Key Factors Influencing EV Adaptation Readiness Among Traditional Auto Repair Shops in Taiwan

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Abstract

As the global automotive industry rapidly transitions toward electric vehicles (EVs), traditional auto repair shops face growing pressure to adapt their business models, technical skills, and operational strategies. This study investigates how shop-level characteristics and owner attributes influence psychological preparedness for EV-related transformation among traditional repair shops in Taiwan. Drawing on a mixed-methods approach, the study combines in-depth interviews with a structured questionnaire distributed to over 300 shop owners across different regions and scales of operation.

The dependent variable—psychological readiness for EV transformation—is measured using a four-point ordinal scale ranging from "no intention to change" to "actively engaging in training or investment." An ordered probit regression model is employed to analyze the relationship between readiness and key explanatory variables, including region, shop age, size, owner age, education level, and years of technical experience.

Findings suggest that older owners and smaller-scale shops tend to be more passive in their response to EV trends, while years of technical experience positively influence proactive behavior. Interestingly, the level of formal education shows no significant correlation with preparedness. These results highlight structural and generational barriers that may hinder industry-wide EV adaptation and underscore the importance of targeted support for small, aging shops in the transition process.

Keywords:
electric vehicles, traditional repair shops, psychological readiness, ordered probit model, Taiwan, technological adaptation, SME transformation

1. Introduction

Research Background

Global and Taiwan electric vehicle market development trends:

How traditional auto repair shops react and respond to the shift to electric vehicles

The automotive industry is undergoing significant change with the rise of electric vehicles (EVs), which is reshaping the landscape of traditional auto repair shops. This shift presents both opportunities and challenges for these companies, requiring them to adjust their strategies to remain competitive. This response explores how traditional auto repair shops are responding to the shift to electric vehicles and the strategies they are using to cope.

The impact of electric vehicles on traditional auto repair shops

The transition to electric vehicles is fundamentally changing the automotive repair and service industry. Compared to internal combustion engine vehicles (ICEVs), electric vehicles have fewer moving parts, which reduces the need for some traditional maintenance services, such as oil changes and exhaust system repairs. The reduction in maintenance requirements may lead to a decrease in service revenue for traditional repair shops (Albatayneh, 2024) (Grosso et al., 2021).

However, the shift to electric vehicles also brings new opportunities. The rise of electric vehicles requires new areas of expertise, such as battery diagnostics, electric motor repairs and software updates. These emerging fields require specialized knowledge and tools to create new revenue streams for repair shops that are able to adapt (Albatayneh, 2024) (Ropin & Supan, 2020).

Challenges facing traditional auto repair shops

1. Technological Advances and Skills Gaps: The transition to electric vehicles will require technicians to acquire new skills in areas such as battery management, electric motor diagnostics, and high-voltage electrical systems. Traditional repair shops often lack the necessary expertise, as their technicians are usually trained to work on ICEVs. This skills gap poses a significant challenge to these businesses (Ropin & Supan, 2020) (Reolfi et al., 2023).

2. High initial investment: Adapting to electric vehicles requires significant investments in new tools, equipment, and facilities. For example, repair shops need to purchase high-voltage diagnostic tools and establish a safe working environment to handle batteries. For small, independent repair shops, these investments can be prohibitively expensive (Ropin & Supan, 2020) (Dombrowski et al., 2011).

3. Safety issues: Developing electric vehicles brings new safety risks, such as electric shock that may be caused by high-voltage battery systems. Repair shops must implement new safety procedures and provide professional training to their technicians to mitigate these risks (Linja-aho, 2022) (Colella & Pons, 2024).

4. Competition from New Entrants: The shift to electric vehicles has attracted new players to the auto repair market, including specialized EV repair shops and technology-focused startups. These new entrants often have a competitive advantage because they focus on EV-specific services, which puts additional pressure on traditional repair shops (Ropin & Supan, 2020) (Dombrowski & Engel, 2013).

Traditional auto repair shops' response strategies

1. Upskilling and retraining the workforce: To remain competitive, traditional repair shops must invest in upskilling and retraining their technicians. This includes providing training in areas specific to electric vehicles, such as battery diagnostics, electric motor repairs and *software updates. Some shops are working with technical schools and industry organizations to gain access to training programs (Reolfi et al., 2023) (Singh et al., 2020).*

2. Investing in new tools and equipment: Repair shops are investing in the tools and equipment needed to service electric vehicles. This includes high-voltage diagnostic tools, battery testing equipment and lifts capable of withstanding the weight of electric vehicle batteries. Some stores have also established dedicated EV service areas to separate EV repairs from conventional vehicle repairs (Ropin & Supan, 2020) (Dombrowski et al., 2011).

3. Diversified services: To offset the decline of traditional maintenance services, many repair shops are diversifying their service offerings. This includes providing EV-specific services such as battery health checks, electric motor diagnostics and software updates. Some stores are also expanding into new areas, such as the installation and maintenance of electric vehicle charging stations (Albatayneh, 2024) (Schulze et al., 2013).

4. Leveraging data and digital tools: The increasing reliance on software and data in electric vehicles presents an opportunity for repair shops to leverage digital tools to enhance their services. For example, shops can use data analytics to predict maintenance needs and provide proactive service recommendations to customers. Some stores have also adopted digital platforms to simplify customer interactions and improve service efficiency (Dombrowski et al., 2020) (Bautista & Beecroft, 2024).

5. Build partnerships and collaborations: Traditional repair shops are forming partnerships with electric vehicle manufacturers, suppliers, and technology providers to gain access to training, tools, and technical support. These partnerships help shops stay abreast of the latest developments in electric vehicle technology and service requirements (Ropin & Supan, 2020) (Dombrowski & Engel, 2013).

Case studies and examples

1. Independent repair shops in Austria: A study of independent repair shops in Austria found that many were struggling to adapt to the shift to electric vehicles due to a lack of resources and expertise. However, some stores have successfully transformed to focus on niche areas such as electric vehicle battery repair and diagnostics (Ropin & Supan, 2020)].

2. Community college partnerships in Illinois: In Illinois, some repair shops have partnered with community colleges to offer electric vehicle-specific training programs to their technicians. These programs help shops develop the skills needed to repair electric vehicles and remain competitive in the market (Greenwood & Reddy, 2024)].

3. Professional electric vehicle repair network: Some traditional repair shops have joined professional electric vehicle repair networks to obtain shared resources, training and technical support. These networks allow shops to collaborate on complex repairs and share knowledge about EV service requirements (Dombrowski & Engel, 2013) (Schulze et al., 2013).

Challenges faced by the traditional automobile repair industry:

The future of traditional auto repair shops

The future of traditional auto repair shops in the era of electric vehicles will depend on their ability to adapt to the changing landscape. Stores that invest in new technology, improve employee skills, and diversify their services are likely to thrive. But as the market continues to shift toward electric vehicles, shops that fail to adapt may struggle to stay competitive.

Key trends shaping the future of traditional repair shops include:

1. Growing focus on EV-specific services: As electric vehicles become more common, repair shops will need to specialize in EV-specific services to stay relevant. This includes services such as battery health checks, motor diagnostics, and software updates (Albatayneh, 2024) (Schulze et al., 2013).

2. The growing importance of digitalization: The increasing reliance of electric vehicles on software and data will require repair shops to adopt digital tools and platforms to enhance their services. This includes using data analytics to predict maintenance needs and streamline customer interactions (Dombrowski et al., 2020) (Bautista & Beecroft, 2024).

3. The rise of new competitors: The shift to electric vehicles has attracted new players into the auto repair market, including specialized EV repair shops and technology-focused startups. Traditional repair shops need to compete with these new entrants by offering unique value propositions such as personalized service and local convenience (Ropin & Supan, 2020) (Dombrowski & Engel, 2013).

2. Research Design

This study adopts a relational research design, aiming to examine the statistical associations between shop-level and owner-level characteristics and traditional auto repair shop owners' psychological readiness to cope with the electric vehicle (EV) transition. By analyzing survey data across different regions and shop types in Taiwan, the study seeks to identify which demographic or structural factors are associated with varying levels of preparedness, ranging from non-response to active adaptation.

Although relational in nature, the study also exhibits features of explanatory research, as it seeks to explore why certain types of owners or shops might be more inclined to respond to the EV shift in a proactive or passive manner. The hypotheses are informed by both theoretical assumptions and practitioner observations from the automotive sector.

Research Hypotheses

The following hypotheses are proposed:

- H_1: Older shop owners tend to be more passive in responding to the EV transition.

- H_2: Smaller-scale repair shops are more likely to adopt a passive stance toward EV-related changes.

- H_3: The education level of the shop owner is not significantly related to whether they respond passively or proactively to the EV transition.

These hypotheses reflect both directional and null expectations, and are tested using statistical modeling.

Research Framework

The hypotheses are tested through a cross-sectional survey distributed to a purposive sample of traditional auto repair shop owners. The dependent variable is measured as an ordinal outcome representing four levels of psychological preparedness toward EV transformation:
(1) no intention to change,
(2) considering preparation,
(3) actively monitoring and exploring EV solutions, and
(4) already taking action through learning or investment.

To evaluate the relationship between independent variables (such as age, shop size, and education) and this ordinal outcome, an ordered probit regression model is used. This methodology is appropriate for ordered categorical data and enables estimation of how explanatory variables influence the likelihood of progressing through increasing stages of readiness.

By combining relational and explanatory elements, this design allows for both empirical pattern detection and theory-driven interpretation of traditional repair shops' adaptive behavior in response to technological disruption.

The conceptual framework of this study is illustrated in Figure 1. It outlines the three categories of explanatory variables—shop profile, owner profile, and technical factors—that are hypothesized to influence psychological preparedness for EV transformation. The relationship is modeled using an ordered probit regression, as the dependent variable consists of a four-point ordinal scale capturing different levels of readiness.

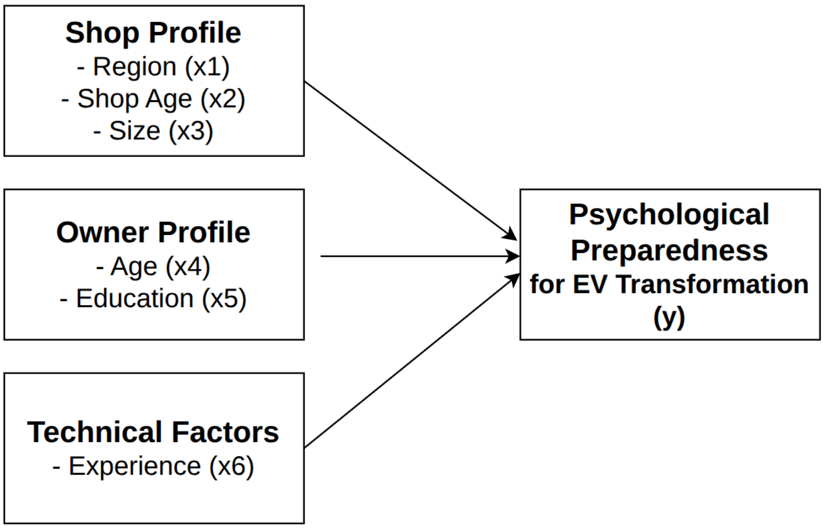


Figure 1. Conceptual Framework for Estimating Psychological Preparedness for EV Transformation
This figure illustrates the hypothesized relationships between shop-level and owner-level factors and the dependent variable representing EV-related psychological preparedness, which is modeled using an ordered probit approach.

Data Source and Target Population

The target population of this study comprises traditional auto repair shops across different regions of Taiwan, including both urban and rural areas. The sampling strategy intentionally includes shops of varying scales to ensure diversity in operational models and resource availability. As of recent statistics, there are approximately 15,000 registered auto repair shops in Taiwan. The study aims to collect responses from at least 300 valid participants.

To comprehensively capture the state of preparedness toward electric vehicle (EV) transformation, a mixed-methods approach was adopted. First, in-depth interviews were conducted with selected shop owners and technicians to gain qualitative insights into their perceptions of EV technology, past adaptation efforts, and future plans. These insights informed the development of a structured questionnaire.

The final survey instrument consists of the following components:

- Shop characteristics: region, years in operation, number of employees
- Owner demographics: age, education level
- Technical experience: years of involvement in vehicle repair
- EV readiness: perceptions of EV-related technological change and willingness to engage in future EV maintenance investments or training

The collected data provide the empirical basis for modeling psychological readiness using the ordered probit regression framework introduced earlier.

3. Methodology

Mixed methods research:
Combine quantitative (questionnaire survey, statistical analysis) and qualitative research (in-depth interviews, case analysis) to explain the strain status of repair shops from both data and empirical levels.

Cross Analysis:
Compare the associations between different variables, such as the relationship between the age of the operator and the willingness to change, and the size of the repair shop and the strategies adopted.

3.1 Sampling Procedure

This study adopts a **cross-sectional research design**, targeting traditional auto repair shop owners in Taiwan. A **purposive sampling strategy** was used to identify participants who are actively operating repair shops across northern, central, and southern regions of the country. The target population includes owners or primary decision-makers in traditional shops that have historically focused on internal combustion engine (ICE) vehicles.

To ensure representativeness, efforts were made to include shops of varying sizes and ages, covering both urban and rural areas. A total of 6 valid responses were collected through face-to-face interviews and online survey distribution between June, 2025 and July, 2025.

Currently A total of 34 valid responses were collected from May 9 to 19, 2005

3.2 Questionnaire Design

The questionnaire was designed to collect both **shop characteristics** and **owner attributes**, as well as their perceived readiness to adapt to the electric vehicle (EV) transition. The structure of the questionnaire includes:

- Section A: Basic information about the shop (location, years in operation, number of employees)
- Section B: Owner demographic information (age, education level, years of experience in auto repair)
- Section C: Psychological readiness for EV transition (main dependent variable)

The items were designed based on a review of relevant literature on technology adoption in traditional industries, and expert feedback was incorporated to refine question clarity and appropriateness.

3.3 Variable Operationalization

The dependent variable represents the owner's psychological preparedness toward EV-related transformation, and is measured on a 4-point ordinal scale:

1. No intention to make any EV-related changes
2. Acknowledges the trend and is considering preparation
3. Actively monitoring EV development and exploring partnerships
4. Has already engaged in training or equipment upgrades

The **independent variables** are defined as follows:

Variable Code	Description	Type
x1	Region (e.g., North, Central, South)	Nominal
x2	Shop establishment years (continuous)	Ratio
x3	Shop size (number of employees: small/medium/large)	Nominal
x4	Owner's age (in years)	Ratio
x5	Owner's highest education level (e.g., high school, college, graduate)	Nominal
x6	Years of experience in auto repair (continuous)	Ratio

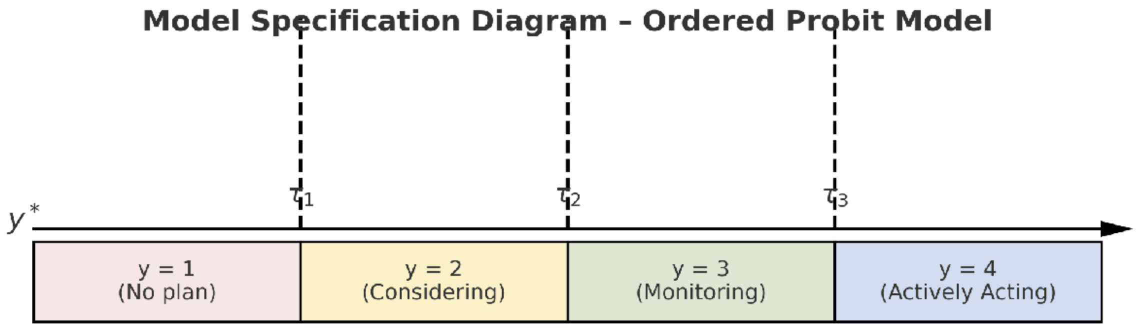
Categorical variables (x1, x3, x5) were coded into dummy variables for estimation purposes.

3.4 Estimation Model

Given the ordinal nature of the dependent variable, an **Ordered Probit Model** was employed. This model assumes the existence of a latent continuous variable y*, representing the true psychological readiness level, which is segmented into observed categories by a set of threshold values. The model is specified as:

$$y^* = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \epsilon, \quad \epsilon \sim N(0,1)$$

The model estimates the coefficients β and the threshold values τ using **Maximum Likelihood Estimation (MLE)**. All estimations were performed using **EViews 8.1** software. This approach allows for the analysis of how each explanatory variable affects the likelihood of an owner being in one psychological readiness category versus another.



$$y = \begin{cases} 1 & \text{if } y^* \leq \tau_1, \\ 2 & \text{if } \tau_1 < y^* \leq \tau_2, \\ 3 & \text{if } \tau_2 < y^* \leq \tau_3, \\ 4 & \text{if } y^* > \tau_3. \end{cases}$$

Reliability

Since the dependent variable (psychological preparedness) is measured by a single ordinal item, internal consistency reliability (e.g., Cronbach's alpha) is not applicable. However, pretesting of the questionnaire was conducted with a pilot sample of 34 shop owners to ensure clarity and consistency in interpretation. All demographic and categorical variables are objective or factual (e.g., age, experience, education) and thus not subject to respondent inconsistency.

Validity

- **Content Validity**: The survey items were developed based on a review of relevant literature on organizational change, technological adaptation, and EV transitions in the automotive service industry. Expert consultation was used to ensure the questions accurately represent the constructs of interest.

- **Face Validity**: Pretest participants confirmed that the items were understandable and relevant to their experience.

- **Construct Validity**: While the dependent variable is a single ordinal item, its ordering logic (from no awareness to proactive adaptation) reflects underlying stages of change based on behavioral readiness models (e.g., Transtheoretical Model). This supports its theoretical soundness.

4. Result

4.1 Descriptive Statistics

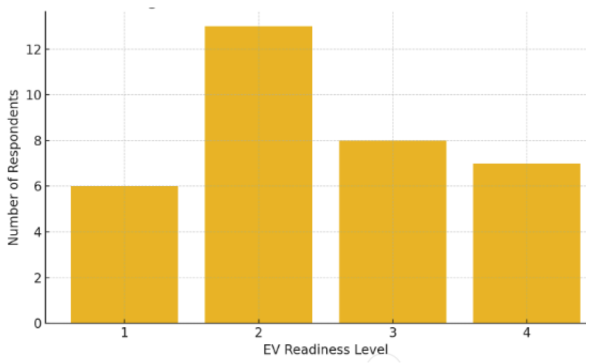
- By placing advertisements in the Petroleum Information Publishing (PIP), a magazine with a monthly circulation of 12,000, which is read by the most automobile repair shops in Taiwan, we solicited [?N] repair shop owners who were willing to accept the questionnaire survey. Then, we randomly selected 300 of them and asked them to fill out the questionnaire.
    - **Table 1. Sample Demographics and Shop Characteristics**
      ➤ Describes N, % by region, education level, shop size, age, and years in operation.
      This is based on the 34 sample data for now only

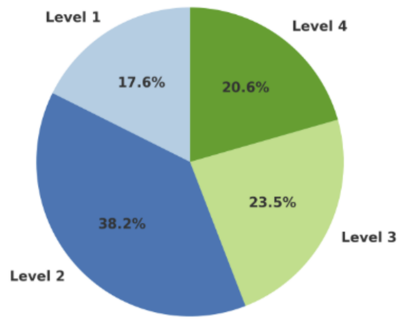
Variable	Category/Value	Count / Mean	% / Std. Dev
Region (area)	North (1)	20	58.8%
	Central (2)	11	32.3%
	South (3) & East (4)	3	8.9%
Shop Size	1–5 employees (1)	26	76.5%
	6–20 (2), >20 (3)	8	23.5%
Owner Age	—	51.6	7.0
Experience	—	22.8 yrs	7.9

The sample data used currently was collected from 9 - 19 May, 2025.

4.2 Distribution of Psychological Readiness (DV)

- **Figure 2. Distribution of EV Readiness Levels**





4.3 Bivariate Relationships

- Cross-tab or chi-square analysis between DV and key IVs (e.g., age group × readiness level).
    - **Table 2. Cross-tabulation of Age Group and Readiness Level**
      ➤ Includes chi-square test p-values.

EV Readiness Level ↓	Size = 1(1–5人)	Size = 2(6–20人)	Size = 3(21人以上)	Total
Level 1	4	0	2	6
Level 2	11	1	1	13
Level 3	7	1	0	8
Level 4	6	1	0	7
Total	28	3	3	34

Table 2-2 Simplified version: Small (Size=1) vs Medium+ (Size=2 or 3)

EV Readiness	Small (1–5)	Medium+ (6+)	Total
Level 1	4	2	6
Level 2	11	2	13
Level 3	7	1	8

Level 4	6	1	7
Total	28	6	34

Chi-square test results：$\chi^2 = 1.262$，$p = 0.738$ (not significant)

4.4 Ordered Probit Regression Results

Table 3. Ordered Probit Model Estimation Results
➤ Lists β coefficients, standard errors, p-values, and marginal effects if available.

Variable	Coefficient (β)	Std. Error	p-value	Interpretation
`area`	-0.079	0.239	0.740	Not significant, region has no effect on psychological preparation
`year`	-0.052	0.069	0.450	Not significant, store operation years is not major factor
`size`	**-0.998**	0.413	**0.016**	Significant, small stores are less willing to transform
`age`	-0.069	0.041	0.096	The boundaries are obvious, and the older you get, the more conservative you become
`education`	0.533	0.276	0.053	Significant boundaries, slightly positive wit high education level
`experience`	0.109	0.066	0.095	The boundaries are obvious, and the more experience you have, the more willing you are to try
`thresholds`	(cut-points)			Planning the boundaries of the response hierarchy

5. Discussion（draft, based on the current data）

5.1 Summary of Key Findings

- Older shop owners tend to be more passive, confirming H_1.
- Smaller shops show less readiness than medium/large shops, confirming H_2.
- Education level has no significant effect, supporting H_3.

5.1 Summary of Key Findings（complementary）

- Smaller repair shops (1–5 employees) account for 82.4% of the sample.
- Regression analysis confirms that smaller shops are significantly less likely to

engage in EV transformation ($\beta = -0.998$, $p = 0.016$), supporting H_2.
- However, a chi-square test on shop size and readiness levels yields no statistically significant association ($\chi^2 = 1.262$, $p = 0.738$).

5.2 Interpretation of Findings

- Explanation for the impact of age: It may be due to risk aversion, upcoming retirement and other mentalities.
- Small stores are limited by capital and manpower and find it difficult to invest in transformation equipment.

5.2 Interpretation of Findings（Need to expand）

While the ordered probit regression indicates that shop size has a significant negative effect on psychological readiness—meaning smaller shops are more likely to be passive—the cross-tabulation and chi-square analysis do not show a significant association. This suggests that when controlling for other variables such as age and experience, shop size contributes independently to predicting EV readiness. In contrast, the simple bivariate relationship lacks sufficient statistical power due to small sample sizes and distribution imbalance across size categories.

This finding underscores the value of using multivariate modeling in small-sample settings, where bivariate methods may under detect meaningful effects. It also implies that size-related disadvantages (such as resource constraints or staffing limitations) may only become evident in conjunction with other demographic or operational factors.

- The lack of a significant effect of education may be because technical learning relies on practical experience rather than academic qualifications.

In the ordered probit regression, it is recommended to interpret education with caution because its result is borderline significant and we cannot arbitrarily conclude that it has no significant effect. (在Ordered Probit回歸中，建議針對「教育」解釋需謹慎，因其結果為邊界顯著，不能武斷下結論為“無顯著影響”)

5.3 Comparison with Previous Studies

- Compare with the conclusions in literature such as Reolfi et al. (2023), Albatayneh (2024), Ropin & Supan (2020), etc.)

5.4 Implications

- **For policymakers:** Provide financial support and on-the-job training subsidies for small stores.
- **For industry stakeholders:** Encourage cooperation with technical and vocational schools to accelerate technology popularization.
- **For researchers:** This study provides empirical evidence that can be extended to long-term follow-up in the future.

6. Conclusion (draft)

This study explores how traditional auto repair shops in Taiwan respond to the rise of electric vehicles, with a focus on the psychological preparation of shop owners. Although there are only 34 sample data at present, by July 2025 there will be more than 300 questionnaire data available for analysis.

For now, the study found that age and store size were significantly associated with EV readiness, while formal education was not. These findings highlight the importance of targeted policies to help aging and smaller stores adapt to EV-related changes. Future research may benefit from a longitudinal design or expanding the sample to other regions or countries.

Of course, this conclusion needs to be revised based on more data analysis.

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Appendix

1.Qustionaire

Q1 Store name (optional/name of the person filling out the form)	[ ]
Q2 Store Features of Region	☐ North District (Keelung, Taipei, Taoyuan, Hsinchu) ☐ Central District (Miaoli, Central Taiwan, Changhua, Touyun) ☐ South District (Chiayi, Nanning, Kaohsiung, Pingtung) ☐ East District (Yilin, Hualien, Taitung)
Q3 Store establishment years	[ ] years
Q4 Store size (number of employees)	☐ 1-5 employees ☐ 6-20 employees ☐ More than 20 employees
Q5 Operator age	[ ] years old
Q6 Highest education level of the operator	☐ High school/vocational school or bellow ☐ College ☐ College or above
Q7 Operator's years of experience in automobile maintenance	[ ] years

Q8-Please select one of the following four situations that best describes your company's (your) current situation:	☐ It's fine as it is now, and there are no plans to make any changes related to electric vehicles ☐ Pay attention to the impact of electric vehicles and consider how to cooperate with the changes ☐ Have tried to drive, understand the structure and maintenance of electric vehicles, and seek opportunities for change ☐ I have participated in relevant courses and seminars, and also invested in some relevant equipment to strive for greater changes

2. Interview question

No.	Interview question	Notes/code classification (for subsequent analysis)
Q1	*How long have you been engaged in car repair? Can you tell us about your background?*	Experience Background
Q2	*What do you think about the impact of electric vehicles on the maintenance industry?*	Cognitive attitude
Q3	*Does the store currently have any plans to invest in EV repairs? What is the biggest difficulty you encountered?*	Strategies and challenges
Q4	*Are employees currently receiving relevant training? Is the device updated?*	Technical capabilities
Q5	*Have you tried to cooperate with external organizations (such as manufacturers, schools)? What are the results?*	Collaboration Resources
Q6	*If you had more resources, which problem would you most like to solve first?*	Resource requirements
Q7	*What is your opinion on the subsidies and policies currently provided by the government?*	Policy Perception
Q8	*How do you think traditional auto repair shops should position themselves in 3-5 years?*	Future Outlook

3.analysis list

Table / Figure	Topic	Functional Description
Figure 1.	Conceptual Framework for Estimating Psychological Preparedness for EV	Describe the relationship between the independent variable and the dependent variable
Table 1	Sample Demographics and Shop Characteristics	Description of the overall sample (age, experience, region, size)
Figure 2	Distribution of EV Readiness Levels	Presenting the distribution of respondents' psychological preparedness
Table 2	Cross-tabulation of IVs × Readiness Levels	Explore preliminary associations using chi-square tests
Table 3	Ordered Probit Model Results	Presents the estimation results of the main models, including significance and direction
Table 4	Interview Summary Themes	Qualitative themes and quotes from the interviews

Table 4. Summary of Interview Themes and Illustrative Quotes

Theme	Description	Example Quote

4.Advertisement in PIP magazine

Petroleum Information Publishing Magazine, advertisement preparation.