Application of Business Intelligence in Multidimensional Profitability Analysis

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Abstract—Multidimensional profitability analysis is an important element of management accounting, which can be used for measuring and analyzing management results from different dimensions, to provide supports for enterprises' internal management and managers' decision-making. As a modern information technology, business intelligence can be used in the process of multidimensional profitability analysis well. Take company Y as a case study, this paper demonstrates how business intelligence provides supports in the whole process of multidimensional profitability analysis, and summarizes the superiorities and relevant precautions.

Keywords- business intelligence; multidimensional profitability analysis; application

1 INTRODUCTION

In December 2018, Chinese ministry of finance issued a series of guidances for applicating management accounting, including Guidance No.405—multidimensional profitability analysis. As defined, multidimensional profitability analysis refers to an analysis methodology, in which an enterprise measures the operating results within a certain period according to the dimensions of region, product, department, customer, channel and employee, and analyzes the motivation of profit and loss, to support the enterprise's refined management and internal operation management [1].

Business intelligence was firstly described by Gartner Group as: It describes a set of concepts and methods to aid business decision-making by applying fact-based support systems. Brian Larson, a consultant at Microsoft, defines it more readily: Business intelligence is about delivering accurate and useful information to the right decision makers in time to support effective decision-making [2]. After years of practice, business intelligence has been widely used in enterprises' management activities.

1.1 Necessity

When applying multidimensional profitability analysis, enterprises need to deal with massive information generated in producing and operating activities comprehensively and

MSIEID 2022, December 09-11, Chongqing, People's Republic of China

DOI 10.4108/eai.9-12-2022.2327649

systematically, that is, carry out internal transfer pricing, costs allocation, performance sharing, EVA measurement and so on, according to the minimum granularity of management [1], as well as collect and deal with the information to provide reports for different needs. As a result, huge workload and high complexity can be expected, which requires an certain ability of informationization [1].

1.2 Possibility

According to the definition, business intelligence aims to support decision-making activities, which corresponds well with the "decision-making usefulness" of management accounting. Data mart, online analytical processing (OLAP) system and data visualization system are three critical technologies of business intelligence, which would be discussed next.

Data Mart, unlike data warehouse organizing and storing all aspects of historical data, focuses on organizing some specific aspects and time periods of data. In one hand, it avoids the disadvantages of large volume and long time cycle, and comes faster and more adaptable; In another hand, it inherits the advantages of data warehouse–storing multidimensional data in the form of "fact table plus dimension table". When applied to multidimensional profitability analysis, dimension table can store the dimensional information, and fact table can store information of indicators in the analysis model. In addition, to deal with enterprises' raw data, which are generally inconsistent in sources, specifications and even quality, the extract-transform-load (ETL) process of data mart could transform them into uniform and standardized ones before storing. As stated in Guidance No.405, qualified enterprises may establish data warehouses or data marts to form uniform and standardized data sets [1].

OLAP system, first proposed by E.F.Cod, is an interactive system that allows analysts to view different kinds of aggregate data of multidimensional data [3] to quickly and easily retrieve information from data (usually data marts) for analysis [2]. It helps analysts to find useful information on different sides and hierarchies through "drilling down", "winding up", "slicing" and "rotating axis" operations, thus helps to understand and analyze data more intuitively [4]. This character fits the concept of "multidimension" well. In addition, the "online" nature of the OLAP system improves the timeliness of accounting information by quick responses to analysts' requests.

Data visualization system, helps to examine large amounts of data and detect patterns in a visual manner by presenting data succinctly. It supports the comprehensive application of various analysis (trend analysis, ratio analysis, etc.) and evaluation methods (bubble chart, radar chart, etc.) and visualizes results, providing help for preparing multidimensional profitability analysis reports conveniently and flexibly.

In the following case study, data mart and OLAP system are based on the relevant suite of Microsoft SQL Server 2008; Data visualization system is based on Microsoft Office Excel 2019 and Microsoft Power BI Desktop 2.92.706.0.

2 FEASIBILITY– A CASE STUDY

Based on Guidance No.405, a case study of Y company [5] is made to illustrate the feasibiity of applicating business intelligence in multidimensional profitability analysis.

2.1 Evaluating the environment

As a leader in Chinese household appliances industry, Y company has a sophisticated organizational structure, and makes diversified product due to increasingly fierce competition. Meanwhile, it has a relatively complete information system as well as related technical support. Summarize its requirements for multidimensional profitability analysis as follows: Focuses on key customers from the customer dimension; In channel dimension, it mainly focuses on e-commerce platforms, and in employee dimension, it mainly focuses on the employees within the sales center. Its organizational structure is shown in Figure 1. In order to meet the needs of internal management, Y company defines the minimum business evaluation unit (i.e. the minimum granularity of management) as employees, platforms and customers, according to which it carries out internal transfer pricing, costs allocation, performance sharing, EVA measurement and so on.

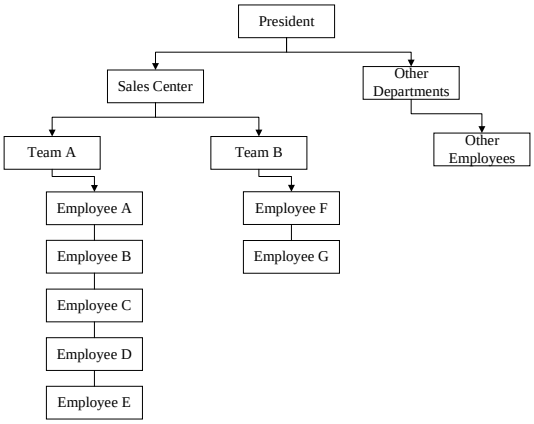

Figure 1. Organizational structure of sales center

2.2 Determining the dimensions and establishing the model

According to the organizational structure, and the management needs in performance, sales and channel, the three dimensions of employee, customer and channel are determined, and the lowest hierarchies of the three dimensions are employee, customer and platform, respectively.

Profitability indicators are consist of operating revenues, operating costs, gross profits, operating profits, net profits and EVA, with two ratio indicators of gross profit rate and net profit rate.Net profit rate shows how much of the revenues created in business ultimately are transformed into wealth, which is a comprehensive indicator. Gross profit rate reflects how much surplus of operating revenues after deducting operating costss can be used to cover the expenses, and generate profits furthermore. The above two ratio indicators reflect the

"efficiency" in creating values, and compares companies of different size well. Combined with the three dimensions, the multidimensional profitability analysis model is constructed as shown in Figure 2 (the black box part is the index used for specific analysis).

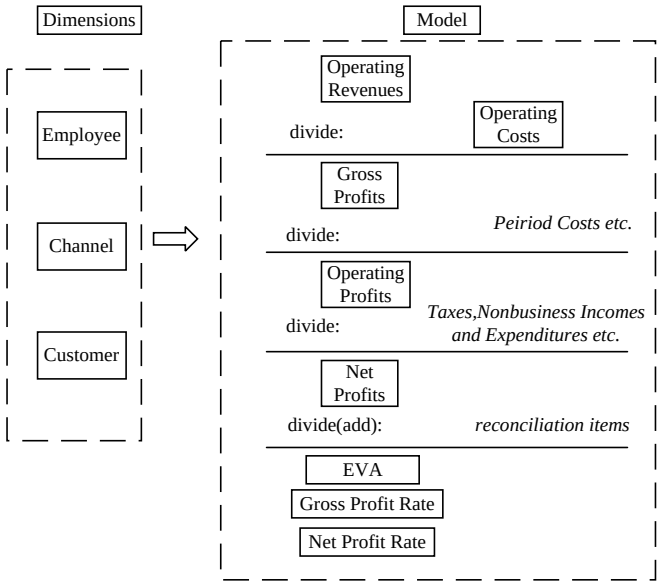

Figure 2. Multidimensional profitability analysis model

2.3 Developing data standards

A model of three dimensions with eight indicators is established (gross profits, gross profit rate and net profit rate can be directly calculated from the other five basic indicators). In order to use the model in different combinations and hierarchies of dimension, it's necessary to classify and summarize profitability information of each minimum business evaluation unit in dimensions. Therefore, each minimum business evaluation unit should contain at least three dimensions as well as five basic indicators, that is, each tuple data should contain eight fields (and not allowed to be empty) at least.

2.4 Collecting and processing data

In order to collect and manage data intensively and specifically, Y company establishes a data mart according to Guidance No.405 as follows.

1)Design the architecture: According to the previous steps, the data mart is designed to be a snowflake structure as shown in Figure 3.The fact table consists of eight fields, among which five indicator fields are measurement values so as to set as compound primary key, and three dimension fields are set as foreign keys referencing related dimension tables. As mentioned above, gross profits, gross profit rate and net profit rate can be directly calculated by the other five basic indicators; Considering efficiency and error reduction, these three indicators are not included in the data mart, but are added in the establishment of the data cube.Dimension table

of each hierarchy contains an encoding field(set as primary key),a name field, and(for non-top-hierarchy dimension table)a field that references the encoding of the dimension table at the previous hierarchy.

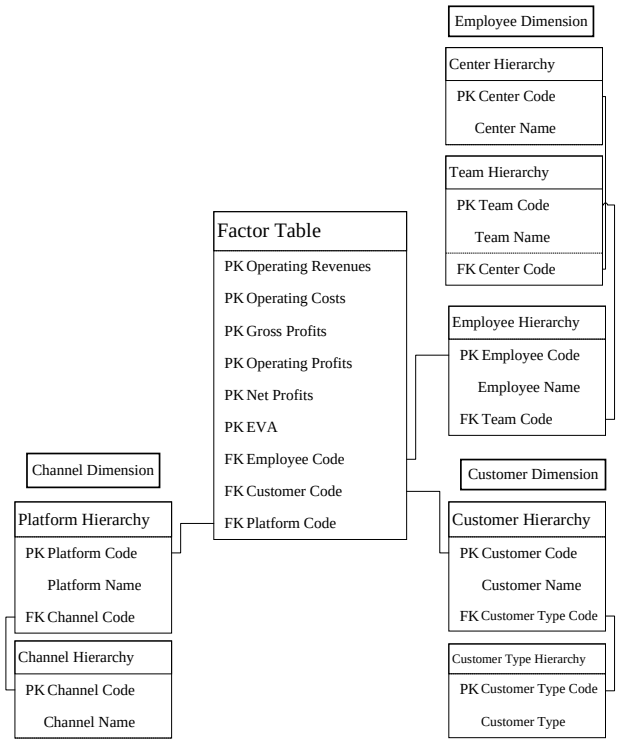

Figure 3. Data mart architecture

2)Establish the data mart: Although foreign key relationships are identified between related tables in the design of architecture, there are two reasons not to create foreign key constraints actually.On one hand ,the amount of data loaded into the data mart are usually large, which will increase pressure on the data engine if foreign key constraints exit.On the other hand,the ETL process of Microsoft SQL Server Integration Services (SSIS) can be substituted for foreign key constraints to ensure referential integrity of data.

3)Populating the data mart: In order to verify and ensure referential integrity between the fact table and the dimension table,as well as different hierarchies of the same dimension,dimension tables should be populated ahead of the fact table, and from the highest hierarchy down. The data types may not be the same in different data sources,so they needs to be converted to one type compatible with the data mart in the extraction process.Various data sources may contain duplicate, non-standard or even wrong data, which needs to be cleaned before loading into the data mart (completed in the ETL process by SSIS).

4)Establish the data cube: Data cube is the core of OLAP system,which collects data of multidimension and multihierarchy. Analysts can interactively view the cube through "drilling down", "rolling up", "slicing" and "rotating axis" from different angles for personalized

needs .When using data mart,analysts may need only part of the data,or calculating and extending them, and for Y company,it needs all the data in the data mart, and to calculate the three indicators of gross profits, gross profit rate and net profit rate,in order to create a multidimensional dataset in Microsoft SQL Server Analysis Services (SSAS).

2.5 Preparating the reports

By connecting the data cube to the visualization system, an OLAP system is formed, which can be used for real-time, multidimensional and visual analysis. "Pivot table" and, "simulation analysis" of Microsoft Office Excel 2019 can support multidimensional analysis and prediction well, and visualization of results is capable in Microsoft Power BI Desktop. In accordance with Guidance No.405, the reports are prepared as follows.

1)Multidimensional analysis of overall profit and loss: As shown in Table 1, it can be seen that the net profit rate, gross profit rate and EVA are all positive, indicating that the company is generally profitable.

Table 1 Overall profit and loss analysis in all dimensions

Financial indicators	***Values***
Operating revenues	643.09
Operating costs	433.96
Gross profits	209.13
Operating profits	91.88
Net profits	79.52
EVA	58.13
Gross profit rate	32.52%
Net profit rate	12.37%

2)Analysis of profit and loss in each dimension and relevant driving factors: The profit and loss condition and relerant driving factors can be analyzed from different dimensions. The following takes employee dimension as an example.

a)Analysis in team hierarchy: For a clearer comparison, add two columns of differences between two teams; And in order to exclude the influence of size (team members) when comparing EVA, divide EVA by the number of employees of the two teams respectively, by adding a line of "(per capita) EVA", as shown in Table 2. Generally speaking, the gross profit rate and net profit rate of both teams are positive, indicating they have made contributions in creating values for the company. Compared with team B, team A has a lower gross profit rate and a higher net profit rate. Its operating revenues is 409.68% higher,while its gross profits is only 349.19% higher, which results in a lower gross profit rate.However, with a net profits of 541.10% higher, its net profit rate becomes higher ultimately. As a conclusion, team A has a lower "efficiency" in creating values in business activities,with a better performance in non-business activities,and finally has a overall higher "efficiency" in creating values for the company. EVA refers to the residual revenues of the net operating profits after deducting all the costs of capital invested and tax, so it becomes an important indicator to comprehensively

evaluate managers' usage of capital and creatation of values for enterprises [6].EVA of two teams are both positive, indicating that both teams are creating values, which is also verified by the result of net profit rate in previous analysis. Comparatively, the EVA per capita of Team A is significantly higher (6.81 higher, or about 198 percentage points higher), indicating that team A performs much better in terms of using corporate capital to create values effectively.

Table 2 Profit and loss of Team hierarchy in employee dimension

Financial indicators	***Team A***	***Team B***	***Company***	***Difference (Team A- Team B)***	***Difference ratio [(Team A-Team B)/Team B]***
Operating revenues	537.61	105.48	643.09	432.13	409.68%
Operating costs	366.56	67.4	433.96	299.16	443.86%
Gross profits	171.05	38.08	209.13	132.97	349.19%
Operating profits	76.35	15.53	91.88	60.82	391.63%
Net profits	68.79	10.73	79.52	58.06	541.10%
EVA	51.25	6.88	58.13	44.37	644.91%
Gross profit rate	31.82%	36.10%	32.52%	- 4.28%	- 11.87%
Net profit rate	12.80%	10.17%	12.37%	2.62%	25.78%
(per capita) EVA	10.25	3.44	8.30	6.81	197.97%

b)Drilling down to employee hierarchy: In order to analyze the driving factors affecting the profitability of two teams, we can drill down from the team hierarchy to the employee hierarchy and check it.Meanwhile, for visualization, three measurement values of gross profit rate, net profit rate and EVA of all employees are taken to make a bubble chart, as shown in Figure 4.Taking team A for instance, among all five employees, employee E contributes the most (14.88%), while employee A contributes the least (3.02%), in terms of net profit rate; For further analysis of gross profit rate,The best contributor is not employees E, but employee D (43.61%). In other words, employee E creates values most efficiently on the whole,while employee D creates values most efficiently in business activities. In terms of EVA, all employees in team A have positive EVA, indicating that all of them have created values. The best contributor of EVA is employee E (26.97),while the worst is employee A (0.27).The profitability analysis of other dimensions is the same.

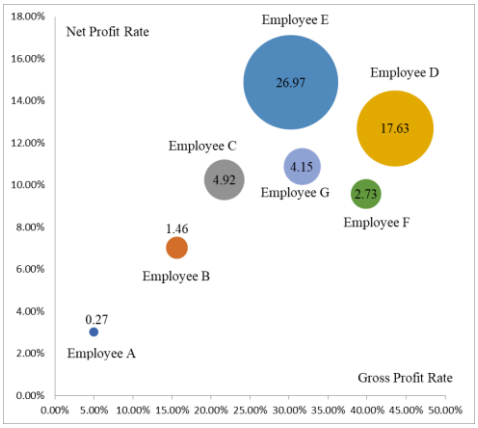

Figure 4. Bubble chart of profit and loss in employee dimension

c)"Slicing" the cube: In the OLAP system, analysis can be conducted not only from one dimension, but also from any two combined dimensions, thus extending the previous analysis from "one-dimension" to "two-dimensions". Taking operating revenues in employee and channel dimensions of team A for instance, as shown in Table 3, the best contributor is employee E (250.45), which is achieved only through "jingdong" and “other platforms” in channel dimension, other than "taobao"– a famous e-commerce platform. Employee A generates operating revenues only through "other platforms", other than "jingdong" and "taobao"–two mainstream e-commerce platforms, and contributes the least(9.61) as a result.

Table 3 Profit and loss in employee and channel dimensions

Operating revenues	***Employee A***	***Employee B***	***Employee C***	***Employee D***	***Employee E***
jingdong	0	19.99	21.65	61.01	87.31
taobao	0	22.16	22.45	64.09	0
other platforms	9.61	0	21.57	44.63	163.14
subtotal	9.61	42.15	65.67	169.73	250.45

d)"Rolling up" to team hierarchy,and "rotating axis": It’s capable to "roll up" from employee hierarchy to team hierarchy for analyzing operating revenues of each team in each platform.For comparison, divide the operating revenues by the number of employees of each team to exclude the influence of size, as shown in Figure 5. It can be seen that the per capita operating revenues of team A is higher than team B on all three platforms, and team B does not generate any operating revenues on "taobao" platform, which should be noted. It’s capable to combine any other two dimensions for "two-dimensional" analysis by "rotating axis" in the same way metioned above.

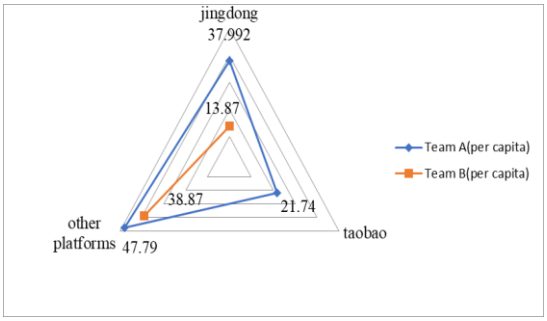

Figure 5. Profit and loss in team and channel dimensions

3)Development trend analysis in all dimensions: So far, historically analyzing in Y company's profitability has been conducted. In order to make the results contributory to future management and decision-making, trend analysis is needed. Analysis is still conducted in operating revenues from the two dimensions of employee and channel. Although contributing the most, employee E has not made use of “taobao” platform, as mentioned in previous analysis; And employee A hasn’t made use of “jingdong” or “taobao” platform, contributing the least. It is reasonably predicted that after business training in future, employee E would generate business revenues on "taobao" platform (the value is 36.23 , the average operating revenues of the other six employees on "taobao" platform), and employee A would generate operating revenues on both "jingdong" and "taobao" platforms (the two values are respectively the minimum non-zero operating revenues of the other six employees on corresponding platforms, which are 19.99 and 22.16), so as to analyze the results of gross profits and gross profit rate, as shown in Table 4 (predictions are underlined). For managers, they may be interested in the impact of changes on the whole company, so the channel dimension could be "rolled up" hidden, and the employee dimension could be "rolled up" to team hierarchy. As shown in Figure 6, compared with history, the predicted gross profits of team A would increase by 78.38 (from 171.05 to 249.43), and the gorss profit rate would increase by 8.67% (from 31.82% to 40.49%), while no change would happen in team B. Furthermore, employee dimension could be "rolled up" hidden, so as to take the company as a whole for analysis, as shown in Figure 7. Compared with history, the company's overall gorss profit would increase by 78.38 (all from employees E and A of team A), while the gross profit rate would increase by 7.33% (from 32.52% to 39.85%).

Table 4 Predictions in employee and channel dimensions

Channel Dimension	**Team A**					**Team B**	
	A	***B***	***C***	***D***	***E***	***F***	***G***
jingdong	19.99	19.99	21.65	61.01	87.31	0	27.74
taobao	22.16	22.16	22.45	64.09	36.23	0	0
other platforms	9.61	0	21.57	44.63	163.14	57.01	20.73
subtotal	51.76	42.15	65.67	169.73	286.68	57.01	48.47

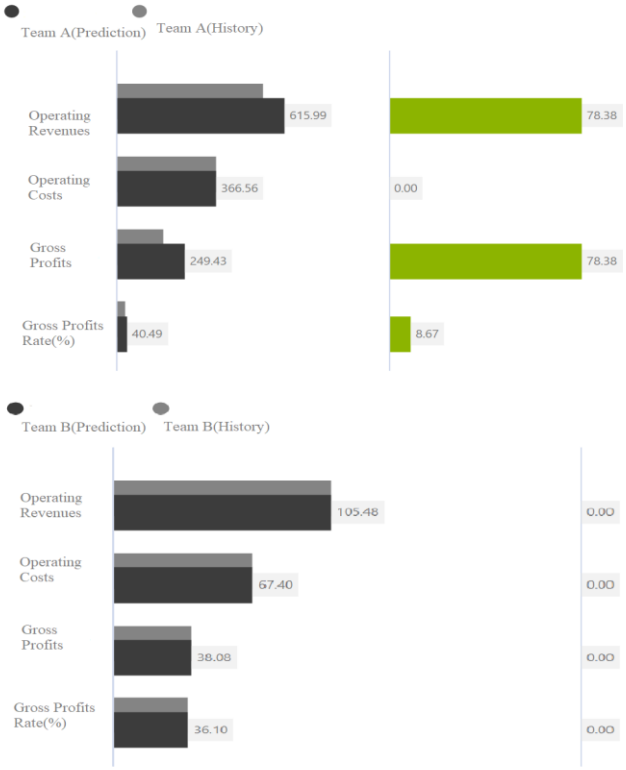

Figure 6. Trend analysis in team hierarchy

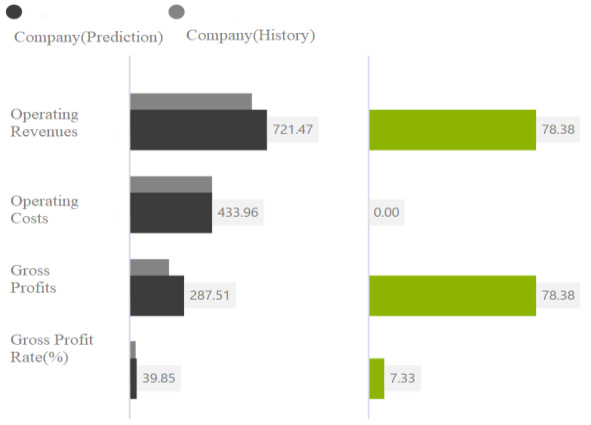

Figure 7. Trend analysis in the whole company

3)Suggestions for next steps: Summarily, Y company's overall profitability is good, while deficiencies exit, and suggestions are made as follows.

- Train the staff of sales center in making use of mainstream platforms to broaden sales channels, mining business potential for better performance.
- Enhance the learning and communication in the company, to transfer team A’s experiences to team B.
- Implementing performance evaluation to motivate excellent employees such as employee E and punish poor employees such as employee A.

3 CONCLUSIONS

Business intelligence provides various technical supports for the application of multidimensional profitability analysis, especifically as follows.

- The "fact table plus dimension table" structure of data mart, and its multidimensional and multihierarchical characteristics can flexibly adapt to the determination of dimensions and the establishment of model.
- In the aspect of collecting and processing data, data mart is able to transform "unclean" data into standard ones in ETL process. OLAP system could support the individual needs for analysis by flexibly establishing multidimensional data sets.
- In the preparation of reports, OLAP system provides support for multiangle and multihierarchy analysis by "drilling down", "rolling up", "slicing" and "rotating axis", while the data visualization system provides support for visual presentation and analysis, trend prediction and so on.

However, there are still some attentions when using business intelligence technology in multidimensional profitability analysis. Take the case study for an example to illustrate.

- In the case, three dimensions and five basic indicators are determined. Therefore, in the formulation of data standards, it is necessary to assign values in five basic indicators of three dimensions to each minimum business evaluation unit. As dimensions and indicators increase, the workload of formulating data standards would surge, which calls for high requirements for internal management of enterprises.
- Business intelligence is composed of a series of interrelated technologies, which needs high levels of technical assistance.
- On one hand, Guidance 405 provides a good framework for the application of multidimensional profitability analysis, on the other hand, there are still some deficiencies. For examples, "time" is not involved in the enumeration of dimensions, which is critical for enterprises’ profitability analysis; When listing dimensions, "department" and "employee" are paralleled, which should be a upper and lower relationship.

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