ARTICLES

TASK INTERDEPENDENCE AND WAGE DISPERSION: AN EMPIRICAL STUDY OF U.S. AND JAPANESE MANUFACTURING PLANTS

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Abstract

Using survey data on workers in manufacturing plants in both the U.S. and Japan, this study examines the relationship between task interdependence and wage dispersion. Data was analyzed using a 2-step regression to determine the relationship between the level of task interdependence and the amount of residual wage variance. Results suggest that in Japan a significant negative relationship exists between the level of task interdependency and wage dispersion. In the U.S. a negative relationship exists between the mean wages for a department and wage variance while no relationship exists between task interdependency and wage dispersion.

Keywords: Equity, Wage dispersion, Work organization

TASK INTERDEPENDENCE AND WAGE DISPERSION: AN EMPIRICAL STUDY OF U.S. AND JAPANESE MANUFACTURING PLANTS

This paper explores the relationship between task interdependency and wage dispersion within departments at comparable manufacturing plants in both the US and Japan. In an era when manufacturing firms increasingly engage in tasks requiring coordination and cooperation among workers, there is a growing need to understand the relationship between wages and the way work is organized to set effective wage policies. Recent theoretical developments combine social psychological theories and labor economic theory to explain the effects of wage policies on productivity. However, there appear to be few empirical studies relating social comparison process, work organization, and wage theory in a comparative setting.

When tasks require greater coordination between individuals, relative wages become relevant as worker interaction and goal interdependence rise. Competitive wage schemes

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may induce greater individual output when the task is independent of other workers. However, when tasks are interdependent, competitive wages may reduce group effort as workers compare wages across occupations, perceive wage inequity, and reduce their work effort. Thus, there may be a relationship between task interdependence and wage dispersion.

In addition to differences in task interdependency, there may also be national differences in the work environment. Recent literature suggests that U.S. firms are moving in the direction of forming work teams in manufacturing plans (Banker, et al, 1996). In contrast, Japan is a group-oriented society which has for years emphasized a cooperative work environment (Rohlen, 1975; Lincoln & Kalleberg, 1990). Yet, there is relatively little comparative research on the relationship between the characteristics of teamwork and wages. Based on these differences, I suggest that there will be a significantly negative relationship between the degree of task interdependency and wage dispersion in the U.S. and in Japan.

THE RELATIONSHIP BETWEEN TASK INTERDEPENDENCE AND WAGE DISPERSION

Theories based in social psychology such as social comparison processes such as equity theory, extend the economic theory and help explain why firms maintain internal wage parity. Research on equity theory suggests that workers reduce their effort when they observe their colleagues doing the same work earning higher wages (Scholl, et al, 1987). Recent studies suggest that task characteristics such as interdependence is related to effectiveness (Campion, et al, 1996; Hyatt & Ruddy, 1997)). Other studies suggest that group goals and group feedback lead to greater group performance when group members must rely on each other to complete the job well (Saavedra, et al, 1993). However, these studies do not discuss the relationship between task characteristics (based on group versus individual performance) and wages.

At the same time, economists argue that individuals base their perceptions of equality not on market valuations, but on subjective valuations (Akerloff & Yellen, 1988). This view supports the evidence that wage compression occurs in industries with high-paying occupations because workers in a firm compare their wages to other members of the same firm, not to workers doing similar work in other firms. As a result, wage compression is more evident in industries with high-paying occupations as these occupations will tend to pull up wages in traditionally lower paying occupations, as well. Wage compression occurs within these high-paying industries because a work environment with high wage disparity may not be a particularly desirable place to work.

Extending this notion, Levine (1991) argues that firms valuing worker participation will reduce wage differentials to raise worker cohesiveness and productivity. Levine suggests that, "... narrowing wage dispersion can increase cohesiveness, and that in participatory firms

cohesiveness can increase productivity." (Levine, 1991:237)

Research suggests that pay equity between upper management and lower-level employees leads to higher product quality (Cowherd & Levine, 1992). However, the effects of wage dispersion may be mitigated by the level of cooperation required for task completion since people are more likely to compare wages with those with whom they most closely work (Frank, 1984). This suggests that wage disparities may have less impact on employees engaged in tasks requiring little interaction or cooperation than on employees whose work requires close worker cooperation.

Where the task does require close interaction or cooperation among workers, or when workers are trained to perform a variety of tasks, pay differentiation based on a set of skills becomes less clearly defined. Workers in a group may perceive that no one person's task is more or less important than other tasks. In this case, workers might expect similar pay.

In such work situations where cooperation is desired, a competitive wage system may produce uncooperative behavior detrimental to the firm (Lazear, 1989). Since work requiring cooperation makes it easier for workers to sabotage the work of those who receive higher wages, when cooperation is important, wage compression will be more evident (Lazear, 1989).

Studies on cooperation, defined as the perception of goal interdependence, suggest that traits such as agreeableness and interpersonal skills were positively related to levels of performance (Neuman & Wright, 1999). This is true especially when the task is complex and requires coordination. (Hackman, 1990; Okun & DiVesta, 1975; Slocum & Sims, 1980; Tjosvold, 1984) While cooperation theory does take into account the role of goal interdependence, equity theory provides insight into the mechanisms by which the perception of equity might induce cooperative behavior, especially when the task requires coordination.

The degree of wage equity can be measured as the wage variation within a work group. Thus, the greater the variation in wages or wage dispersion , the less wage equity workers experience.

Pfeffer and Langton's (1988) study of a university academic department brings together task characteristics, social relations and wage variation in describing inequality in academic departments. Their study found that departments where professors were more demographically homogenous, had more social contact and had greater participation in governing the department, were associated with less wage dispersion. One problem they identify is that causality is difficult to determine (Pfeffer and Langton, 1988). They suggest that work organization both affects, and is affected by, wage dispersion.

There are a number of studies which indicate a positive relationship between wages allocated to subordinates by managers and their level of dependence on these subordinates (Fossum & Fitch, 1985; Tjosvold, 1985; Martin, 1987; Bartol & Martin 1988). Indeed,

studies suggest that when managers' dependence on subordinates is high and the threat of disruption of this relationship is also high, managers tend to be more generous in allocating wages (Bartol & Martin, 1988). By extension, where worker interdependence is high, we would expect lower wage dispersion in the work group. These studies suggest that,

Hypothesis 1: When individual wage differences are accounted for, there will be lower wage variance when cooperation is required for task completion.

The discussion so far has focused on the relationship between wage dispersion and the level of cooperation required for successful task completion. If one of the factors hypothesized to affect wage dispersion is cooperation, then it is worth examining a country where its work culture emphasizes teamwork and group values.

THE U.S. AND JAPANESE EMPLOYMENT SYSTEMS

There has been much written about the Japanese employment system. Much of this literature, with the exception of Cole (1979), Kalleberg and Lincoln (1988) and Lincoln and Kalleberg (1990) base their findings on either qualitative methods or case studies.

The Japanese employment system has been characterized by "lifetime employment" and firm internal labor markets (FILMs) (Dore, 1973, 1986; Koike, 1975). While there is some debate regarding the actual extent of these employment practices in Japan (Cole, 1979; Tan, 1982), Japanese companies, regardless of size, strive to achieve this ideal.

In contrast, there is agreement that Japanese companies emphasize the maintenance of worker ties to the organization (Rohlen, 1975; Lincoln & Kalleberg, 1985). Research suggests that training workers to perform a number of different tasks and career development may prevail more in Japan than in the U.S. (Cole, 1971; Dore, 1973; Koike, 1975).

Group emphasis is maintained through a variety of means including leadership, informal group-centered activities and participation in decision-making (Rohlen, 1975). Work group relations were also found to be more valued in the Japanese work setting than in the U.S. (Cole 1979). It is no surprise that Japanese workers are more likely than their American counterparts to report that they work more closely with others to do the job well (Lincoln & Kalleberg, 1990).

In addition, there is little in the way of individual rewards (Weiner, 1982). Group incentives are favored over individual incentives to promote cooperation among workers (Dore (1973). These observations suggest that there is greater emphasis in Japan than in the U.S. on creating a work environment where individual contributions are less relevant than group output.

Lincoln and Kalleberg (1990) found less of a difference in earnings between managers and workers compared to American employees. Their finding is consistent with Cole, who determined that differences in wages between managers and workers narrowed in Japan

during the 1960s (Cole, 1971).

The literature suggests that in Japan, where work relationships endure over time due to long-term employment practices, there would be little incentive for managers to be generous to those on whom they rely the most, their subordinates. However, Japan's long-term employment practice is a double-edged sword, applying to all workers. Under these conditions, superiors and subordinates may spend their entire careers working together. In this case career advancement of superiors is dependent on the performance of their subordinates. Without cooperation from their subordinates, especially their more capable workers, advancement is limited (Rohlen, 1975). Conversely, since subordinates also advance when superiors succeed, cooperation between ranks of workers is desired by both sides. One would expect that in this situation, mechanisms such as low wage dispersion would be in place to promote close cooperation even between ranks. Because in Japan group processes appear to play a far greater role in work organization than in the U.S.

Hypothesis 2a: Task interdependence will tend to have a greater effect on wage variance in Japan than in the U.S.

In the U.S., where social relations at work are not as emphasized as in Japan, other factors such as economic conditions, market demand for particular skills, or the industry's average wage may have greater effects in determining wage dispersion than task interdependency. Moreover, in the U.S., workers can switch jobs easily. There is less association to the firm and much greater attachment to occupations or skills in determining status and rewards (Kalleberg & Lincoln, 1988). These observations suggest the task interdependency factor in wage compression may be more applicable to Japan than to the U.S. The literature suggests that there is a positive effect of mean wages on wage compression. That is, there is greater wage compression as mean wages rise (Akerloff & Yellen, 1988). For American plants, we should observe that:

Hypothesis 2b: The mean wage level will have a greater effect on wage variance in American firms than in Japanese

The creation and maintenance of cooperative social interaction is a norm for Japanese business organizations. Where such strong organizational norms prevail, we would not expect differences among Japanese plants. In contrast, in the U.S., where there is no tendency to foster close work groups, we should expect plants to set different wage policies.

Hypothesis 3: Japanese plants will tend to behave more alike with respect to residual wage variance than U.S. plants

However, there does appear to be flexibility in work organization among Japanese departments,

"The Japanese system involves a less rigid and minute division of functions at the lower levels. ... The section as a whole has responsibility for the duties assigned to it, and a

section chief can shunt duties around between individuals according to their capacities." (Dore, 1973: 225)

This suggests that within Japanese departments, there is greater flexibility in how work is organized than in their American counterparts. The greater degree of flexibility may also imply a wider variation in wage dispersion among different Japanese departments. However, due to less flexible wage policies especially within unionized plants in the U.S. (Freeman, 1980), departments in the U.S. may not have significantly different wage-setting policies that would affect the residual wage variance.

Hypothesis 4: Departments in Japan will behave differently with respect to residual wage variance than departments in U.S. plants

DATA

The data, collected by Kalleberg and Lincoln, consist of questionnaires administered to employees of manufacturing plants in the U.S. and Japan. The data sampled manufacturing plants in seven industries; transportation equipment, chemicals, electronics and electronic equipment, food processing, prefabricated metals, nonelectrical machinery, and printing and publishing. In general they describe the Japanese and U.S. samples as comparable with respect to the characteristics of the region and industry distribution.

The sampling scheme used was a stratified random sample based on employment size and industry from a population of manufacturing plants in the seven industries. The population was determined through the chambers of commerce, government agencies, and other similar sources.

Employees in all plants were divided into three groups; manager, supervisors, and workers, with each group completing separate questionnaires. There were 4,567 completed questionnaires in the U.S. and 3,735 in Japan. A more complete description is available in their book based on this data (Lincoln & Kalleberg, 1990).

The data includes the task interdependency variable which measures on a Likert scale worker response to the statement: "I must work closely with others to do my job well." (1=strongly disagree, 5=strongly agree). According to Lincoln & Kalleberg "This measure reflects the extent to which production is organized in work teams and other structures that require considerable coordination." (1990: 89) Their measurement was validated by the fact that, consistent with most research, Japanese workers report they work closely with others to a greater degree than their American counterparts. Table 1 presents descriptions, means and standard deviations on employee rank, age, education level, sex, marital status, tenure, earnings and the response to the task interdependency question for employees in the U.S. and in Japan. These results are consistent with those of Lincoln and Kalleberg (1990).

Table 1 Descriptions, Means and Standard Deviations of Variables for All US and Japanese Employees

Variable	US Mean (SD)	Japan Mean (SD)
Worker rank (1=worker, 2=supervisor, 3=manager)	1.21 (.52)	1.36 (.61)
Age of employee	38.65 (11.31)	35.04 (10.02)
Education (6=elementary, ... 17= more than BA)	12.65 (1.95)	12.22 (1.95)
Sex (0=male, 1=female)	.27 (.44)	.16 (.37)
Marital status (0=unmarried, 1=married)	.72 (.45)	.67 (.47)
Number of years employed at plant	11.25 (9.57)	11.99 (8.14)
Yearly earnings in dollars	$20,319.20 (12,655.67)	$12,699.09 (5,784.87)
Task interdependency	3.22 (1.21)	3.80 (1.01)
N	4,567	3,735

The unit of analysis in this study was the functional department. These include line production, technical production R&D, personnel, sales, finance, planning and other. The number of respondents from each department was used as a proxy for department size. Ideally, a work group level of analysis is preferred since the task interdependency variable implies a group task environment that may not be applicable to the entire department. Because of this, a concern was that there may be such a range of responses to the task interdependency question at the department level that it would add little in predicting wage dispersion. However, visual inspection of the distribution of responses to the task interdependency question for the departments in each plant, shows that while there was some spread, in most cases, responses tended toward either "agree" or "disagree" within each department. Thus, there is general agreement within departments about the nature of the work.

METHODS

This study investigates the relationship between task interdependency and wages using cross-cultural survey data. Two separate regressions were used. The first regression controls for individual demographic effects on wages. The second, evaluates the effect of task interdependence on wage dispersion.

To distinguish between "within organization" and "between organization" effects, Pfeffer

(1988) advises a two-step procedure which first predicts individual wages using a standard wage equation where the independent variables are those generally agreed upon to affect wages such as age, education, job tenure, race and gender. In addition, dummy variables for each plant and / or department are included to take into account the mean wages across the unit of analysis.

In the second step, the standard deviation is calculated for the residuals from the first wage equation for each department at each plant. The standard deviation of the residuals (hereafter referred to as the "residual wage variance") for each department become the dependent variable in the second regression. This residual wage variance is a valid measure of wage dispersion because it represents the wage spread *after* controlling for the usual demographic variables and taking into account the variation both within and between organizations.

This 2-step procedure: 1) estimates how much of the residual for the department is accounted for by task interdependence and, 2) establishes a relationship between the level of task interdependence and the amount of residual wage variance after accounting for variables typically used to predict wages.

Standard wage equation

Following Kalleberg and Lincoln (1988), the measure of individual wages used as the dependent variable was the natural log of earnings. They report that earnings in Japan were converted to U.S. dollar equivalents based on 250 yen per dollar. Table 2 shows the results of the initial wage regression.

Because the purpose of this study was to determine the effects of task interdependency, not gender or status, on residual wage variance, I did not divide the analysis into the three employee rank categories; worker, supervisor and manager. Instead, this model measures the strength of the influence of task interdependency on wage dispersion across employee ranks.

Second regression predicting residual wage variance

To measure the amount of unexplained departmental wage variance, the standard deviations of the residuals from the first wage equation were calculated for each department. This residual wage variance becomes the dependent variable in the second regression. Because standard demographic effects were accounted for in the first standard wage equation, the second regression only examines the effect of the level of task interdependency on the variation of the residuals.

Table 3 presents the means across department level variable for both the U.S. and Japan. While wage and size variables were included as controls, the primary interest of this study is the relationship between task interdependency and residual wage variance. The mean of the log of earnings for each department was included to control for mean wage effects on residual wage variance since the empirical evidence (Katz, 1986) suggests that as the mean wage rises

Table 2 Standardized Regression of the Natural Log of Earnings on Standard Wage Estimators

Independent variable	Parameter estimate (standard error)
US	.861 (.416) +
Worker rank	.275 (.009)**
Tenure	.010 (.001)**
Age	.006 (.001)**
Education	.011 (.003)**
Female	-.306 (.012)**
Married	.111 (.010)**
Department dummies	
Line production	.004 (.017)
Technical production	.045 (.019)*
R&D	.067 (.055)
Personnel	.017 (.036)
Sales	.040 (.045)**
Finance	.121 (.046)**
Planning	.047 (.094)
Plant dummies	52 US plant dummies, 44 Japanese plant dummies

Adjusted R^2 = .64

+ p<.05
*p<.01
**p<.001
Omitted department is "Other"

Table 3 Means and Standard Deviations for Variables Aggregated to the Plant Department Level for US and Japanese Plants

Variable	US	Japan
Standard deviation of residual from standard wage equation	.34 (.17)	.24 (.10)
Task interdependency	3.31 (.45)	3.85 (.38)
Natural log of earnings	9.71 (.34)	9.34 (.30)
Number of respondents in department	36.52 (46.75)	22.89 (26.76)
N	112	136

within a plant or industry, wages for all occupations in that plant or industry also rises.

In addition, the number of workers in the department who responded to the questionnaire was also included as a proxy measure of department size to control for departmental size effects on residual wage variance. Unfortunately, because the number of individuals in a department or work group were not available, specific hypotheses could not be made on the effects of group size on residual wage variance.

Because the department means for all variables were used in the analysis and because the number of respondents varied for each department, all regressions were weighted by the number of respondents for each department. Weighting is useful for two reasons. First, because the number of respondents were different for each department, weighting minimizes biases of the standard errors in the estimated equation. Second, if the parameter variances for departments are not independent of the sample size, weighting corrects for the differential variances so that the standard deviations are independent of the number of observations (Klein, 1974; Maddala, 1977). In addition, to ensure meaningful results, departments with two or fewer respondents were excluded from the analyses.

DISCUSSION

Table 4 shows the association between task interdependence on residual wage variance for regressions done for the U.S. and Japan separately. Table 4 does not support Hypothesis 1, that in general a lower wage dispersion exists where task interdependence is high. Instead, the claim made in Hypothesis 2a, that there will be a greater negative relationship between task interdependence and wage dispersion in Japan than in the U.S. is supported. There is a significant, negative relationship between task interdependence and residual wage variance in Japan while for the U.S. the coefficient is positive and not significant. This result suggests that in Japan, where group processes are valued and maintained through a variety of methods, departments which report relatively greater task interdependency have on average, a smaller residual wage variance than departments reporting less task interdependency.

While Hypothesis 2a argued the importance of task interdependence on wage dispersion in Japanese plants, Hypothesis 2b argues that for American plants the mean wage level is a better predictor of wage variation. The regression results show that the U.S. parameter estimate is negative, highly significant and almost double (-0.183) that for Japan (-0.098). As the mean wage rises for departments, residual wage variance decreases by a much higher factor in the U.S. per unit increase in the mean wage than in Japan. However, this result should be tempered by noting that the earnings difference between the U.S. and Japan may be overstated since earnings reported for Japanese workers includes bonuses but not fringe benefits. Japanese workers tend to be compensated through fringe benefits more than their American counterparts (Kalleberg & Lincoln, 1988).

Table 4 Standardized Regressions of Task Interdependence on Residual Wage Variance Controlling for Industry and Department Effects for US and Japan

Independent variable	Equation							
	1		2		3		4	
	US	Japan	US	Japan	US	Japan	US	Japan
Task interdependence	.059 (.037)	-.048+ (.023)	.039 (.056)	.023 (.026)	.056 (.038)	-.045+ (.023)	.026 (.037)	-.024 (.025)
Natural log of earnings	-.183** (.035)	-.098** (.021)	-.072 (.086)	-.204** (.041)	-.176** (.040)	-.092** (.020)	-.169** (.037)	-.109** (.026)
Number of respondents in department	.0001 (.0002)	-.0001 (.0002)	.0003 (.0002)	.0003 (.0002)	.00008 (.0002)	-.0008 (.0002)	.00003 (.0001)	.00004 (.0002)
Plant dummies	—	—	51 included	43 included	—	—	—	—
Department dummies								
Line production					.061 (.095)	.047 (.026)		
Technical production					.060 (.094)	-.021 (.025)		
R&D					—	-.095+ (.047)		
Personnel					-.016 (.183)	-.033 (.040)		
Sales					.101 (.155)	-.068 (.079)		
Finance					-.020 (.217)	-.055 (.059)		
Planning					—	.075 (.094)		
Industry dummies	—	—	—	—	—	—	7 included	7 included
Adjusted R2	.21	.17	.45	.51	.18	.25	.19	.21
N	112	136	112	136	112	136	112	136
F-statistic			1.90	3.14+	.17	2.68+	.64	.28

+ p<.05
** p<.001
Omitted department is "Other"

Hypotheses 4 and 5 predicted the relationship of plant and department on residual wage dispersion. Hypothesis 4 argues that Japanese plants, by virtue of a more group oriented work organization in Japan, will tend to have more similar wage policies to manage wage

dispersion than U.S. plants. To test this hypothesis, 43 plant dummies were added to the regression for Japan and 51 to that for the U.S. If the addition of plant dummies is found to enhance the prediction of the residual wage variance, it would imply that plants within each country do not behave alike with respect to wage variation. Some plants may have specific plant-wide policies to maintain a cooperative work environment which would result in a low residual wage variance.

The F-statistic was calculated comparing the models with and without the plant dummies. They are shown in Table 4. Contrary to what was predicted in Hypothesis 4, the addition of the plant dummies enhances the prediction of the residual wage variance suggesting that in Japan all plants do not behave alike with respect to wage variation. In fact, with the addition of the plant dummies, the sign for the coefficient for task interdependence changes from negative to positive for the Japanese sample although this result is not significant. Given the influence of task interdependence within Japan without the plant dummies, this result suggests that, 1) there is considerable variation in wage dispersion among Japanese plants or, 2) task interdependence is not a relevant variable for Japanese plants in determining wage dispersion.

Hypothesis 5 argues that there will be significant differences among Japanese departments in residual wage variance. To test this hypothesis seven department dummies were added to the regression for Japan and five (there were no respondents for two of the departments) to that for the U.S. The F-statistic shows that as predicted, the addition of the department dummies to the regression for Japan adds significantly to the ability to predict residual wage variance. Moreover, the coefficient for task interdependence remains negative and significant at the .05 level.

To ensure that possible plant or department effects were not in fact industry effects, the fourth model included only industry dummies. The F-statistic shows that there are no industry effects on residual wage variance for either the U.S. or Japan.

The evidence suggests that there is greater flexibility in how work is organized across Japanese departments than in the U.S., and at the same time that there is a negative relationship between task interdependency and the residual wage variance in Japan. These findings suggest that contrary to the popular literature which often imply that Japanese plants have very similar wage policies, there is considerable variation across Japanese plants and indeed departments in how task interdependence influences residual wage variance.

CONCLUSION

Wage dispersion has been studied as a function of industry (Dickens & Katz, 1986), size (Pfeffer & Langton, 1988), unionization (Freeman, 1980), and as a function of social comparison processes (Levine, 1987; Akerlof & Yellen, 1988; Lazear, 1989). While

theoretical work predicts a negative relationship between groupwork and wage dispersion (Levine, 1991), there has been little empirical study on the effects of task interdependency on wage dispersion. Here, I argue that the social comparison processes are very much a function of task interdependencies because, as workers are required to work closer together, they will also tend to compare one another's wages. In such cases, work groups will attempt to maintain wage equity or risk disintegration of the cooperative behavior needed for efficient production.

This study did not attempt to explain the causal mechanisms between task interdependencies and wage dispersion. While the hypotheses imply causality; task cooperation leads to lower wage dispersion, similar to Pfeffer and Langton's study, causality is difficult to determine. These results simply describe and compare the relationship between task interdependency and residual wage variance and are a first step in determining the mutually causal relationship between task interdependency and wage dispersion.

In Japan where group task environments are encouraged, a significant negative relationship exists between the level of task interdependency and the residual wage variance; as employees in a department work closer together, wage variance decreases. In contrast, in the U.S., the mean wages for a department had a much greater effect on the residual wage variance while task interdependency did not. However, contrary to popular lore, the findings suggest that Japanese plants do not behave uniformly with respect to wage variance.

Further study is needed to determine the relationship between task interdependence and residual wage variation. Other variables that should be considered include the level of technology, level of decision making, as well as other group interaction variables, e.g. level of loyalty to the group, and the interaction among workers, supervisors and managers. Future studies should pay greater attention to the differences among Japanese plants, as well. By systematic study of differences among Japanese plants, we may find that differing social relations and work organizations have historic underpinnings and include more complex relationships than have been assumed.

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