論　文

# Comparison of Consumer Needs for Autonomous Driving in Five Major Markets of China

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## Ⅰ. Introduction

Autonomous driving is an essential component for the next-generation society. Society of Automotive Engineers International (SAE) defines autonomous driving levels from 0 (non-automated drive) to 5 (Full Automation). Currently, level 3 vehicles (Conditional Automation) are in mass production. The research and development of autonomous driving is becoming increasingly competitive. Aggressive empirical research of Level 4 (High Automation) vehicles is being conducted in China, the United States, and European countries. Thus, understanding consumers' needs for autonomous driving is important for the automobile industry.

Our previous study investigated the differences between Japan, the United States and Germany regarding the consciousness and acceptance of autonomous driving [1]. This study focuses on the Chinese market, which is the largest automobile market in the world [2]. Grasping the Chinese consumer consciousness or needs is important for automobile vehicle makers and suppliers to ensure adequate products and services. Also, we hypothesize that drivers or passengers' needs are different in each region because of the difference in their geography, population, culture, and consumption capacities.

This study conducted a survey among Chinese consumers in five key markets within China, namely Beijing, Shanghai, Zhejiang, Jiangsu, and Guangdong, with the aim of elucidating their respective needs. Subsequently, the obtained results were discussed.

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1) K.Fukuzawa and T. Ikeyama: International comparison of consciousness for autonomous driving: Japan, the United States and Germany. IEEE Xplore, (2021).

2) OCIA"2019 Statistics | www.oica.net." https://www.oica.net/category/production-statistics/2019-statistics/ (accessed May 21, 2021).

## Ⅱ. Literature Review

International comparisons and domestic studies on China, focusing on the behavioral characteristics of drivers while driving[3] or their awareness toward driving[4][5], have been conducted.

Atchley et al.[6] investigated the characteristics of driving behavior in Japan, China, and the United States, and found differences according to historical background and traffic culture. They also found that Chinese drivers' behaviors are relatively aggressive.

Edelmann et al. [7] compares decision-making in automated driving in China, Germany, Japan, and the United States, and show that driving behavior is greatly influenced by cultural background.

Li et al. [8] examined the psychometric properties of the Driving Anger Scale (DAS) and its relationship with aggressive driving in the Chinese context. Drivers who reported a higher level of anger tended to be younger, from a congested city, had lower weekly mileage, and were more experienced.

This study attempts to conduct a geographical comparison of consumer

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3) Pengfei Li, Jianjun Shi, Xiaoming Liu, Haizhong Wang, "The Theory of Planned Behavior and Competitive Driving in China", Procedia Engineering, Volume 137, 2016, Pages 362-371, https://doi.org/10.1016/j.proeng.2016.01.270.

4) Yueng-Hsiang Huang, Wei Zhang, Matthias Roetting, David Melton, Experiences from dual-country drivers: Driving safely in China and the US, Safety Science, Volume 44, Issue 9, 2006, Pages 785-795, https://doi.org/10.1016/j.ssci.2006.05.002.

5) K. Yoko, N. Hideki, S. Kazufumi, and K. Yuji, "International Comparative Analysis on Car Drivers' Awareness toward Traffic Safety," IATSS Review, vol. 45, no. 1, pp. 58–66, Jun. 2020, doi: 10.24572/iatssreview.45.1_58.

6) P. Atchley, J. Shi, and T. Yamamoto, "Cultural foundations of safety culture: A comparison of traffic safety culture in China, Japan and the United States," Transportation Research Part F: Traffic Psychology and Behaviour, vol. 26, no. PB, pp. 317–325, Sep. 2014, doi: 10.1016/j.trf.2014.01.004.

7) Aaron Edelmann, Stefan Stümper, Tibor Petzoldt, "Cross-cultural differences in the acceptance of decisions of automated vehicles", Applied Ergonomics, Volume 92, 2021, 103346, https://doi.org/10.1016/j.apergo.2020.103346.

8) Feng Li, Xiang Yao, Li Jiang, YongJuan Li, "Driving anger in China: Psychometric properties of the Driving Anger Scale (DAS) and its relationship with aggressive driving,Personality and Individual Differences",Volume 68,2014, 130-135, https://doi.org/10.1016/j.paid.2014.04.018.

needs related to automated driving. No survey has been conducted on consumer needs that focus on the Chinese market, which is one of the large markets and has been experiencing rapid economic growth in recent years.

## Ⅲ. Research Design

### 3.1. Geographical research

**Table 1** shows the geographical characteristics of each market including the population and the number of cars per 100 households in each place, which are five large markets with the highest Gross Domestic Products in China [9] . Beijing and Shanghai are designated as "direct-controlled cities" that seemingly have the same economic scale as a province. Although some regions have a larger market and a higher average income, they were not selected because of the difficulty in sampling in those regions.

**Table 1. Geographical characteristics of five markets**

| | Beijing | Shanghai | Guangdong | Jiangsu | Zhejiang |
|---|---|---|---|---|---|
| Population in 2020 (Million People) | 21.89 | 24.88 | 126.24 | 84.77 | 64.68 |
| Number of cars per 100 households in China in 2017 (Million People) * only civilian vehicles | 60 | 24 | 41 | 44 | 49 |

Source: Statistica[10]

### 3.2. Respondents and questions

This study was conducted among the residents of five large market regions in China: Beijing, Shanghai, Guangdong, Jiangsu, and Zhejiang. Respondents were approached through GMO Research, an online survey service, and were asked to complete a questionnaire. All participants agreed to the data privacy

9) National Bureau of Statistics of China, Gross Regional Product (2018) ,http://www.stats.gov.cn/tjsj/ndsj/2019/indexeh.htm (accessed 2022-07-05)
10) Population in China in 2020, by province or region, https://www.statista.com/statistics/279013/population-in-china-by-region/

terms. The questions were related to their current driving conditions, such as frequency, driving distance per month, and the awareness of and need for autonomous driving. The study was conducted from September 19 to October 13, 2017. **Table 2** is the overview of the questionnaire survey.

**Table 2. Questions**

| Question Contents |
|---|
| **Profile attributes** |
| Driving frequency(weekly) |
| Driving distance(month) |
| The price of self-owned vehicles |
| Desired activities to do during fully automated driving<br>— Meal<br>— Sleeping(Nap)<br>— Work<br>— Entertainment(Movie, Game, Book)<br>— Chat / Conversation /w passengers |

**Table 3. Target respondents**

| Age | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | Total |
|---|---|---|---|---|---|---|
| **20–29** | **100** | **100** | **100** | **100** | **100** | **500** |
| 1:Male | 50 | 50 | 50 | 50 | 50 | 250 |
| 2:Female | 50 | 50 | 50 | 50 | 50 | 250 |
| **30–39** | **100** | **100** | **100** | **100** | **100** | **500** |
| 1:Male | 50 | 50 | 50 | 50 | 50 | 250 |
| 2:Female | 50 | 50 | 50 | 50 | 50 | 250 |
| **40–49** | **100** | **100** | **100** | **100** | **100** | **500** |
| 1:Male | 50 | 50 | 50 | 50 | 50 | 250 |
| 2:Female | 50 | 50 | 50 | 50 | 50 | 250 |
| **50–59** | **100** | **100** | **100** | **100** | **100** | **500** |
| 1:Male | 50 | 50 | 50 | 50 | 50 | 250 |
| 2:Female | 50 | 50 | 50 | 50 | 50 | 250 |
| **60 >=** | **100** | **100** | **100** | **100** | **100** | **500** |
| 1:Male | 50 | 50 | 50 | 50 | 50 | 250 |
| 2:Female | 50 | 50 | 50 | 50 | 50 | 250 |
| **Total** | **500** | **500** | **500** | **500** | **500** | **2500** |

**Table 3** shows the target respondents of the survey. A total of 1250 male and 1250 female, aged 20–60+ years who had held a driver's license for at least one year were surveyed. The gender and age of the participants were evenly distributed among the five regions.

### 3.3. Methodology

Cross-tabulation analysis was conducted among the regions to grasp their characteristics and differences. Statistical verification was made using the chi-square test (significance level, 0.05) . Further, correspondence analysis[11] was used to investigate the differences in awareness in each region. Python (Version 3.7.8) and Jupyter Notebook (Version 5.6.0) were used for the analysis.

## Ⅳ. Result

The "driving frequency (weekly) " results are shown in **Table 4** and **Figure 1**. The frequency "6–7 days" has a significant difference. The results can be largely separated into two groups: Beijing, Shanghai, and Guangdong with relatively low driving frequency, and Jiangsu and Zhejiang with relatively high driving frequency.

Table 4. Driving frequency (weekly)

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **<= 1 day** | 47 | 42 | 53 | 58 | 49 | 0.567 |
| **2 - 3 days** | 115 | 93 | 101 | 97 | 74 | 0.057 |
| **4 - 5 days** | 180 | 191 | 165 | 139 | 166 | 0.059 |
| **6 - 7 days** | 158 | 174 | 181 | 206 | 211 | 0.031 * |

p<0.05*, p<0.01**

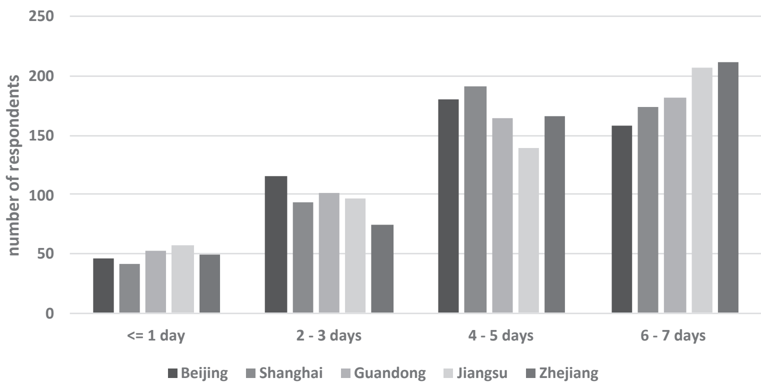


Figure 1. Frequency of driving (weekly)

11) J. Benzécri, "L'analyse des données," 1973, May 21, 2021. http://www.statelem.com/analyse_des_donnees.php (accessed 2022-07-05))

The results of "driving distance (monthly) are shown in **Table 5** and **Figure 2**. "Lower than 100 km" has a significant difference. The results can be divided into two groups: Beijing, Shanghai, and Guangdong with relatively short driving distances, and Jiangsu and Zhejiang with relatively long driving distances. Another result of significance is confirmed in "from 1000 km to 3000 km." This result can also be divided into two groups: Beijing, Shanghai, and Guangdong with relatively high long distance driving, and Jiangsu and Zhejiang with relatively low long distance driving.

Based on these results, Beijing, Shanghai, and Guangdong are considered "long-distance" regions, and Jiangsu and Zhejiang are considered "short distance" regions.

Table 5. Driving distance (monthly)

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **100km <** | 49 | 47 | 47 | 71 | 72 | 0.018 * |
| **100-500km** | 143 | 162 | 132 | 159 | 136 | 0.289 |
| **500-1000km** | 196 | 183 | 216 | 191 | 225 | 0.189 |
| **1000-3000km** | 94 | 87 | 89 | 67 | 58 | 0.015 * |
| **3000km >** | 18 | 21 | 16 | 12 | 9 | 0.201 |

p<0.05*, p<0.01**

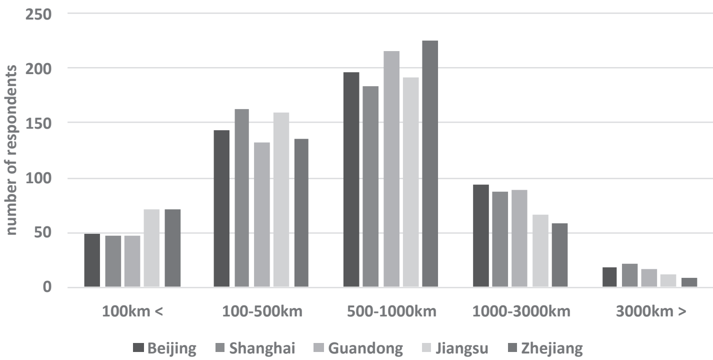


Figure 2. Driving distance (monthly)

The results of the 'The price of self-owned vehicles' is shown in **Table 6** and **Figure 3**. The main price ranges from 24 000 to 38 000 USD, followed by 38 000 to 52 000 USD. However, there is no significant difference in these ranges.

Table 6. The price of self-owned vehicles

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **9.5K USD <** | 5 | 1 | 1 | 7 | 7 | 0.067 |
| **9.5K-24K USD** | 83 | 83 | 108 | 144 | 105 | 0.000 ** |
| **24-38K USD** | 218 | 189 | 202 | 202 | 224 | 0.436 |
| **38K-52K USD** | 127 | 145 | 116 | 117 | 119 | 0.321 |
| **52K-65K USD** | 46 | 61 | 60 | 25 | 30 | 0.000 ** |
| **65K USD >** | 18 | 18 | 9 | 2 | 8 | 0.002 ** |
| **Do not know** | 3 | 3 | 4 | 3 | 7 | 0.558 |

p<0.05*, p<0.01**

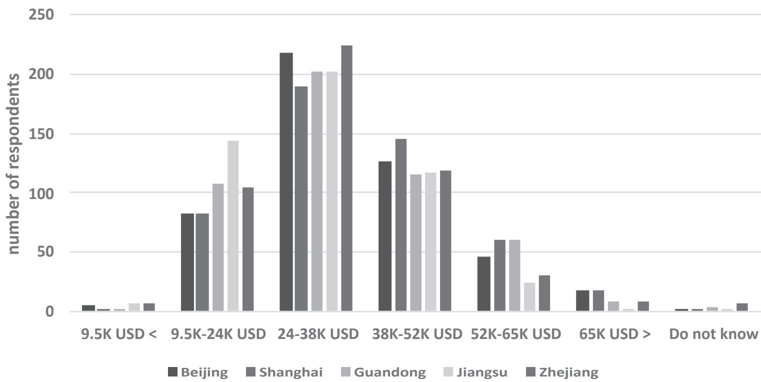


Figure 3. Price of self-owned vehicles

Three-dimensional cross-tabulation analysis was conducted by region, attributes (driving frequency, driving distance, price of self-owned vehicles) , and things to do while fully automated driving, to investigate the differences between consumer needs in each region and each category. Only significant results are shown.

**Table 7** shows the cross-tabulation results of the respondents who selected "work" while fully automated driving, and the attribute is "driving frequency (weekly) ." **Figure 4** shows their correspondence analysis. Similar results were found in Beijing / Shanghai and Jiangsu / Zhejiang. Respondents in Jiangsu and Zhejiang selected "6–7 days" relatively a greater number of times (Jiangsu: 113, Zhejiang: 130).

Table 7. Cross-tabulation result of who selected "work" while fully automated driving, and the attribute is "driving frequency (weekly)"

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **<= 1 day** | 13 | 10 | 32 | 16 | 17 | 0.002 ** |
| **2 - 3 days** | 39 | 36 | 44 | 31 | 31 | 0.494 |
| **4 - 5 days** | 85 | 90 | 87 | 70 | 73 | 0.416 |
| **6 - 7 days** | 82 | 100 | 105 | 113 | 130 | 0.020 * |

p<0.05*, p<0.01**

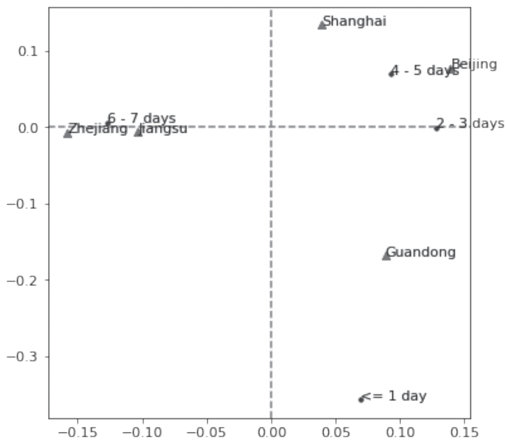


Figure 4. Correspondence analysis of who selected "work" while fully automated driving and the attribute is "driving frequency (weekly)"

**Table 8** shows the cross-tabulation results of those who selected "work" while fully automated driving, and the attribute is "driving distance (monthly)." **Figure 5** shows the corresponding analysis. Significant results were found in middle range distance (500–100 km, 1000–3000 km). Respondents in Zhejiang who drive "500–1000 km" per month especially prefer to work while automated driving.

**Table 8. Cross-tabulation result of who selected "work" while fully automated driving, and the attribute is "driving distance (monthly)"**

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **100km <** | 16 | 16 | 14 | 19 | 25 | 0.391 |
| **100-500km** | 56 | 71 | 61 | 72 | 54 | 0.350 |
| **500-1000km** | 96 | 96 | 134 | 107 | 143 | 0.002 ** |
| **1000-3000km** | 39 | 45 | 50 | 29 | 26 | 0.026 * |
| **3000km >** | 12 | 8 | 9 | 3 | 3 | 0.065 |

p<0.05*, p<0.01**

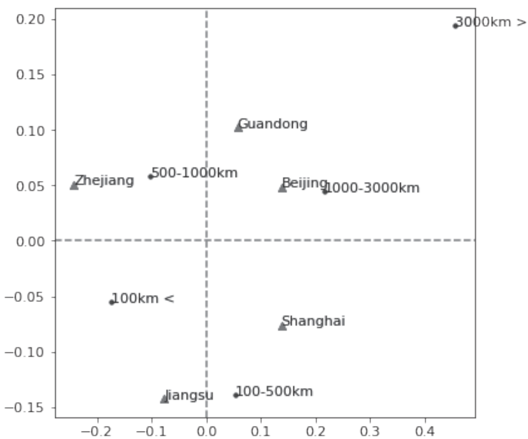


**Figure 5. Cross-tabulation result of who selected "work" while fully automated driving, and the attribute is "Driving distance (monthly)"**

**Table 9** shows the cross-tabulation results of those respondents who selected "work" while fully automated driving, and the attribute is "the price of self-owned vehicles." **Figure 6** shows the corresponding analysis. Respondents in Beijing, Shanghai, and Guangdong, with a higher range (38–52K USD and 52–65K USD), preferred to "work" while automated driving.

Table 9. Cross-tabulation result of who selected "Work" while fully automated driving, and the attribute is "The price of self-owned vehicles"

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **9.5K USD <** | 2 | 0 | 0 | 3 | 3 | 0.219 |
| **9.5K-24K USD** | 24 | 24 | 49 | 45 | 35 | 0.004 ** |
| **24-38K USD** | 94 | 95 | 105 | 99 | 135 | 0.027 * |
| **38K-52K USD** | 60 | 78 | 77 | 69 | 57 | 0.251 |
| **52K-65K USD** | 28 | 28 | 31 | 13 | 15 | 0.017 * |
| **65K USD >** | 11 | 10 | 5 | 1 | 6 | 0.043 * |

p<0.05*, p<0.01**

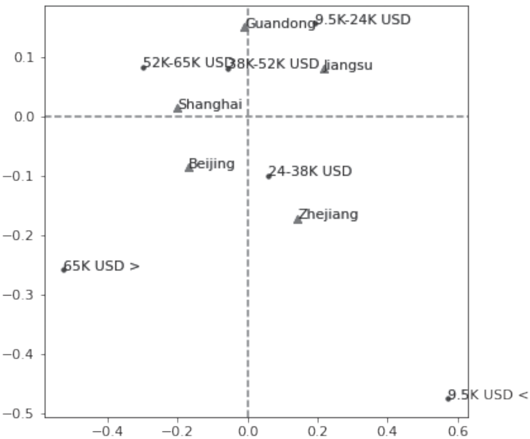


Figure 6. Cross-tabulation result of who selected "Work" while fully automated driving and the attribute is "The price of self-owned vehicles"

**Table 10** shows the cross-tabulation results of those respondents who selected “Meal” while fully automated driving, and **Figure 7** shows the corresponding analysis. Respondents in Zhejiang have a significant difference in middle distance (500-1,000 km). They would prefer to have a “Meal” while automated driving.

Table 10. Cross-tabulation result of who selected “Meal” while fully automated driving, and the attribute is “Driving distance (monthly)”

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **100km <** | 17 | 14 | 15 | 22 | 13 | 0.535 |
| **100-500km** | 65 | 42 | 41 | 53 | 40 | 0.048 * |
| **500-1000km** | 62 | 68 | 79 | 95 | 124 | 0.000 ** |
| **1000-3000km** | 42 | 34 | 34 | 25 | 23 | 0.111 |
| **3000km >** | 8 | 9 | 6 | 3 | 3 | 0.257 |

p<0.05*, p<0.01**

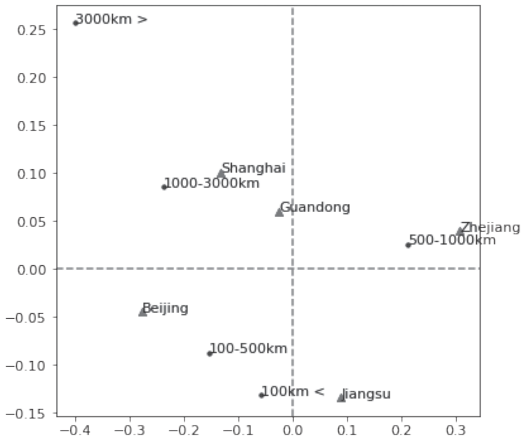


Figure 7. Cross-tabulation result of who selected “meal” while fully automated driving, and the attribute is “Driving distance (monthly)”

**Table 11** shows the cross-tabulation results of those respondents who selected "nap" while fully automated driving, and the attribute is "the price of self-owned vehicles." **Figure 8** shows the corresponding analysis. Respondents in Shanghai who own relatively higher priced vehicles preferred to "nap" compared to other regions. Respondents in Beijing also exhibited this tendency to some degree.

Table 11. Cross-tabulation result of respondents who selected "nap" while fully automated driving, and the attribute is "The price of self-owned vehicles"

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **9.5K USD <** | 2 | 1 | 1 | 2 | 3 | 0.817 |
| **9.5K-24K USD** | 40 | 40 | 59 | 68 | 50 | 0.021 * |
| **24-38K USD** | 102 | 81 | 90 | 77 | 87 | 0.377 |
| **38K-52K USD** | 52 | 66 | 44 | 45 | 55 | 0.195 |
| **52K-65K USD** | 13 | 28 | 10 | 9 | 14 | 0.003 ** |
| **65K USD >** | 7 | 12 | 6 | 2 | 3 | 0.035 * |

p<0.05*, p<0.01**

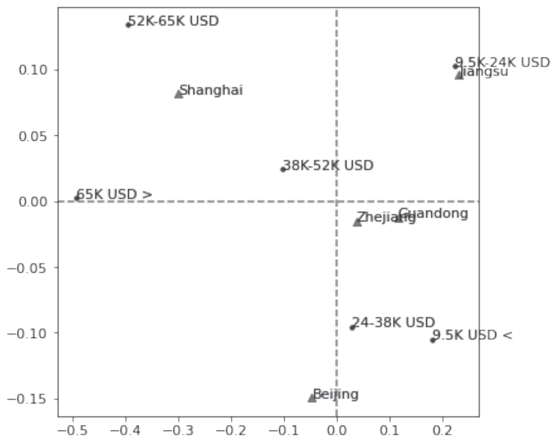


Figure 8. Cross-tabulation result of who selected "nap" while fully automated driving, and the attribute is "The price of self-owned vehicles"

**Table 12** shows the cross-tabulation results of those respondents who selected “entertainment” while fully automated driving, and the attribute is “the price of self-owned vehicles.” **Figure 9** shows the corresponding analysis. Respondents in Shanghai and Guangdong in higher range of the self-owned-vehicle price (52–65K USD) ” prefer “entertainment” compared to other regions.

Table 12. Cross-tabulation result of who selected “Entertainment” while fully automated driving, and the attribute is “the price of self-owned vehicles”

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **9.5K USD <** | 0 | 0 | 1 | 4 | 2 | – |
| **9.5K-24K USD** | 58 | 46 | 57 | 73 | 52 | 0.134 |
| **24-38K USD** | 124 | 107 | 122 | 117 | 147 | 0.134 |
| **38K-52K USD** | 78 | 102 | 68 | 80 | 74 | 0.081 |
| **52K-65K USD** | 27 | 44 | 46 | 13 | 22 | 0.000 ** |
| **65K USD >** | 13 | 13 | 9 | 1 | 5 | 0.010 * |

p<0.05*, p<0.01**

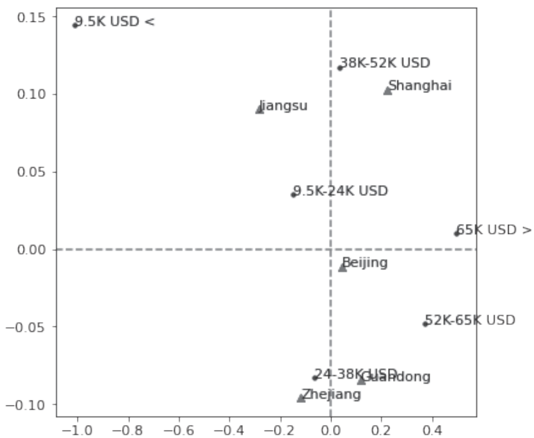


Figure 9. Cross-tabulation result of who selected “entertainment” while fully automated driving, and the attribute is “the price of self-owned vehicles”

**Table 13** shows the cross-tabulation results of those respondents who selected "chat or conversation with passengers" while fully automated driving and the attribute is "the price of self-owned vehicles" and **Figure 10** shows the corresponding analysis. Respondents in Beijing and Shanghai, with a higher range of self-owned-vehicle price (52–65K USD and more than 65K USD) prefer "chat or conversation with passengers".

**Table 13. Cross-tabulation result of who selected "chat or conversation with passengers" while fully automated driving, and the attribute is "the price of self-owned vehicles"**

| | Beijing | Shanghai | Guandong | Jiangsu | Zhejiang | p-value |
|---|---|---|---|---|---|---|
| **9.5K USD <** | 2 | 0 | 0 | 4 | 1 | 0.092 |
| **9.5K-24K USD** | 44 | 39 | 60 | 83 | 49 | 0.000 ** |
| **24-38K USD** | 57 | 73 | 74 | 102 | 88 | 0.005 ** |
| **38K-52K USD** | 56 | 61 | 40 | 51 | 55 | 0.315 |
| **52K-65K USD** | 25 | 35 | 18 | 19 | 16 | 0.033 * |
| **65K USD >** | 13 | 12 | 6 | 1 | 7 | 0.016 * |

p<0.05*, p<0.01**

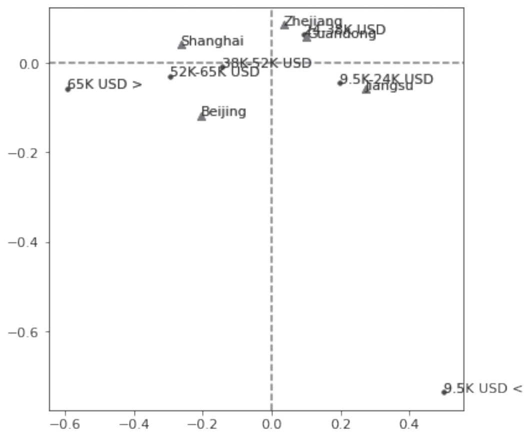


**Figure 10. shows the cross-tabulation results of those respondents who selected "chat or conversation with passengers" while fully automated driving, and the attribute is "the price of self-owned vehicles."**

## Ⅴ. Discussion

**5.1. General tendency**

Based on the overall results, the general tendency in the five regions was estimated. Several of the respondents in China drive on a daily basis (4–5, 6–7 days a week) . A monthly driving distance of 500–1000 km is the most common, followed by 100–500 km. The price of most self-owned vehicles was around 24–38K USD, followed by 38–52K USD. Based on these results, the characteristics of each region was analyzed.

**5.2. Regional characteristics**

It was found that the regions can be divided into two groups: Beijing, Shanghai, Guangdong into "working-oriented region" and Jiangsu, Zhejiang into "work-life-balanced region."

The results in 4.1 show that the driving frequency in Beijing, Shanghai, and Guangdong is 4-5 days, which tends to be less frequent than in the two regions of Jiangsu and Zhejiang. On the other hand, the monthly driving distance of the former is longer than that of the latter, indicating that road traffic conditions vary by region. In other words, it can be inferred that the former traveled from the suburbs to urban areas (to go to work) more frequently than the latter. The latter tend to drive shorter distances and more frequently (6-7 days a week) than the former, suggesting that they use cars on holidays as well.

From the results of 4.2, the former three regions have a relatively high need to work while driving an automatic car. On the other hand, the latter two regions have relatively high needs for eating while driving.

## Ⅵ. Conclusion

This study investigates whether there are differences in the needs for automated driving in five regions of China - in Beijing, Shanghai, Zhejiang, Jiangsu, and Guangdong. The study found that the region can be divided into two groups roughly: Beijing, Shanghai, and Guangdong into “working-oriented region” and Jiangsu and Zhejiang into “work-life-balanced region.”

The results of the simple tabulation show that there are differences in driving frequency, mileage, and vehicle purchase price between the former three regions and the latter two. In addition, since the survey in this study was conducted in 2017, consumer needs may have changed in recent years. However, we do not believe that the broad characteristics of Chinese consumers and the differences in regional characteristics in China have changed significantly.

### Acknowledgments

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ワーキングペーパー

# The Gemba Kaizen Costing (GKC) Framework
# －Introduction to the Opportunity Loss Concept－

Shino Hiiragi
Yasuyuki Kazusa

Traditionally, the Kaizen effect has been recognized first as a cost reduction through cost accounting and then as an increase in operating profit on an income statement. Unfortunately, it is difficult to recognize and measure all Kaizen effects as cost reductions or increases in operating profit. To solve this problem, a "change of mindset" is necessary. In this study, we have discarded the majority view that "Gemba Kaizen reduces costs," and focused on the free capacity created by Gemba Kaizen. The effect of Gemba Kaizen is first considered to be the "creation of free capacity," following this, the Kaizen effect is calculated as an increase in sales, cost reduction, and opportunity loss as a result of the strategic use of this free capacity.

## Ⅰ The Concept of Gemba Kaizen Costing

### 1. Muda as waste and its cost

Eliminating Muda in manufacturing is a key concept of GKC. Muda is the subject of Gemba Kaizen, but neither the term nor its definition is clear, which can be inferred from the fact that the word is expressed in Japanese kanji (Chinese characters), katakana, and hiragana. After considering its many definitions, one of the authors defined Muda as that which "refers to all actions in corporate activities that do not produce customer value and all resources reserved and consumed for them" (Hiiragi [2021], p. 66). Similarly, based on the viewpoint of Mr. Taichi Ohno of Toyota Motor Corporation (Ohno [1978]), this book[1)] defines Muda as an action that does not create customer value in corporate activities.

Gemba Kaizen is the elimination of Muda, which occurs when manufacturing firms do not convert all input management resources in a production system into good products. In corporate activities, management resources are consumed along with each action. Although Muda is an action that does not create customer value, it still consumes management resources. The cost of Muda can be calculated by measuring these wasted management resources in monetary terms. Cost accounting generally prioritizes calculating the cost of products produced by actions that add customer value, but it is not used to calculate Muda (waste) costs. In this book, which advocates Gemba Kaizen Costing (GKC), a new accounting theory that contributes to Gemba Kaizen, the cost of Muda is considered an important cost concept (Chapter 5 will detail).

## 2. Production system and Muda

While respecting the Muda concept presented by Mr. Ohno, which classifies workers' movements into three categories (waste, non-value-added work, and real work), we would like to develop the GKC based on the definition that Muda does not create customer value in corporate activities. Muda is the original "waste" from a worker's movement, and "non-value-added work" is also conditional waste (i.e., work that is originally considered waste, but must be done under the current conditions). It is only "real work" that contributes to the production of a product.

Management resources such as raw materials, labor, machinery and equipment, energy, and information, are usually input into a production system. When converting these management resources into products, good products (finished products) are produced. **Figure 4-1** shows a conceptual diagram of the production system in this book.

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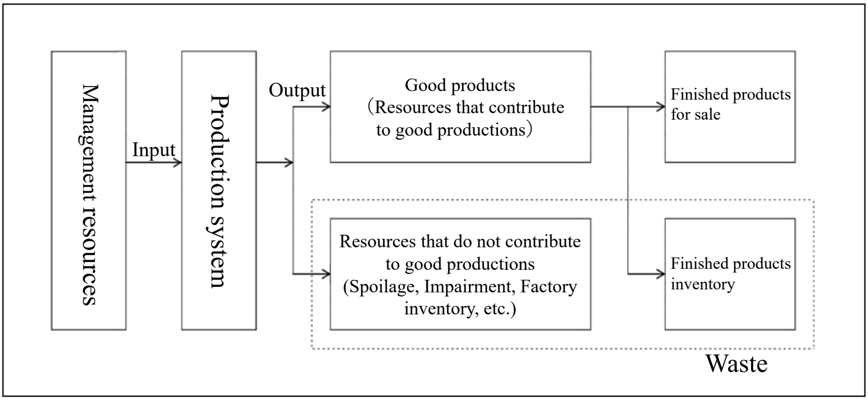
1) 本稿は，刊行予定の上總康行・柊紫乃「現場改善会計論：改善効果の見える化（仮題）」の第4章の英訳版である。書籍は第1章から第6章で構成され，そのうち第4章では従来の製品原価計算とは異なる新たな改善のための計算構造が提唱される。海外の会計研究者との議論のため，日本語版刊行前に当該章の英訳をワーキング・ペーパーとして公表する。
This paper is an English translation of Chapter 4 of "Gemba Kaizen Costing: Visualization of Kaizen Effect (tentative title)" by Kazusa Yasuyuki and Hiiragi Shino, which is scheduled for publication. The book consists of Chapters 1 through 6, of which Chapter 4 proposes a new costing structure for Kaizen that differs from conventional product costing. The English translation of this chapter is published as a working paper before the publication of the book for the purpose of discussion with overseas accounting researchers.

**Figure 4-1 Conceptual diagram of the production system**




Source: Author

According to **Figure 4-1**, the management resources that contribute to the production of good products are "value-added resources," while those that do not are "non-value-added resources." Non-value-added resources include product loss, impairment, waiting time, and "factory inventory," such as raw materials, parts, and works-in-process stored in each process, factory, and warehouse. Non-value-added resources and all management resources that do not become sales goods (the area enclosed by the dotted line) are Muda. The relationship between the management resources input into the production system, the output (good product), and the Muda that did not become a good product can be expressed using the following equation:

Management resources = Value-added resources + Non-value-added resources
= Sold products + Muda

According to the above equation, management resources are transformed through the production system into sold goods delivered to customers and Muda. Muda further includes unsold product inventories, factory inventories of raw materials, parts, and works-in-process, as well as the impairments and process losses that occur in the production process, the idle time of workers, and idle machinery and equipment. Unsold product inventories are considered Muda because they do not create customer value. There are different types of Muda, resulting from a variety of factors. For manufacturers, the elimination of Muda is an "eternal challenge" that Gemba Kaizen tries to address.

## Ⅱ Creating free capacity through Gemba Kaizen

Gemba Kaizen is constantly being practiced at the production site. It eliminates Muda, improves productivity and quality, shortens lead time, and realizes flexibility. Traditionally, these Gemba Kaizen effects have been recognized in cost accounting terms as "cost reductions," and as increases in operating income on the income statement. Unfortunately, it is difficult to recognize all Gemba Kaizen effects as cost reductions or increases in operating profit. While practitioners and researchers have been working for years to solve the problem of measuring the Gemba Kaizen effects, a "change in mindset" is the likely solution.

As a first step in solving the aforementioned problem, we decided to go back to the simple question of "Why does the Gemba Kaizen effect lower costs?" We concluded that Gemba Kaizen does not simply lower costs over time as there are cases where costs do not decrease due to Kaizen.

Different from the general theory that recognizes the Gemba Kaizen effect as a cost reduction or increase in operating profit, we introduce the concept of "free capacity." First, we see the effect of Gemba Kaizen as the "creation of free capacity." Next, based on the free capacity created, the cost reduction or opportunity loss, which is the Gemba Kaizen effect for accounting purposes, is calculated.

[Example 1] illustrates the creation of free capacity using simple production data before and after Kaizen as follows: