{i=1}^{n} l_i \]
\[ q_a = \text{total output of a}^{\text{th}} \text{ department, } q_a = F(L) \]
\[ F(L) = \text{production function} \]
\[ Q = \text{total output of college, } Q = \sum_{a=1}^{A} q_a \]
\[ R = \text{total available reward for college.} \]

Measurement of output:

Output of a department consists mainly of teaching and research. While many practical measurement problems exist in evaluating both teaching and research output, these problems are not addressed here. Rather, it is assumed that some objective or subjective measure is available.
Output and reward functions:

1. \( q_a = F(L) \): department output function

2. \( Y_a = g(q_a) \): department reward function

3. \( y_i = h(l_i, Y_a) \): faculty reward function.

Specific forms of \( h() \) considered are:

4. \( y_i = \frac{1}{n} Y_a \), the communal function, and

5. \( y_i = \frac{1}{L} Y_a \), the collective function.

Specific forms of \( g() \) considered are:

6. \( Y_a = \frac{1}{A} R \), the communal function, and

7. \( Y_a = \frac{Q}{Q} R \), the collective function.

From equations (4)-(6), we can identify the various combinations of \( h() \) and \( g() \), with the corresponding faculty reward functions:

<table>
<thead>
<tr>
<th></th>
<th>communal</th>
<th>collective</th>
</tr>
</thead>
<tbody>
<tr>
<td>( g ): ( Y_a = \frac{1}{A} R )</td>
<td>( y_i = \frac{1}{n} Y_a )</td>
<td>( y_i = \frac{1}{L} Y_a )</td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{nA} R )</td>
<td>( \frac{1}{LA} R )</td>
</tr>
<tr>
<td></td>
<td>( \frac{q_a}{nQ} R )</td>
<td>( \frac{q_a}{LQ} R )</td>
</tr>
</tbody>
</table>
Equations (7)-(10) represent the communal-communal, communal-collective, collective-communal, and collective-collective forms of the faculty reward function.

Incentives:

The work incentive is defined as the change in faculty reward which accompanies an additional unit of work effort, or $\frac{\partial y_i}{\partial L}$, the marginal income from work. Equations (11)-(14) below give the marginal incomes which correspond to faculty reward functions (7)-(10), respectively. Signs given assume $0 \leq \frac{R}{Q} \frac{dR}{dQ} \leq 1$.

\begin{align*}
(11) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{nA} \frac{dR}{dQ} F'(L) < F'(L) \\
(12) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{n} \left[ \frac{dR}{dQ} \left( \frac{Q}{Q} \right) R \right] F'(L) < F'(L) \\
(13) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{A} \left[ \frac{dR}{dQ} \left( \frac{Q}{Q} \right) R \right] F'(L) + \left( 1 - \frac{L}{L} \right) R > F'(L), \text{ if } R = Q \text{ and } \frac{L}{L} < \frac{MP}{AP} \\
(14) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{L} \left[ \frac{dR}{dQ} \left( \frac{Q}{Q} \right) R \right] F'(L) + \left( 1 - \frac{L}{L} \right) R > F'(L), \\
\text{ if } & \frac{R}{Q}, \frac{dR}{dQ} > \frac{MP}{AP}.
\end{align*}

Equations (15)-(18) give the respective marginal incomes for the special case when the size of $R$ is not affected by changes in $Q$, i.e., when $\frac{dR}{dQ} = 0$.

\begin{align*}
(15) \quad & \frac{\partial y_i}{\partial L} = 0 \\
(16) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{n} \left( 1 - \frac{R}{Q} \right) R F'(L) \\
(17) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{A} \left( 1 - \frac{L}{L} \right) R \\
(18) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{L} \left( 1 - \frac{R}{Q} \right) R F'(L) + \left( 1 - \frac{L}{L} \right) R \frac{Q}{L}.
\end{align*}

Equations (19)-(22) give the respective marginal incomes for the special case when changes in $Q$ result in equal changes in $R$, i.e., when $\frac{dR}{dQ} = 1$.

\begin{align*}
(19) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{nA} F'(L) \\
(20) \quad & \frac{\partial y_i}{\partial L} = \frac{1}{n} \left[ \frac{dR}{dQ} \left( \frac{Q}{Q} \right) R \right] F'(L) = \frac{1}{n} F'(L) \text{ if } R = Q
\end{align*}
As can be seen from the above equations, incentives to work in academic departments depend crucially on the reward allocation system. Work incentives under the communal-communal and communal-collective systems are inefficiently low, with marginal income being lower than marginal product even when \( R = Q \). Under the collective-communal and collective-collective systems, however, the incentives are likely to be inefficiently high, with marginal income being greater than marginal product. The sufficient conditions for this to be the case, as indicated in equations (13) and (14), are likely to be met in departments with more than two faculty members. It can be inferred from the above analysis that the crucial organizational structure for incentives is the department, rather than the college. In both cases using communal faculty reward equations, incentives are low, while in both cases utilizing collective faculty reward equations, incentives are high. The type of department reward equation seems to have only a minor impact on incentives. This observation is illustrated by the hypothetical example which follows.

Application of model:

Assume the following:

\[
\begin{align*}
n &= 20 \\
A &= 5 \\
I_i &= 5 \\
L &= 100
\end{align*}
\]
\[ q_a = 1,000 \quad L^{\frac{1}{6}} = 10,000 \]
\[ Q = 50,000 \]

Given the above values, \( y_i \) will be equal to .01 \( R \) regardless of the reward functions chosen, as may be verified in equations (7)-(10). Incentives, however, are crucially dependent on the allocation scheme, as may be seen in the following table.

<table>
<thead>
<tr>
<th>Reward Structure</th>
<th>( \frac{dR}{dQ} = 0, R = Q )</th>
<th>Incentive ( ) when:</th>
<th>( \frac{dR}{dQ} = 0, R = .5Q )</th>
<th>( \frac{dR}{dQ} = 1, R = Q )</th>
<th>( \frac{dR}{dQ} = 1, R = .5Q )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communal-communal</td>
<td>2</td>
<td>0</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Communal-collective</td>
<td>2</td>
<td>1</td>
<td>2.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Collective-communal</td>
<td>95</td>
<td>47.5</td>
<td>95.5</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Collective-collective</td>
<td>97</td>
<td>48.5</td>
<td>97.5</td>
<td>49</td>
<td></td>
</tr>
</tbody>
</table>

Several comments are in order here. First, the relative responsiveness of \( R \) to changes in \( Q \) matters little in determining work incentives, as is seen in comparing the first and third or second and fourth columns. The ratio of \( R \) to \( Q \), however, matters to almost the same degree in determining work incentives as it does in determining faculty income. Finally, communal faculty reward systems produce incentives (marginal income) much below marginal product (\( F'(L) = 50 \) in this example) regardless of the ratio of \( R \) to \( Q \), while collective faculty reward systems create incentives which are considerably larger than the marginal product a worker could expect in a competitive market system, if \( R \) is reasonably close to \( Q \). This is because in a collective reward system, when a faculty member contributes an additional unit of work effort, two things happen. First, total output and total reward (as long as \( \frac{dR}{dQ} > 0 \)) increase. Second, the faculty member's share of the available reward increases. That the second factor is considerably
more important than the first is seen by comparing the first and third or second and fourth columns in the table above. The fact that marginal income is greater than marginal product in these collective reward systems has an interesting corollary. Unless \( \frac{dR}{dQ} > 1 \), if marginal income is greater than marginal product, when one faculty member contributes an additional unit of work effort, the income of remaining faculty members must necessarily fall, other things being equal. This negative relationship between one faculty member's work effort and other faculty members' incomes is more pronounced the less responsive \( R \) is to changes in \( Q \). The relationship between faculty member \( i \)'s income and faculty member \( j \)'s work effort, \( \frac{\partial y_i}{\partial q_j} \), is reversed in communal reward systems, since reward shares are unaffected by work effort. In communal systems, \( \frac{\partial y_i}{\partial q_i} = \frac{\partial y_j}{\partial q_j} > 0 \), as long as \( \frac{dR}{dQ} > 0 \). Hence, within the context of a collective reward system, one would expect to see more work performed than in a communal system for two reasons: substitution of work for leisure because of higher marginal income in the collective system, and substitution of work for leisure in order to prevent income from falling when another faculty member works more in a collective system. Perverse effects on one worker's income from another worker's effort are normally absent in a capitalist reward framework, since workers are paid a fixed wager per hour worked over the contract period. However, in piecework systems, a similar effect is seen when increased effort by one worker results in a higher norm for all workers, thus, reducing their incomes, other things equal. Equations (23)-(26) below give \( \frac{\partial y_i}{\partial q_j} \) and \( \frac{\partial^2 y_i}{\partial q_j \partial q_l} \) for communal-communal, communal-collective, collective-communal, and collective-collective reward systems, respectively.
(23a) \[ \frac{\partial y}{\partial q} = \frac{1}{n_A} \quad F'(L) > 0 \]

(23b) \[ \frac{\partial^2 y}{\partial q \partial q} = \frac{1}{n_A} \left[ \frac{dR}{dQ} F'(L) + \frac{d^2 R}{dQ^2} (F(L))^2 \right] \leq 0, \text{ if } F'(L), \frac{d^2 R}{dQ^2} \leq 0 \]

(24a) \[ \frac{\partial y}{\partial q} = \frac{1}{n} \left[ q_a \frac{dR}{dQ} + (1 - \frac{q_a}{Q}) \frac{R}{Q} \right] F'(L) > 0 \]

(24b) \[ \frac{\partial^2 y}{\partial q \partial q} = \frac{1}{n} \left\{ \left[ q_a \frac{dR}{dQ} + (1 - \frac{q_a}{Q}) \frac{R}{Q} \right] F'(L) \right. \]
\[ + \left. (F'(L))^2 \left[ q_a \frac{d^2 R}{dQ^2} + (1 - \frac{q_a}{Q}) 2 \left( \frac{dR}{dQ} - \frac{R}{Q} \right) \right] \right\} \]
\[ \leq 0, \text{ if } F'(L), \frac{d^2 R}{dQ^2} \leq 0 \]

(25a) \[ \frac{\partial y}{\partial q} = \frac{1}{A} \int_{Q}^{L} \left[ \frac{dR}{dQ} F'(L) - \frac{R}{Q} \right] < 0, \text{ if } F'(L) < \frac{R}{Q} \]

(25b) \[ \frac{\partial^2 y}{\partial q \partial q} = \frac{1}{A L} \left[ \int_{Q}^{L} \left( \frac{dR}{dQ} F'(L) + \frac{d^2 R}{dQ^2} (F'(L))^2 \right) + (1 - 2 \frac{L}{Q}) \frac{dR}{dQ} F'(L) \right. \]
\[ + \left. \frac{R}{L} \left( \int_{Q}^{L} \left( 1 - \frac{1}{L} \right) - 1 \right) \right\} \]

(26a) \[ \frac{\partial y}{\partial q} = \frac{1}{L} \left[ \left\{ q_a \frac{dR}{dQ} + (1 - \frac{q_a}{Q}) \frac{R}{Q} \right\} F'(L) - \frac{q_a R}{Q} \right] \leq 0, \text{ if } \frac{R}{Q} > \frac{F'(L)}{q_a} \]

(26b) \[ \frac{\partial^2 y}{\partial q \partial q} = \frac{1}{L} \left\{ (F'(L) - \frac{1}{L} F'(L)) \left[ q_a \frac{dR}{dQ} + (1 - \frac{q_a}{Q}) \frac{R}{Q} \right] \right. \]
\[ + \left. \left[ F'(L) \right] \left[ q_a \frac{d^2 R}{dQ^2} + 2(1 - \frac{q_a}{Q}) 1 \left( \frac{dR}{dQ} - \frac{R}{Q} \right) \right] + \frac{R}{Q} \frac{q_a}{L} \right\} \]
\[ + \left( 1 - \frac{1}{L} \right) \left\{ \frac{R}{Q} (F'(L) - \frac{q_a}{L}) + \frac{q_a}{L} \left( \frac{dR}{dQ} - \frac{R}{Q} \right) \frac{1}{Q} F'(L) \right\} \]

**Conclusions**

Direct economic incentives in academic departments differ markedly according to reward allocation systems adopted at college and department levels, with the largest work incentives being produced in systems using collective allocation at the department level.
If the real marginal product of faculty labor is the opportunity cost of providing additional work effort in the academic department, rational faculty members in communal reward systems should allocate available time at the margin to nondepartmental pursuits, since marginal income from additional work in the department is far below opportunity cost. The reverse is true for faculty members in departments utilizing collective reward systems, as long as the reward pool is reasonably close to real output. If $R$ is very low relative to $Q$, the faculty member in the collective-reward department find himself in the same position as a worker on a traditional Soviet collective farm. Even though incentives to work on the collective are much higher than on the same farm organized as a commune, available reward is so low relative to real output that marginal income is less than marginal product, and the optimal strategy is to minimize time spent laboring on the collective and to maximize time spent cultivating the private plot.

References