What Is Next for Companies with Low Human Efficiency: The Quantitative Talent Planning Model

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Abstract. Quantitative workforce management has become more popular since the pandemic as companies are eager to find methods to accurately locate the sources of their reducing human efficiency and ROIs of human capital. This paper aims to shed light on the applicable methods of quantitative talent planning to adjust the workforce costs and staff ratios between different departments of a company. The present study analyzed the average workforce costs and cost benefit ratios data from electronics production & design companies. The regression method was also applied to illustrate these two factors' trends and relationships. The paper's main findings are the *Equal Workforce Efficiency Curve* and the four-zone coordinate axis, which can help companies understand their current economic position compared to other competitors in their field. We also propose a strategic management framework to assist companies in using our methodologies more conveniently and confidently.

Keywords: human resources; human efficiency; workforce planning; quantitative talent planning; strategic human management; data science.

1. Introduction

The COVID-19 pandemic has abruptly stopped the engine of global economic growth, and many companies are now transferring their targets from making profits to reducing costs (Bartik et al. 2020). Besides reducing company employee benefits programs, more actions have been taken to adjust workforce planning. Companies that have already matured in their business and workforce management tend to discover more problems in this unique era because their structures and business logics are strict and have little tolerance for replanning (Belhaj & Tkiouat 2017). The core problem they have discovered is the low human efficiency and reduced ROIs on human capital (Xu, You, & Shao 2020). Human resource scientists have been exploring this issue for an extended period, but they cannot find a satisfactory answer. Therefore, companies urgently need a rigorous but flexible workforce planning tool to overcome the challenges rising from the pandemic.

Quantitative workforce planning then is an ideal tool for these nervous companies. In fact, quantitative human management has been primarily used by companies from high-tech and health sectors before the pandemic (Behan et al. 2009), and it is the first time that human resource management (HRM) is acknowledged to be strategic by nature with the aid of the quantitative workforce management tools (Belhaj & Tkiouat 2017). However, quantitative workforce management is still at the " concept refining stage," and there are few applicable quantitative workforce planning models for companies to solve the pressing inefficiency problem.

Thus, our study's main target is to define and illustrate a practical quantitative talent planning tool that can be directly used for critical decision-making scenarios. The rest of the paper will examine the specific actions to determine the current economic position of the company and propose quantitative methods to lead companies to adjust their workforce planning strategies. Finally, we will propose a management framework to help companies apply our methodologies efficiently and confidently.

2. Methodologies

2.1 Research Object Description

Our research intends to find out the quantitative methods of workforce planning for companies in the private sector. Quantitative workforce planning is one type of algorithmic management, which has three essential features: (1) machine-readable data as input, (2) automated processing of data, and (3) decision-making and -execution as output (Meijerink & Bondarouk, 2021). Therefore, an electronics company named P was selected to summarize and interview the necessary data sources, which can help us build the decision-making framework. Company P was defined as the "Technology-driven Megacorporation," which has developed its products and business in this field for an extended period. Therefore, company P should have a comprehensive set of business and management logic and is one of the most profitable companies in the field of electronics (Fogarassy, Szabo & Poor, 2017). In the aspect of workforce planning, the labor costs of research and business development have taken a large part of company P's total annual revenue because the management of the company has paid much emphasis on the self-development of cutting-edge technology. Usually, a megacorporation like company P will be regarded as having a narrow space for improving workforce efficiency because the business and research operation has already been rigid for changes (McCartney & Fu, 2021). However, efficient workforce planning is urgently needed by company P because it gradually realizes that the Return on Investment (ROI) rates for the business and operation has kept on decreasing annually, leading to a much lower cost-benefit ratio than that of the early stage.

2.2 Data Collection

The Human Resources Department (HRD) of company P in China provided the labor cost and quantitative operation data. The data was from the company's 2016 and 2017 annual reports, and analysis will be focused on these two years. Moreover, the data types included total revenue, headcount, net profits, labor costs, sales figures, and compensation data. These data were practical to explore the correlation between the annual revenue changes and labor costs, namely the ROI values of the labor costs.

Besides the data from company P, labor data from other companies in the electronics design and production field were also collected to benchmark the workforce performance of company P. More importantly, by comparing other electronics companies' data with those of company P, we can quickly identify and understand the relative position of company P in its field. The comparison would provide meaningful guidelines to plan the workforce more efficiently for company P. These data were mainly from Statista (https://www.statista.com/statistics/702062/japan-labor-productivity-index-electronic-components-industry/), which have already been cleaned to fit our analysis on the ROI performance of companies in the field of electronics.

2.3 Calculating the Average Workforce Cost and Cost-Benefit Ratio Per Yuan

Many categories of human resource data have already been produced during the company's operation. However, it is often arduous for HRD to determine the exact types of labor data for analysis. Herein, the average workforce cost and cost benefit ratio per yuan will be used for the analysis of companies' effectiveness of workforce planning as these two factors are closely related to individual employees' performance and can illustrate the companies' ROI based on actual costs (Boon, Hartog, & Lepak, 2019). When the individual workforce is emphasized over the ROI planning, the average workforce cost should be applied to the calculation to ascertain the "amount of investment."

The formula for calculating the average workforce cost is as follows:

$$\bar{x} = \frac{Pure\ Salary\ Cost}{Head\ Count}$$

Where $\bar{x}$ indicates the average workforce cost, and pure salary cost only covers salary payment without the consideration of equity & option incentives. For headcount, it summarizes the number of staff in the company for the current year.

The formula for the cost-benefit ratio per yuan is as follows:

$$r = \frac{Total\ Revenue}{Pure\ Salary\ Cost}$$

Where r indicates the cost-benefit ratio per yuan, and total revenue and pure salary cost data are both limited to the current year's calculation. The cost benefit analysis can be used to measure the company's business performance based on workforce planning, which provides an accurate and efficient tool to quantify the effects of HRD decisions. The average workforce cost and cost benefit ratio per yuan will be calculated for each electronics production company in the dataset.

2.4 Trend and Regression Analysis

When average workforce cost multiples the cost benefit ratio per yuan, revenue per person (RPP) will be determined.

$$\bar{x} \times r = \frac{Total\ Revenue}{Head\ Count},\ Revenue\ Per\ Person\ (RPP)$$

This index is practical for us to plan the workforce by conducting the regression analysis. As the total revenue is a settled value, the workforce configuration can be simulated by adjusting the head counts, which leads to an inverse proportional function.

$$f(x) = \frac{k}{x}$$

Where k indicates the total revenue, and x indicates the head counts for a specific year. In this formula, k also represents the overall labor productivity, namely the product of average workforce cost and cost benefit ratio per yuan.

The trend of the companies' workforce planning development will be analyzed based on the coordinate axis wherein the horizontal axis represents the average workforce cost, and the vertical axis represents the cost-benefit ratio per yuan. The coordinate axis can be initially divided into four zones for analysis. The first zone is the bottom left area named "Startup Zone," in which companies have low average workforce cost and low cost benefit ratio per yuan. The second zone is the top left area, defined as the "Growth Zone." The companies gradually settle down their strategy and business logic, and the cost benefit ratio per yuan keeps increasing. The third zone is the top right area, the "EoS (Economies of Scales) Zone." In this zone, the companies are very mature in their business development and have a high average workforce cost and cost benefit ratio. The final zone is the "Rigid Zone", in which companies now have much lower ROI than in their early stages as they have a low cost benefit ratio per yuan but much higher average workforce cost (figure 1). We will track the temporal trend of the companies' development by locating their movement across the four zones. The four zones will be divided according to the dataset's median levels of cost benefit ratio per yuan and average workforce cost.

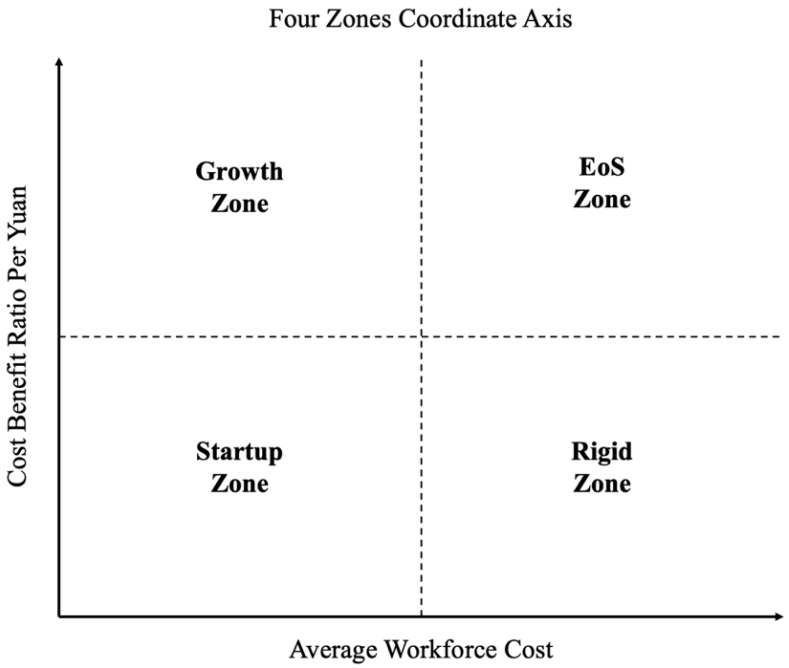

Figure 1. Division of Coordinate Axis into Four Zones

3. Results

3.1 Data Summaries

The data was collected from 2014 to 2016 and stored in Table 1, Table 2, and Table 3. The dataset includes companies' names, head counts, total annual revenue, and pure salary cost. The data was mainly from the companies' official financial reports, which can be downloaded from their websites or Securities Regulation Commission. Due to legislative requirements, we have only received Company P's data for 2016. Therefore, Company P's performance analysis would be limited to 2016.

Table 1. Companies' Financial and Management Dataset in 2014. Data include ID, Company Names, Head Counts, Total Annual Revenue, and Pure Salary Cost.

ID	Company Names	Head Counts	Total Annual Revenue	Pure Salary Cost
2014A01302	Jinlong Electric	9,307	1,226,575,982	212,603,275
2014A01278	Kaizhong Jingmi	4,126	829,966,538	259,678,282
2014A01261	Huineng Energy	3,196	700,535,333	161,892,979
2014A01155	Rongyu Group	685	161,042,614	33,512,758
2014A01227	Mengshi Energy	1,866	488,287,063	93,216,725
2014A01184	Lejin Health	1,078	284,121,068	57,578,816
2014A01141	Ningbo Shenglaida	550	150,967,864	41,827,272

Table 2. Companies' Financial and Management Dataset in 2015. Data include ID, Company Names, Head Counts, Total Annual Revenue, and Pure Salary Cost.

ID	Company Names	Head Counts	Total Annual Revenue	Pure Salary Cost
2015A01105	Xinjiang Alloy	242	44,816,199	13,835,553
2015A01275	Kaizhong Jingmi	4,284	879,924,583	284,576,272
2015A01166	Wenyi Tech	926	191,636,935	64,385,349
2015A01125	Ningbo Shenglaida Jiangxi Electric	506	105,230,232	30,115,083
2015A01269	Penghui Energy	4,020	892,846,984	112,847,889
2015A01260		3,579	878,735,747	188,988,595
2015A01232	Mengshi Energy	2,222	550,431,123	104,161,082

Table 3. Companies' Financial and Management Dataset in 2016. Data include ID, Company Names, Head Counts, Total Annual Revenue, and Pure Salary Cost.

ID	Company Names	Head Counts	Total Annual Revenue	Pure Salary Cost
2016P00000	*Company P*	*392*	*411,150,000*	*67,391,464*
2016A01126	Dongbei Electric	540	63,514,424	27,359,908
2016A01106	Xinjiang Hejin	255	52,007,023	22,425,037
2016A01124	Rongyu Group	536	120,062,609	38,611,791
2016A01114	Ningbo Shenglaida	419	95,212,097	31,429,987
2016A01266	Kaizhong Jingmi	4248	1,115,804,642	327,576,592
2016A01213	Kelier Electric	1919	504,252,434	96,952,316
2016A01152	Sanjia Tech	794	213,959,248	63,094,882

3.2 Average Workforce Cost and Cost-Benefit Ratio Per Yuan Calculation Results

To determine the average workforce costs and cost benefit ratios per yuan for each company in our data list, head counts, total annual revenues, and pure salary costs data will be used. The workforce costs in a company's total costs are also calculated. The new columns will be created according to the companies' names and specific IDs. The results are stored in Table 4, Table 5, and Table 6.

Table 4. Companies' Average Workforce Costs and Cost Benefit Ratios in 2014. Data include ID, Company Names, Percentage of Workforce Costs in Total Costs, Average Workforce Cost, and Cost Benefit Ratios Per Yuan.

ID	Company Names	Percentage of Workforce Costs in Total Costs	Average Workforce Cost	Cost Benefit Ratios Per Yuan
2014A01302	Jinlong Electric	17%	22,843	5.77
2014A01278	Kaizhong Jingmi	31%	62,937	3.20
2014A01261	Huineng Energy	23%	50,655	4.33
2014A01155	Rongyu Group	21%	48,924	4.81
2014A01227	Mengshi Energy	19%	49,955	5.24
2014A01184	Lejin Health	20%	53,413	4.93
2014A01141	Ningbo Shenglaida	28%	76,050	3.61

Table 5. Companies' Average Workforce Costs and Cost Benefit Ratios in 2015. Data include ID, Company Names, Percentage of Workforce Costs in Total Costs, Average Workforce Cost, and Cost Benefit Ratios Per Yuan.

ID	Company Names	Percentage of Workforce Costs in Total Costs	Average Workforce Cost	Cost Benefit Ratios Per Yuan
2015A01105	Xinjiang Alloy	31%	185,191	3.24
2015A01275	Kaizhong Jingmi	32%	205,398	3.09
2015A01166	Wenyi Tech	34%	206,951	2.98
2015A01125	Ningbo Shenglaida	29%	207,965	3.49
2015A01269	Jiangxi Electric	13%	222,101	7.91
2015A01260	Penghui Energy	22%	245,525	4.65
2015A01232	Mengshi Energy	19%	247,719	5.28

Table 6. Companies' Average Workforce Costs and Cost Benefit Ratios in 2016. Data include ID, Company Names, Percentage of Workforce Costs in Total Costs, Average Workforce Cost, and Cost Benefit Ratios Per Yuan.

ID	Company Names	Percentage of Workforce Costs in Total Costs	Average Workforce Cost	Cost Benefit Ratios Per Yuan
2016P00000	*Company P*	*16%*	*171,917*	*6.99*
2016A01126	Dongbei Electric	43%	117,619	2.32
2016A01106	Xinjiang Hejin	43%	203,949	2.32
2016A01124	Rongyu Group	32%	223,997	3.11
2016A01114	Ningbo Shenglaida	33%	227,237	3.03
2016A01266	Kaizhong	29%	262,666	3.41
2016A01213	Jingmi	19%	262,768	5.20
	Kelier Electric			
2016A01152	Sanjia Tech	29%	269,470	3.39

3.3 Trend and Regression Analysis Results

The data of electronics companies were plotted as scatter plots for 2016. The data was divided into six series according to their total revenue levels per person. The interval for each series is 200,000 Yuan, and series 1 includes companies with total revenue per person from 100,000 to 300,000 Yuan. Thus, the intervals for each of the following series are increased by 200,000 Yuan. Also, we divided the coordinate axis into four zones according to the median values of the average workforce costs and cost benefit ratios per yuan in the dataset. From the figure, we found that companies with generally lower total revenue per person (below 500,000 Yuan) mostly remain in the "Startup Zone" (figure 2). As discussed in the methodology section, the companies in this zone have low average workforce cost and low cost benefit ratio per yuan, seeking breakthrough points. It was also observed that when the companies' total revenue per person gradually increased, they tended to enter into the "Rigid Zone," in which companies have much lower ROI than that of their early stages as they have a low cost benefit ratio per yuan but much higher average workforce cost. The data were first divided into six series according to their total revenue levels per person as it would be more statistically meaningful.

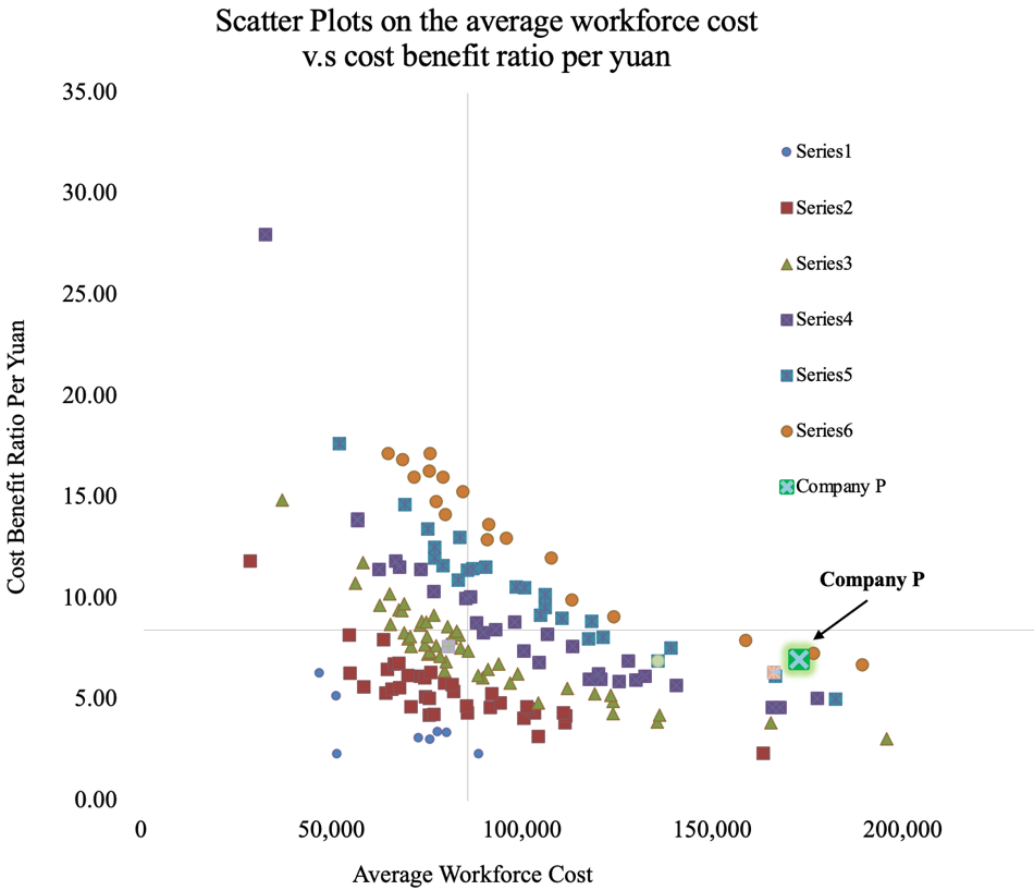

Figure 2. Scatter Plots of the Electronics Companies for 2016

We emphasized the position of Company P in the dataset by specializing in the color and shape of this data entry (figure 2) as a bright green square. It was noticed that Company P now stayed at the "Rigid Zone" as they had a very high average workforce cost but a low cost benefit ratio per yuan. Around 10 percent of the companies in the dataset were at the same levels as Company P.

For the regression analysis, the method of inverse polynomial regression was chosen to perform the analysis. The inverse proportional correlation was finally found from all six series of the data with R-squared values 0.4474, 0.8094, 0.9017, 0.9759, 0.9612, and 0.9213 ($p < 0.05$) from series 1 to series 6 (figure 3). It was observed that all of the series tended to have a high coefficient of determination. We also noticed that companies with relatively higher total revenue levels per person tended to have larger R-squared values, indicating a closer correlation. Finally, we define the regression curve as the "Equal Workforce Efficiency Curve." If the companies are on the same curve, they have the same workforce efficiency as they have the same product of average workforce cost and cost benefit ratio per yuan. The regression equations and R-squared values are attached beside each of the series.

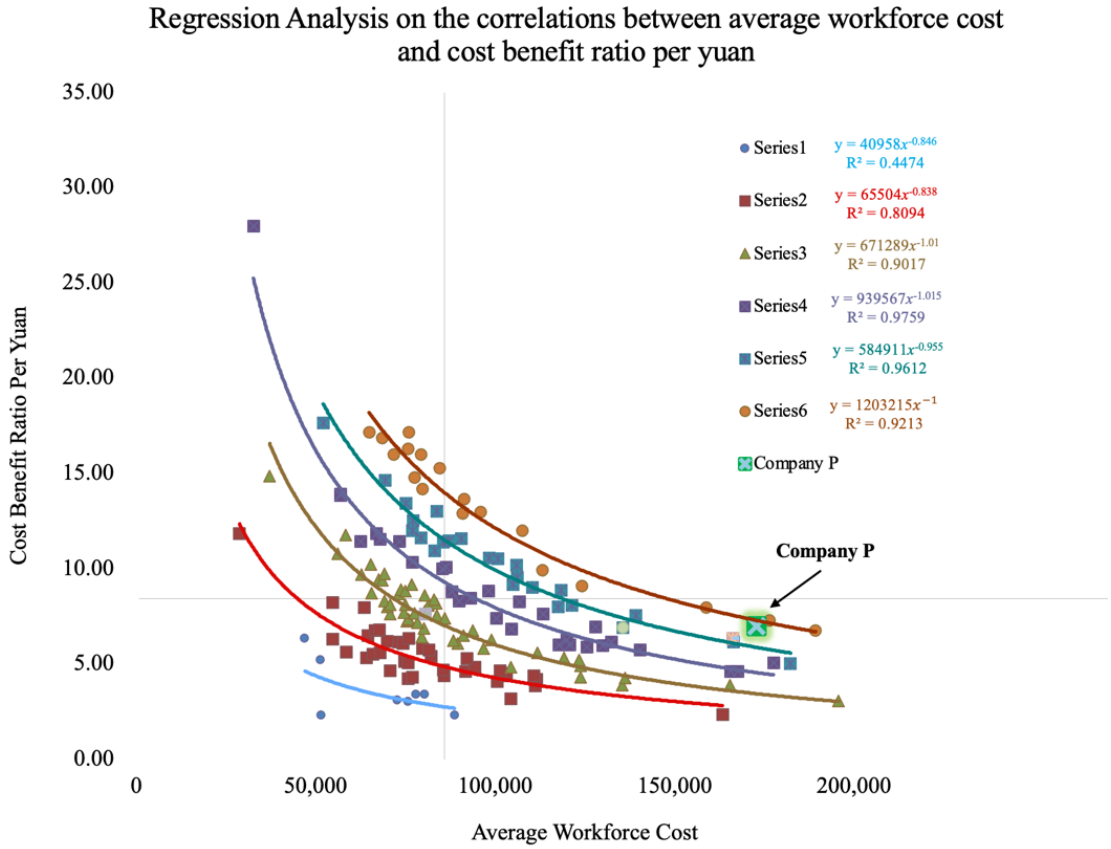

Figure 3. Regression analysis of the Electronics Companies for 2016

4. Discussions

4.1 Economic Significance of the Division of Four Zones

The division of the four zones was based on the average workforce cost and cost benefit ratio, two important microeconomic indicators for private sectors. When analyzing the average workforce cost, we should also consider the marginal workforce cost (MWC), that is, the marginal cost (MC) in economics. MWC is calculated by dividing the change in total workforce costs by the change in head counts. The formula is as follows:

$$Marginal\ Workforce\ Cost = \frac{\Delta\ Total\ Workforce\ Costs}{\Delta\ Head\ Counts}$$

We will have a marginal cost curve and a constant marginal revenue in a free market economy. The critical point for the companies is to determine the optimal production level. Regarding the human resource inputs, optimal production will be activated when the marginal workforce costs equal the marginal revenue (figure 4). The optimal production level is achieved when the marginal workforce cost equals the marginal revenue. The orange dashed arrows indicate the recommended adjustments on marginal workforce costs by companies.

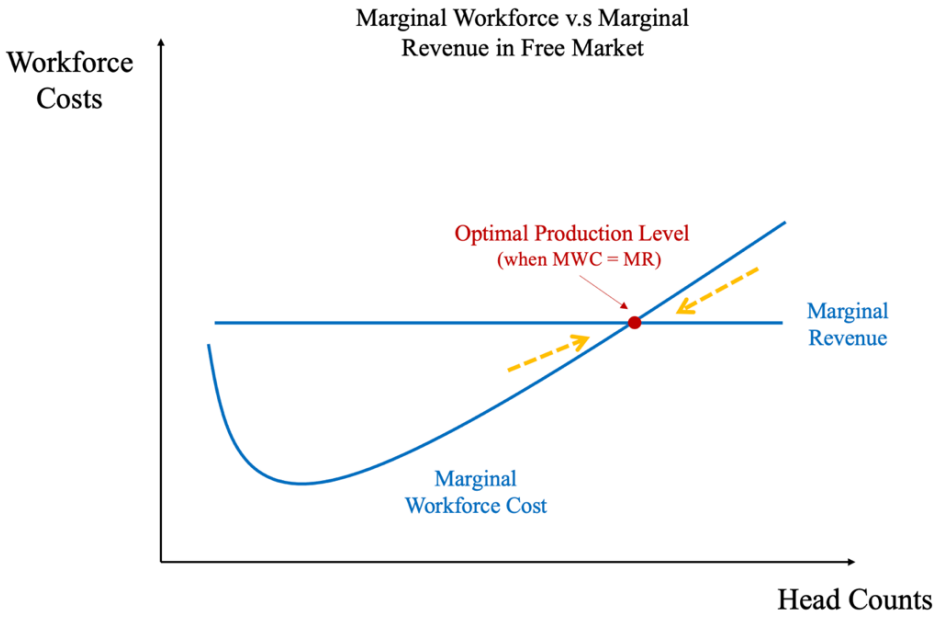

Figure 4. Marginal Workforce Cost Curve in a Free Market

Considering the division of four zones, we propose that the optimal production level should be achieved when the companies are in the "Economies of Scale Zone," which is the top right zone in the coordinate. In the "EoS Zone," the companies have high cost benefit ratios per yuan and high average workforce costs. The companies are experiencing economies of scale at this stage, indicating high ROI and human efficiency. Before the optimal production point, the companies are in the "Startup Zone" and "Growth Zone," in which companies have low average costs and low to medium cost benefit ratios per yuan. Moreover, companies' marginal cost is closing to the marginal revenue at these two stages. Companies must expand their productions and development approaches by increasing the number of employees. Finally, when the companies' marginal workforce cost exceeds the marginal revenue, it enters into a new inefficient production zone, namely the "Rigid Zone," in which average workforce costs are very high but low cost-benefit ratios. Company P is then in this zone. Workforce planning measures are required for companies at this stage to boost the ROI and reduce the dispensable costs to return to the optimal production point.

4.2 Trajectory of Companies' Development Based on the Four Zones Coordinate

After interviewing and analyzing the temporal data on electronics companies, we have also observed a similar trajectory in companies' development based on the four zones' coordinate axis (figure 5). Companies start their life cycle from the "Startup Zone." After they have found the correct approach to development, they will soon enter into the "Growth Zone". The average workforce costs are low for both zones as they have a limited number of employees and talents. Instead, they are putting more emphasis on finding the correct path to success. Although it looks like every company should stay at the comfortable "Growth Zone" due to low average workforce cost but high cost benefit ratio there, companies will only stay at this stage for a short period once they have found their "sweet spots"—they will continue to enlarge their workforce because they need innovation and expansion, or they will become inferior in competition.

If the companies can successfully pass to the "EoS Zone," they are close to or already at the optimal production point. As we have mentioned, they have high workforce costs and cost benefits ratios. Companies still set expansion as the primary target due to the competitive market. Soon, without flexible workforce planning tools, most companies will enter the final "Rigid Zone". The constantly decreasing ROI and increasing workforce costs will put the companies in a dilemma where rigid company' rules and structures become barriers to companies' further growth. The red dashed arrow line indicates the direction of companies' movement across the four zones' coordinate axis.

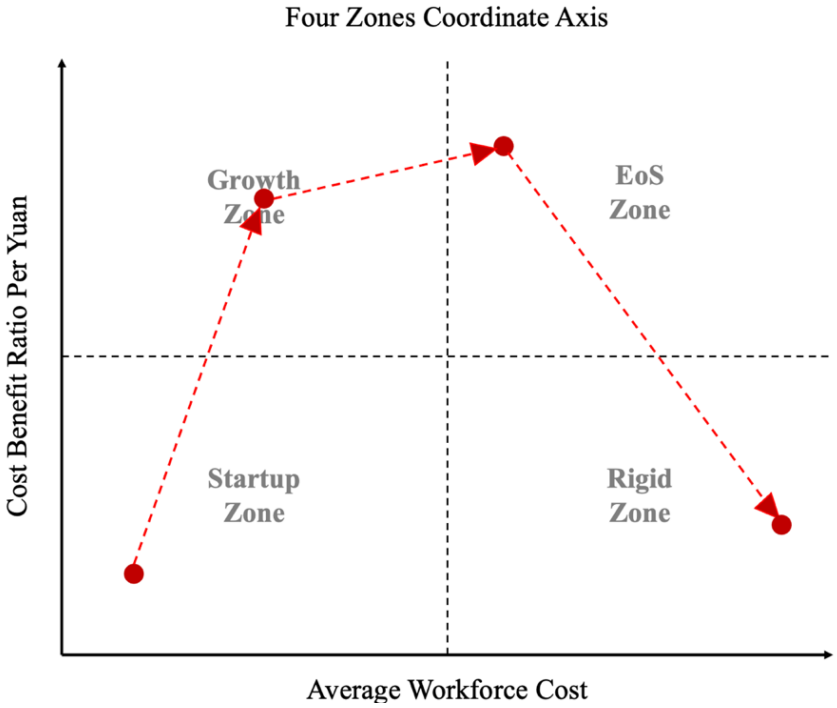

Figure 5. The trajectory of Companies' Development

4.3 What is Next for Companies Like P: The Quantitative Workforce Planning

We named the final zone "Rigid Zone" because the room for companies' workforce efficiency improvement is rigid, and flexible adjustments are urgently needed for companies in this zone. Our recommended approach for Company P is quantitative workforce planning by adjusting the number of people in different departments using the Key Performance Indicator (KPI) score and workforce costs data. We propose that the average KPI scores for all departments, KPI score for one department, average workforce costs for all departments, and average workforce costs for one department should be used to build a ratio equation. The formula is as follows:

$$The\ Workforce\ Efficiency\ of\ One\ Department = \frac{\frac{P_{One\ Department}}{P_{Average}}}{\frac{C_{One\ Department}}{C_{Average}}}$$

Where P indicates the KPI, and C represents the workforce costs. The ratio equation can quickly determine the percentage of one department's KPI in the whole company. This percentage is an essential reference for the HRD or management levels to understand whether this department's current workforce cost planning is appropriate or needs accommodations. For example, suppose the ratio between the KPI score for department A and the KPI scores for all departments is higher than 1. In that case, it indicates that department A outperforms other departments, and department A's request for additional funding for recruiting new staff is acceptable and prior. For departments with a ratio below 1, funding should be postponed, and they should attempt to improve workforce efficiency first.

Quantitative workforce planning is only a tool for companies like P to tackle known problems. A more meaningful action for them is to recognize the potential workforce planning problems in advance so they can take timely actions to avoid potential profit loss or ROI decrease. In the final section of our discussion, we summarize the insights and formulate a "CPUQA" strategic framework for companies in the "Rigid Zone" to make agile and flexible workforce adjustments (figure 6). Companies should first collect and clean the workforce and revenue data. After plotting the "Equal Workforce Efficiency Curve" in the four-zone coordinate, companies can understand their position clearly. Finally, with the quantitative planning tool, they can adjust the workforce costs and staff ratio

based on factual evidence, expecting on gradual recovery of ROI. The framework includes collecting data, plotting the data, understanding the position, quantitative planning, and finally, adjusting the workforce based on evidence.

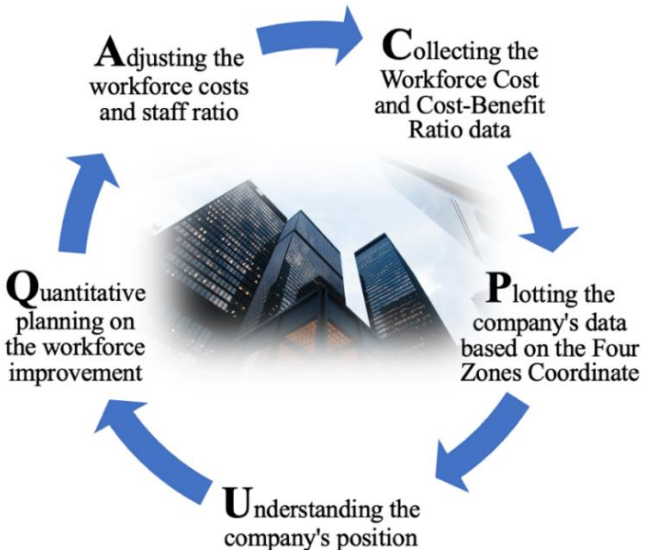

Figure 6. "CPUQA" Strategic Quantitative Workforce Framework

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