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# IDENTIFYING FACTORS AFFECTING PRODUCTIVITY IN GROCERY DISTRIBUTION CENTERS

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Emphasizes that management is the principle factor in explaining large labor productivity differences among grocery distribution centers.

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## INTRODUCTION

Food distribution center productivity has been essentially flat in recent years while wages rose by over 100 percent from 1968 through 1977 (Kochersperger 1978, p. 59). The resultant rapid rise in distribution center costs has been a considerable concern to industry and public officials.

Industry personnel see distribution center costs further eroding profits during the current cost-profit squeeze. Public policy analysts for their part see center costs as contributing to the spiraling farm-retail margin which in 1980 rose more than twice as fast as the farm share of the \$193.7 billion spent on at-home food consumption (USDA, ESS 1981, p. 22). There is concern that center operations which have been estimated at 2.5 percent of the retail value of food will command an in-

creasingly larger share in the future (Kaylin 1968, p. 13; Ray 1975).

Reversing this scenario in an inflationary economy will require renewed labor productivity improvements. Evidence exists that such improvements are possible and indeed have been adopted by some operations. Physical productivity standards developed for many warehouses show that 10 percent reduction in costs can be achieved without new investments or major organizational changes (Wolff 1980, p. 43). Grinnell has also found that organizational changes can improve the productivity of existing warehouses by up to 40 percent. Yet firms have found this information difficult to act on. One midwestern chain, for example, had performance standards established which showed many workers operating at only 60 percent of the standard. Several years later, management is still looking for means of improving performance levels.

## OBJECTIVE

The purpose of this paper is the identification of operating characteris-

tics associated with higher productivity in grocery distribution centers. The delineation of these characteristics will assist warehouse managers in deciding which aspects of their operations to consider first in productivity improvement efforts.

The analysis is limited to physical productivity in conventional non-automated dry grocery distribution centers. Thus, the results are valid for the major cost area in conventional warehouses where labor constitutes 50 to 80 percent of total costs (Progressive Grocer, Grinnell and Crawford, 1977, p. 17), and for the great bulk of distribution centers as more than 90 percent are conventional. Nevertheless, it must be remembered that improving physical productivity does not necessarily reduce total center costs in either the short or long run. A detailed analysis on a facility-by-facility basis should be made before the recommendations presented here are applied to any particular warehousing operation.

We proceed by reviewing briefly previous work and opinion on the factors affecting warehouse productivity. Next, we discuss the empirical analysis and make specific recommendations for the industry.

#### FACTORS INFLUENCING WAREHOUSE PRODUCTIVITY

Numerous industry observers and analysts using a wide range of procedures have identified an array of factors which impact on distribution center productivity. These are reviewed here in the interest of recognizing the most significant for use in the subsequent analysis. These factors may be classified under three major headings: physical characteristics, operating practices and labor management.

Physical characteristics include those aspects of warehousing related to the structure and its use. An obvious factor of potential relevance is facility size. Some analysts using engineering economic techniques have identified slight to sizeable economies in physical productivity - that is, productivity increases along with the

size of the facility (Pierson, 1972, Crawford and Grinnell, 1978).

There is some justification for this view as larger operations allow more labor specialization. However, after some minimal efficient size is reached, the coordination problem among more employees in larger warehouses may cancel the positive specialization effect. The engineering approach, which involves designing an operation on paper and calculating the expected response as one factor (e.g., size) is varied, may not be well suited to measuring the impact of labor management on operations. Engineers are describing how a facility ought to operate, which can be quite different from the actual performance. Additionally, the longer distances which must be travelled in the larger warehouse involve greater use on nonproductive time. Hence, overall warehouse size is not expected to have a strong impact on productivity, at least beyond the smallest, and the relationship may even be negative.

Other physical factors possibly affecting productivity are product proliferation and its handmaiden, crowding. The large number of new products introduced in recent years - 3,000 in 1978 along (Progressive Grocer) - creates more slow-moving items which require proportionally more labor (Grinnell and Crawford, 1977, p. 19). Crowding reduces productivity either by inhibiting the free flow of product or by requiring double handling of some cases stacked in temporary locations around the facility (Bauma and Kriesberg, 1960, p. 27). This situation may have become more critical in recent years as management has become increasingly reluctant to invest in additional distribution capacity (Harris and Stevenson, 1980, pp. 37-44).

Operating practices include a large array of interrelated activities which may significantly affect warehouse productivity. Many of these, such as the use of batch picking, limiting the number of repacks, and using outside delivery

personnel for unloading, are widely seen as enhancing productivity. Other factors such as slot selection criteria may influence productivity, but the only one which was found to be significant in an earlier analysis was moving loaded pallets directly into the trailer compared to staging it on the dock for subsequent loading (Lesser and Roller, 1980, p. 156).

Labor management and motivation are keys to high productivity in the labor intensive warehousing operation. Yet with repetitive tasks and little opportunity for advancement for warehousemen, there is little incentive to perform well. One executive stated the situation succinctly (Supermarket News, 1970):

Order picking has to be one of the worst jobs in the world. This guy has to go around the warehouse all day picking out cases--and it has no meaning for him. No wonder he does a lousy job.

In fact, a major attribute of mechanized selection systems is that they, not the individual warehouseman, determine the rate of activity for the entire operation (Chain Store Age Executive, 1975, p. 11). And automated equipment does not require motivation.

The way in which labor is managed and the interaction of management style with employee abilities and union agreements will be major determinants of the productivity of individual distribution centers. Other analysts have recognized the importance of labor management but have failed to identify specific means of enhancing productivity through improved management (cf. Grinnell and Crawford, 1976, p. 12)

Unions in warehousing as in other sectors have a multifaceted effect on labor productivity. (For a survey, see Kochan, 1980, pp. 329-83). On the positive side, unions are seen as enhancing on-the-job training and cooperation by reducing competition. They may improve motivation by making workers feel more in control of their working environment through the use

of negotiations and grievance procedures. Unions can assist management by serving as an effective conduit for explaining day-to-day changes in the work routine. Finally, by elevating wages, the quality of workers attracted to a unionized operation may be higher than for non-unionized ones. Higher union wages also elicit a managerial response which typically involves paying close attention to the increased investment in human capital. More training of both workers' and managers' emphasis on labor saving procedures and capital for labor substitution often result when a union organizes a bargaining unit. Unionized workers tend to stay longer with a firm giving the firms the benefit of a more stable and experienced workforce as well as reduced training costs.

Negative effects exist simultaneously. Supervisors see these as restrictive work rules which reduce flexibility of management, or as seniority based promotions under which positions are awarded based on longevity rather than ability. The opportunity to provide positive incentives is further reduced by contract stipulations which control productivity-based pay incentives. Negative incentives in the form of contractual progressive disciplinary procedures for poor performance can inhibit some of the flexibility required for effective managerial control. Hence, the balance between the positive and negative effects of unionization in warehousing is an empirical question to be addressed in this analysis.

Management has a range of responsibilities for the coordination and direction of labor besides those which may be provided by the union. Here, a principle requirement is the coordination of activities between functional areas, an activity requiring first level supervision. It is difficult to determine the optimal ratio of supervisors per direct workers, but one observer has suggested a level of .17 (Delaney, 1975, p. 620). Observed levels have always been lower than this, from .14 to .04 (Cornell Report, 1980,

p. 11). Allocation across functional levels is also important, but in many cases seems to be improper. For the firms in the Cornell Report, average supervisory levels in truck receiving are .33 while for selection it is .035 (1980, pp. 18 and 37). Considering the relative autonomy of order selectors, this allocation appears misaligned. Productivity incentives are a possible alternative to high supervisory levels, but one which few firms have yet taken advantage of (Cornell Report, 1980, p. 32).

### EMPIRICAL ANALYSIS

Attention is now turned to measuring which of the factors described above have the greatest impact on warehouse productivity. Identification of the most significant factors will help management determine which areas to emphasize in a productivity improvement program.

The analytical procedure used here is factor analysis. Factor analysis is appropriate as it is "based fundamentally on the faith that the observed correlations are mainly the results of some underlying regularity in the data" (Nie, et. al., 1975, p. 471). That is the hypothesis underlying this analysis - the existence of a limited number of basic factors or conditions which explain the sharp productivity differences observed among dry grocery distribution centers. The value of factor analysis is its usefulness in reducing the number of variables to a smaller group of characteristics which continue to account for a substantial portion of the observed relationships in the data.

### Source of Data

Data were drawn from the 1979 and 1980 editions of the Cornell Report on Productivity in Grocery Distribution Centers. Thirty-eight participants in the report (retail food chain and wholesaler warehouses) submitted operating data from the same four-week period in at least one of those years. Operating conditions were considered to have remained sufficiently consistent over that period to allow a

simple pooling of the data, which were collected and reported in three broad areas: physical characteristics of the warehouse (size, ownership, location), management related factors (unionization, supervisory levels, wages, incentive systems, inventory systems), and productivity related variables (cases, tons, man-hours).

Data are compiled independently by employees at each warehouse, leading to the possible variability in the quality and quantity of data provided. Careful screening and editing was used to correct this situation, but the possibility of inaccuracies remain. This editing, coupled with anomalies in the sample, such as no rail receiving in one warehouse, caused disparate sample sizes for inbound (32) and outbound (29) operations.

Participation in the Report is voluntary so that the warehouses included do not necessarily represent a random sample of dry grocery warehouses in the U.S. and Canada. The representation of facility size ranges is good, but the sample is heavily dominated by integrated chain warehouses as compared to wholesaler and cooperative operations. Unionized operations also predominate in the sample. Although no distortions of the results are apparent, some consideration of the representativeness of the sample must be given when interpreting the results. Moreover, some of the results reflect characteristics of the sample rather than important underlying relationships. These are discussed below.

Data in the Cornell Report are recorded for the six major functional areas of distribution center operations: truck and rail receiving, storing, replenishing, selection and shipping. When preparing the data for this analysis, it became apparent that the problems of allocating labor time between interfacing functions such as selecting and shipping involved arbitrary decisions which could introduce unexplainable errors into the analysis. As an alternative, the data were

aggregated into two general functional areas: inbound operations incorporating receiving and storing, and outbound which includes selecting and shipping. Replenishment is excluded because the data on this function were sketchy. Indeed, many warehouses maintain little control over this operation, leaving restocking to the discretion of lift operators and order selectors.

### Factor Models

Proper statistical procedures require that a relationship among the variables, or model, be specified prior to the analysis. In this way, expectations can be compared with the empirical results permitting greater assurance in the results if the two are in agreement, or better insights if the two diverge. For factor analysis, the model specification involves (a) identifying the number of factors and (b) characterizing the relationship among the variables within each factor.

In general, the factors for both inbound and outbound operations are expected to fall into two broad groups - physical characteristics and management. Physical characteristics include facility size and a potentially large number of operating characteristics such as crowding, inventory policies, use of batch picking, etc., each of which has an anticipated effect on productivity. These variables are expected to load onto two factors, one describing the particular characteristics of the warehouse and the other describing its size. However, given the mixed evidence on the effect of size on productivity, it is likely that the loading on this latter factor will be small.

Management may be subdivided into practices followed in warehouses with and without strong union locals. Thus, management should load on two factors. The management domination factor is expected to show a positive relationship to productivity while the union-domination factor may be either positively or negatively associated with productivity.

### EMPIRICAL RESULTS

Estimation was done using the FACTOR subroutine of the SCSS conversational statistical program (Nie, et. al., 1980, pp. 457-510). A maximum likelihood extraction technique is used and the factors are rotated to assist interpretation.

### Inbound Results

A total of 18 variables were included in the first analysis (Table 1). Standard factor analytical procedures were used to exclude all but eight of these as being nonsignificant in explaining the underlying relationships. The eight remaining variables loaded on three factors (Table 2).

The first factor relates heavily to a strongly unionized warehouse and is termed "effects of strong unionization." The relatively large positive loading on productivity (.525) demonstrates that for input operations, unionization is associated with higher rather than lower productivity. Unionized workers are, as expected, paid more than nonunionized ones as a wage variable loaded heavily in another iteration of this analysis (not reported).

Factor two describes a poorly-run warehouse which is not heavily unionized. It is titled "poorly managed," and is characterized by high employee to first-line supervision levels (INSPAN) and positive although not very large supervisory turnover (SUPTO). Hourly turnover (negative, HRT0) and disciplinary procedures (DISCIP) both load relatively heavily, suggesting perhaps that while procedures are in place for discharging workers, supervision may be inadequate to implement them. For workers, the relative laxness of the supervisory atmosphere in these warehouses may reduce voluntary terminations.

The third factor we interpreted as another form or technique of management,

TABLE 1. Description of Variables for the Inbound Analysis

Variable		Description/Effect on Productivity
INCHM	cases per man hour inbound	defines labor productivity
FLAREA	facility size	slight negative effect
ITEMS	no. items carried	more items reduce productivity slightly
REPACKS	no. repack items	more repacks reduce productivity
PCTBH	backhaul percent	more backhaul means more warehouse unloads and lower productivity
TRUNLOAD	truck unloading by warehouse labor	more labor on unloading reduces productivity
DOCKSTOR	use of dock for storage	measures potential crowding
STORDENS	storage density (units/sq. ft.)	measures potential crowding
INVTO	monthly physical inventory turnover	lower turnover indicates greater investment and potential crowding
INSPAN	hourly employees to supervisor ratio	higher ratios may lead to poor control and productivity
HRT0	annual turnover of direct labor	high turnover can cause poor productivity or reflect low morale
SUPT0	annual turnover of supervisors	high supervisor turnover may reduce coordination and productivity
UNION	union organized or not	unions have ambiguous effects on productivity
ABSTP	proportion of absent direct workers	absense impedes coordination, reduces productivity
DISCIP	disciplinary procedures in contract	measures degree of formality in enforcing standards
REGION	identifies southern warehouses	warehouses in the South are frequently considered to be more productive
RAWAGIN	base hourly wage	union workers typically receive higher wages
WRATIONIN	firm wages compared to area's	higher relative wages attract higher quality workers

Source: Cornell Report on Productivity in Dry Grocery Distribution Centers, 1979, 1980.

that is, management removed from the direct coordination of the activities. Consequently it is referred to as "second-line supervision." This factor is dominated by high levels of turnover, particularly for supervisory personnel. In the absence of a strong union presence, these results would be consistent with upper level management

putting pressure on employees to produce. The result is the appearance of dedication by employees as measured by low absentee rates, but the important strong positive effect on output is missing. Levels of hourly employees compared to first-line supervisors are relatively low, but the high turnover of supervisors

TABLE 2. Factor Analysis of Inbound Data on Food Distribution Center Productivity\*

Variable	Factor 1	Factor 2	Factor 3
UNION	.940	.210	.015
INCHM	.525	-.408	.194
TRUNLOAD	.330	.197	.387
INSPAN	-.039	.578	.264
HRT0	-.134	-.626	.132
DISCIP	.198	.393	.517
SUPT0	-.010	.060	.604
ABSTP	-.025	.060	-.170
Percentage of variance explained in the unrotated solution	18.1	15.0	9.4
Goodness-of-fit	$\chi^2 = 2.90$ d.f. = 7		

Source: Cornell Report on Productivity in Grocery Distribution Centers, 1979, 1980.

\*Maximum-likelihood extraction of normalized variables, varimax rotation.

appears to be diminishing supervisory effectiveness.

As interesting as the variables which loaded heavily in Table 3 are those which did not also warrant attention. The loadings on facility size were small, supporting the belief that there are no important size economies in physical labor productivity in food distribution centers. The weights on the other facility-related variables were also low. This can imply that while these factors may be important in some operations, the singlemost important factor explaining interwarehouse productivity differences in management.

From the results it is evident that close supervision is essential to high productivity. Whether the supervision leads to better coordination or better morale or a combination is not known. However, in the absence of good morale, as is seemingly the situation with the "second-line supervisor" case, productivity suffers. When analyzing the effects of unions, it is as always difficult to

identify the base cause. Unionized operations may be relatively productive because (a) higher wages attract more able workers, or (b) management responds to higher labor costs by enhancing the level and quality of first-line supervision, provides more training for warehousemen, improves procedures and substitutes capital for labor, or (c) unions provide an important coordination mechanism. While the causality cannot be determined here, the implication of the above analysis is that the principal contributions of a union are to improve coordination and facilitate managerial adjustments. Thus, when the levels of union and nonunion wages are compared, the possible contribution of unions to higher productivity should be considered as well.

#### Outbound

In a manner similar to the inbound operations, 19 variables were tried in the outbound operation and eight retained (Tables 3 and 4). Outbound activities,



TABLE 3. Description of Variables for the Outbound Analysis

Variable		Description/Effect on Productivity
OUTCMH	cases per man-hour outbound	defines labor productivity
FLAREO	facility size	slight negative effect
ITEMSO	no. items carried	more items reduce productivity slightly
REPACKS	no. repack items	more repacks reduce productivity
PCTLOAD	portion of loading done by selectors	direct loading increases productivity
PCTUNIT	percent shipment unitized	greater unitization reduces handling and increases productivity
ORDSIZE	average order size	larger orders increase the order selection "hit" frequency and enhance productivity
INVT00	physical inventory turnover	higher turnovers may characterize better coordinated warehouses
OUTSPAN	first-level supervisory span of control	higher levels may lead to poor coordination and control
HRT00	annual turnover of direct labor	higher turnover can cause poor productivity or reflect low morale
SUPT00	annual turnover of supervisors	higher supervisory turnover may reduce coordination and productivity
UNIONO	union organized or not	unions have ambiguous effects on productivity
ABSTPO	proportion of absent direct workers	absence impedes coordination, reduces productivity
DISCIPO	disciplinary procedures in contract	measures degree of formality in enforcing standards
REGIONO	identifies southern warehouses	warehouses in the South are frequently considered to be more productive
OSTAND	engineering-based work standards	the existence of standards may identify better managed operations
INCENT	use of productivity incentives	performance incentives can enhance productivity
RAWAGOUT	base hourly wage	union workers typically receive higher wages
WRATIONOUT	firm wages compared to area's	higher relative wages attract higher quality workers

Source: Cornell Report on Productivity in Dry Grocery Distribution Centers, 1979, 1980.

TABLE 4. Factor Analysis of Outbound Data in Food Distribution Center Productivity\*

Variable	Factor 1	Factor 2	Factor 3
SUPT00	.798	-.154	.111
INCENT	.447	.152	-.030
OUTSPAND	.804	-.544	.010
INVT00	-.092	.090	-.770
UNION	.079	-.075	.490
FLARE0	-.162	.228	.505
OUTCMH	.145	.941	-.305
ABSTP0	-.156	.392	.200
Percentage of variance explained in the unrotated solution	17.9	21.4	13.8
Goodness-of-fit	$\chi^2 = 6.88$ d.f. = 7		

SOURCE: Cornell Report on Productivity in Grocery Distribution Centers, 1979, 1980.

\*Maximum-likelihood extraction of normalized variables, varimax rotation.

like inbound, loaded on three factors, none of which related output to physical characteristics (Table 4). In this instance the importance of high levels of first-line supervision is even clearer. In factor two, referred to as "well managed," relatively high supervisory levels explain 30 percent of the variability of productivity among warehouses in the sample. This result is expected considering the difficulty of supervising order-selector work in many parts of the warehouse and the need to coordinate closely selection activities with those on the shipping dock. Despite this, many warehouses seemingly allocate supervisors improperly. For the warehouses in this sample, the average number of workers per supervisor is 9.7 in truck receiving, but 28.2 in order selection (Cornell Report, 1980, pp. 18, 37). Perhaps one reason for this is the scheduling of selection at night (a less desirable time to work compared to the day shift) when the receiving is done.

Comparing this factor with a similar one on the input side, the obvious question

arises - why does unionization load so moderately on the output function? The answer could lie with the way the two functions are organized, although a firm conclusion is difficult because the samples for the inbound and outbound operations vary slightly. Output receives substantial management attention both because of its relative importance in terms of total employee hours and the significance of the outbound operation in providing high service levels to the stores. In addition, the delivery truck drivers are generally employees of the firm so that management controls the entire operation.

Operations at the input side, on the other hand, are considerably more autonomous. Inbound shipments are typically delivered by contract or common carriers who cannot necessarily be compelled to adhere to a schedule established by management. At the same time, both the drivers and the warehousemen in unionized warehouses are typically members of the Teamsters Union. The camera-

derie and brotherhood existing among Teamster members as well as among members of other strong unions enhance an informal arrangement and coordination at the receiving dock. Warehouse management for its part is often excluded from this working arrangement, unable or unwilling to control the critical aspects of the operation. As a result, the coordination of the receiving operation often becomes de facto under the control of the union members.

When absolute pay levels were included among the variables in an analysis not presented here, unionization was again, as expected, associated with higher wages. Relative wage rates of the sample firms compared to warehousemen in neighboring SMSA's showed little effect on either labor turnover or directly on productivity. Relative wage levels were, however, strongly associated with turnover among supervisors. This result makes sense if upper management practices wage compression - the close pegging of supervisors' wages to those of hourly employees. Data are not available to measure this assertion directly, but it is generally recognized as existing in the warehousing sector. If true, wage compression is further evidence of the underrating of first-line supervision by upper level management. Gerald Peck, President of the North American Wholesale Grocers Association (NAWGA), however, notes a recent change in attitudes among employers which is reflected in an increased interest in training first-line supervisors (Modern Materials Handling, 1980, p. 113).

While factor two describes the importance of supervision for outbound productivity, factor one relates to the substitution between supervisors and incentives. Consequently, it is titled "supervisor/incentives substitution." Incentives have been found to substitute for direct supervision by motivating hourly employees to work diligently in areas where they are often hidden from sight. Incentives are viable only in instances where accurate labor standards exist. Only a small percentage of distribution centers are using incentives and in 1979 only 15 percent of

responding warehouses had any standards for warehousing activities (Modern Materials Handling, 1980, pp. 62, 67). There has, nevertheless, been a notable increase in the use of incentives in grocery warehousing in recent years, perhaps signaling a trend in this area (Cornell Report, 1979, p. 29 and 1980, p. 36). While some labor contracts prohibit direct monetary incentives, the awarding of goods, like color television sets or time off for exceeding standards, can be substituted.

The heavy positive loading on supervisory turnover in the first factor could reflect a cause or an effect. The institution of incentives could lead to the laying off of supervisors as superfluous. Considering the difficulty of locating a good supervisor, the seems unlikely. More plausible is the substitution of incentives for supervisors in operations which have difficulty retaining qualified supervisors.

The third factor relates to warehouse efficiency, but not to physical labor productivity. The negative relationship between inventory turns (INVT00) and warehouse size (FLARE0) describes larger warehouses as carrying relatively greater inventories compared with smaller ones. This factor is titled "inventory efficiency," and, while it lies outside the principal scope of this paper, it is nonetheless significant for overall warehouse efficiency. The interpretation of this result is not entirely clear from the available data. On the one hand, the inventories may result from speculative purchases of products with anticipated price increases. On the other, they may be due to careless buying which proceeds until the physical capacity of the warehouse is reached, necessitating more careful planning. Based on our experience with the industry, we feel careless buying is a more likely explanation than the other. If this is indeed correct, then the excessive inventory costs for larger warehouses is substantial, especially during the current period of record interest rates.

The high loading on the union variable in this factor, is more a trait of the sample than illustrative of a causal relationship. The sample is characterized by a group of larger warehouses located in the Northeast, a heavily union-dominated area. Thus, the loading on unions simply characterizes the sample.

#### SUMMARY AND RAMIFICATIONS FOR MANAGEMENT

Factor analysis is used in a cross-warehouse study for the purpose of identifying characteristics associated with high labor productivity. Data from the Cornell Report on Productivity in Dry Grocery Distribution Centers for approximately 30 warehouses are used in the analysis. The results may be used by warehouse managers attempting to identify, among the myriad factors potentially affecting productivity, those which are the most significant. Considering the nature of the sample and the analytical procedure, the results presented here should be considered preliminary only, and careful analysis should be made before these results are applied to individual operations.

The results point strongly to management as being the principal factor explaining large labor productivity differences among grocery distribution centers. Physical characteristics and procedures on the other hand are found to be relatively unimportant as is the amount of absenteeism. Proper management is synonymous with close supervision at the foreman level, and productive warehouses are uniformly more heavily supervised. Differences, nevertheless, exist in how this supervision is achieved. Some operations employ a high ratio of supervisors to workers while others apparently rely on unionized employees to contribute to coordination on the inbound side. For outbound operations, incentives are found to be a good substitute for high supervisory levels. Larger warehouses in the sample have lower inventory turnover than smaller ones, but whether this is due to speculative buying or careless inventory management cannot be determined from the available data.

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