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Research in the Impact of COVID-19 on the Energy Service Industry in Taiwan

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Abstract: The study proposes the methodology of event study integrated with industrial survey to analyze the impacts of COVID-19 on Taiwan's energy service companies (ESCOs). Event study approach heavily relies on price fluctuation to estimate the influence on firm value. The fieldworks in industrial survey are auxiliary used to fill up the shortage of event study in unlisted companies. This study can also estimate the decline of revenue due to COVID-19, and analyze the modification of international ESCO outputs.

Three hypotheses are proposed to be tested. On the aspect of event study, the hypothesis 1 is confirmed that Taiwan's ESCOs experienced significantly abnormal return drops, about 7.5% on March 2020, then rapidly price rebound. The whole ESCO industry recovered gradually original activities in August, 2020. As for industrial survey, the hypothesis 2 is confirmed that the value and export ratio of ESCOs significantly decline around COVID-19 event period. Our research also confirms the hypothesis 3 and conclude that the energy-saving equipment companies suffer the most influence in annual revenue and export, compared with the other groups.

Key words: energy service company, event study, industrial survey, COVID-19
JEL code: O53

1. Introduction

It is increasingly clear that energy saving can bring numerous economic and environmental benefits. Energy efficiency is widely recognized as a cost-effective strategy to meet energy demand. To encourage investment in energy-efficiency projects, the energy performance contracts (EPCs) has been introduced in many countries through energy services companies (ESCOs) that help implementing energy-saving activities with zero initial investment by end-users. ESCOs are those companies that conduct energy-efficiency projects by guaranteeing energy savings, and associated design and installed services (Zheng et al., 2018). ESCOs usually using energy performance contracts to identify and implement energy efficiency activities. ESCOs are key enablers of investments in energy efficiency, and deliver efficiency projects based on long-term contracts tied in energy performance.

International Energy Agency tracks key trends and developments in the global ESCO markets, which grew to US$ 30.2 billion in 2019 (International Energy Agency, 2020). China continued to dominate the 56% of global ESCO markets, annual growing 1% to nearly US$ 16.9 billion. In the United States, the market grew to just over

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US$ 6.3 billion in 2019, and European ESCO market represents 16% of the global total.

The U.S. energy services industry has an over 30-year track record of providing cost-effective energy efficiency, primarily to customers in the public and institutional sectors (Carvallo et al., 2019), and public policy has also played an influential role in the development of the U.S. ESCO industry, specifically its popularity in the public/institutional sectors.

After Taiwan's government promoting this kind of activities, the number of ESCOs significantly increases to over three hundred on February 2020. However, Taiwan's ESCOs still stay on early and middle stages of development. The projects with energy efficiency are small and the manufacturers or end-users are mostly medium-sized enterprises compared with the ones of other developed countries. The annual output value is estimated to grow to US$ 539.0 million in 2019 (Yeh, 2019). In addition, China is the main export region of Taiwan's ESCOs which accounted for about 33% of total ESCO export. Exports to Southeast Asian regions, including Vietnam, Thailand and Philippines, Indonesia and Malaysia, are summed about 40%.

Unfortunately, the COVID-19 has created huge global crisis in generations, sending shock waves through health systems, economies around the world. To date, there is no official medical treatment for the disease, causing a tremendous panic for world citizens. Thus, governments around the world have prohibited cross-country transportation. The energy sector is also severely affected by this crisis, which has slowed transport, trade and economic activity across the globe. Simultaneously the export of Taiwan's ESCOs has been greatly hindered.

The event study methodology is employed to investigate the impact of COVID-19 on ESCO's stock returns and corporation values in this study. This financial approach heavily relies on daily price fluctuation to estimate the capacity of impact. Because Taiwan's ESCOs mostly belong to medium-sized enterprises, there are only about 10% companies to be listed in Taiwan Stock Exchange. The fieldworks in industrial survey are auxiliary used to fill up the shortage of event study in unlisted companies. Additionally, we interviewed over 103 ESCOs, including 14 listed companies, those companies are outstanding enterprises for ESCO projects executing and recommended by Taiwan Energy Service Association to be investigated in this study, they accounted for 31.02% of all Taiwan's ESCO members. With the survey, we also estimated the decline of revenue due to COVID-19, and analyze the adjustment of international ESCO outputs.

This study contributes to prior literature on catastrophes in the ESCO industry. To the best of our knowledge, we are among the first to explore the impact of this unprecedented event on energy efficient sector. In addition, the samples are relatively distinctive, including the listed and unlisted firms, which is different from other papers that focus on a particular industry.

This research is composed of five sections. The introduction will be discussed in the first section. The literature of event study approach is enunciated in section two. The third section discusses our research methodology and empirical hypotheses. Then, the fourth and fifth section are empirical analyses of the impacts of COVID-19 on Taiwan's ESCO industry. Finally, the sixth section is the discussion of management implications.

2. Literature Review

Given the enormity of the current pandemic, researchers have begun to examine the impact of COVID-19. Baker et al. (2020) identify this current pandemic as having the greatest impact on stock market volatility. They also demonstrate government limitations on commercial activity as the reasons for increased volatility. Baek et al. (2020) show that changes in volatility are more sensitive to COVID-19 news than economic indicators. Simultaneously,

the negative news is estimated about twice as impactful as positive news regarding recoveries suggesting a negativity bias. In general, Pandey and Kumari (2020) confirmed that early lockdowns/restrictions imposed by the nations have yielded positive results, thus, rebuilding the investor's confidence and sharp reversal in the stock market returns.

As for specific industries, Maneenop and Kotcharin (2020) selected three crucial announcements and found the underreaction and overreaction to the announcements in those events respectively. This research also outcrops airlines stocks in Australia, Canada, the U.K., and the U.S., are the worst performers in the post-event period. Amankwah-Amoah (2020) suggested global airlines can no longer rely solely on their environmental commitments to compete, but also require to build-in additional safety in protecting the passengers' health from potential virial infections. Additionally, Kim et al. (2020) analyzed nine events on four epidemic disease outbreaks during 2004–2016, event study method was used to estimate the effect of three firm characteristics (brand reliability, advertising effects, and service types) on firms' value.

The review of event study literature can be divided into two parts, viz., methodologies and test statistics for event studies (Pandey & Kumari, 2020). The studies which implemented the event study methodologies suggest best parametric and non-parametric test statistics with their power to detect the statistical significance of the results (Dimson, 1979; Brown & Warner, 1980, 1985; Dutta, 2014). As for test statistics, there are numerous literatures have studied the impact of macroeconomic news announcements on the stock markets (Kim et al., 2020; Pandey & Kumari, 2020). Almost all the studies have found significant impacts of the observed events. However, this kind of financial event study of global disease outbreaks heavily focuses on the volatility form stock markets, the reduction of revenue and the modification of export areas cannot be observed in energy services industry, which is not well defined and indexed in any stock market.

For overcoming this shortcoming, the industrial survey of ESCOs is applied in this study. Some literatures on the U.S. and international ESCO industries has focused on emerging ESCO models, broad market trends, and barriers to end users engaging in EPCs (Bertoldi & Boza-Kiss, 2017; Carvallo et al., 2019; Chitnis et al., 2020). Yeh et al. (2021) show that the relationship between internationalization and profitability of ESCOs displays a non-linear trend, while the export ratio exceeds the optimal point, it will reveal a reversed phenomenon due to high overseas operation costs.

3. Model Building and Industrial Survey

The event study methodology is designed by Ball and Brown (1968) to investigate the effect of an event on the value or stock price of a firm. The basic idea is to find the abnormal return to the event being studied by adjusting for the return that stems from the price fluctuation of affected market. We have to first decide on the event that we wish to investigate, and then collect price data of companies that had went through such an event. This study aims to examine the impacts of the COVID-19 outbreak on stock prices of listed ESCOs. For this purpose, the daily returns of the listed ESCOs both before and after the declaration are collected.

Figure 1 depicts the data structure of the whole COVID-19 event window period. It includes three parts. The data that we need identified the announcement date of event (e.g., first announcement date of COVID-19 by China might be 1/11/2020, T_0). Too short post event period will not be able to display the full economic effects. Because of long spread of this infectious disease period, we suggest the estimated period be extended from previous 150 trading days to further observe next 150-trading-day, T_{150}, price fluctuations. The null hypothesis is tested that "the

abnormal returns on and around the event day are less than or equal to zero".

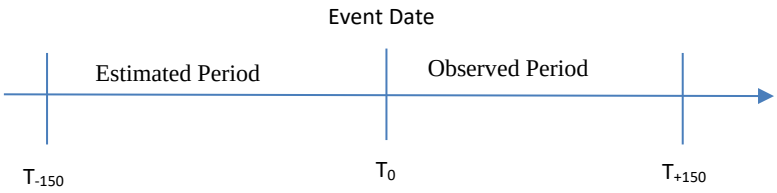

Figure 1 The Data Structure of COVID-19 Event Window

Let $t = 0$ represent the time of the event. For each sample security i, the return on the security for time period t relative to the event, R_{it}, is:

$$R_{it} = E(R_{it}) + e_{it} = \alpha_i + \beta_i R_{mt} + e_{it} \quad (1)$$

where $E(R_{it})$ is the predicted return given a particular model of expected returns, R_{mt} is the market return of Taiwan Capitalization Weighted Stock Index, and e_{it} is the component of returns which is abnormal or unexpected. A variety of expected return models (e.g., market model, constant expected returns model, capital asset pricing model) have been used in event studies, and the market model is applied in this study. An event study also seeks to establish whether the cross-sectional distribution of returns at the time of an event is abnormal. For a sample of N energy service companies, the cross-sectional mean abnormal return for any period t is:

$$AR_t = \frac{1}{N}\Sigma_1^N e_{it} \quad (2)$$

Typically, the specific hypothesis, tested is whether the mean abnormal return (average residual, AR) at time t is equal to zero, is set as following.

H_1: The AR of Listed ESCOs Stock Prices Significantly Exist Around COVID-19 Event Period.

It is also of interest to examine whether cumulative abnormal returns for periods around the event are equal to zero. In estimating the performance measure over some interval (e.g., time 0 through +150), the cumulative average residual (CAR) uses as the abnormal performance measure the sum of each daily abnormal performance.

$$CAR_{t=0}^{t_1} = \Sigma_{t=0}^{t_1} AR_t \quad (3)$$

We assume that all information can be reflected in the stock price and return immediately due to the efficient market hypothesis. Therefore, we have to look at the effect on one single item, the returns. Our ultimate goal is to examine whether abnormal returns exist surrounding the determined event periods.

Although we can calculate each company's abnormal return caused by COVID-19 event, the performance of individuals cannot represent the status of the overall industry. Using the individual capitals, C_{it}, as weights, the return of whole ESCO index can be integrated as follows:

$$R_{ESCO(t)} = \frac{(C_{1t}R_{1t}+C_{2t}R_{2t}+\cdots+C_{nt}R_{nt})}{(C_{1t}+C_{2t}+\cdots+C_{nt})} \quad (4)$$

Input $R_{ESCO(t)}$ into equation (1), the expected value can be estimated in equation (5) with market model. Furthermore, the abnormal normal return, $AR_{ESCO(t)}$, of ESCO industry for any period t can be estimated.

$$E\left(R_{ESCO(t)}\right) = \alpha_{esco} + \beta_{esco} R_{mt} \quad (5)$$

There are only about 10% energy service companies to be listed in Taiwan Stock Exchange. The fieldworks in industrial survey are auxiliary used to fill up the shortage of event study in unlisted companies. Additionally, we interviewed about 103 ESCOs, including 14 listed companies. The data is based on the retrieved questionnaires for document and interview. In addition to descriptive statistics and chart analysis for inclusion, the approach used for

relevant issues are as follows:

Cross-period comparison: Based on questionnaire surveys from last year and this year, this study has examined issues regarding whether the operating environment of the energy service providers is more severe, whether the business model and export markets of vendors have to be modified.

H_2: The Project Value and Export Ratio of ESCOs Significantly Decline Around COVID-19 Event Period.

Difference analysis of each group: Independent samples t-test is adopted to judge whether the expected values of the different groups, as energy-saving professional companies, energy-saving equipment company and energy-saving supporting companies, are equivalent in seriousness.

H_3: The Impacts of Different Types of ESCOs Are Significantly Different Due to COVID-19.

This study investigates the business operations and international output characteristics of the ESCOs in Taiwan from 2020/7~12. As for the regional distribution of enterprise registration area of samples in Table 1, New Taipei and Taipei City still had the highest ratio of the total sample of manufacturers at 66.02% which was slightly higher than the actual ratio, 56.20%. Similarly, those in Taoyuan, Hsinchu, and Miaoli area with 12.62% also had less proportion compared to the actual ratio. On the contrary, the sample manufacturers' ratio in the other two regions were near to their ratios of registered manufacturers.

This study used the goodness-of-fit test to analyze whether the sampling distribution is corresponding to the maternal one. The first entry is whether the registered area of the surveyed samples and the registered area of the manufacturers in the overall industry are consistent. The suitability in Table 1 shows that $X^2 = 4.7681 < X^2(0.05, 4) = 9.4877$, p-value = 0.1896. The result shows no significant difference. The second verification entry is whether the capital amount of the sample suppliers under investigation is consistent with the distribution of capital amount of the manufacturers in the overall industry. Table 1 shows that $X^2 = 2.1129 < X^2(0.05, 3) = 11.0705$, p-value = 0.7150. The results verify that on the whole, the sample ratios were not significantly different from the ones of whole population, regardless of the amount of capital or regional allocation.

Table 1 The Verification of Distribution of Surveyed Samples and Whole Population

Region	Taipei and New Taipei	Taoyuan, Hsinchu and Miaoli	Taichung, Changhua and Nantou	Southern area and others	
Sample ratios	66.02%	12.62%	7.77%	13.59%	
the maternal ratios	56.20%	18.25%	11.68%	13.87%	
Chi-Square (χ^2) value =	4.7681	$\chi^2(0.05, 4)$ =	9.4877	p-value =	0.1896
Capital amount (US$)	Under 500 thousand	500 thousand ~ 1 million	1 million ~ 3 million	3 million ~ 35 million	More than 35 million
Sample ratios	16.50%	22.33%	16.50%	26.21%	18.45%
the maternal ratios	14.12%	22.35%	21.18%	27.06%	15.29%
Chi-Square (χ^2) value =	2.1129	$\chi^2(0.05, 3)$ =	11.0705	p-value =	0.7150

4. Empirical analysis in Event Study Approach

The event study approach was used to investigate the effect of the COVID-19 disease outbreaks on ESCOs' financial performance. The estimation results from the market model provide evidence of negative relationship consistently to stock market in the initial event period. The expected return in equation (5) is transferred into the original index (2020/1/10 ESCO index) daily, the expectation of ESCO index can be depicted in Figure 2.

Simultaneously, the real ESCO index with equation (4) also present in the same drawing. Comparing the real with expectative fluctuating lines, we can see that the real index heavily drops down more than the expected ones in the early stage (2020/1/10~2020/3/19), then, the both lines rise up quickly. The actual index rebound more than expected in the second stage (2020/3/20/~2020/7/2). After the second stage, the expectation slowly catches up with the other in 2020/8/3 again.

Figure 2 The Actual and Expected ESCO Index in the COVID-19 Event Window

Simultaneously, we estimated the daily expected returns of 14 listed ESCOs with market models. The real daily returns minus expected returns, and the abnormal daily returns can be calculated. The results of integrated AR of whole ESCOs industry are shown in Figure 3. The general impact of the epidemic disease outbreaks was mostly significantly negative for ESCOs over the early event window (2020/1/10~2020/5/19) as shown in Table 2. Then AR performs better significantly after July, 2020. Therefore, the hypothesis 1 (H_1) is confirmed significantly to exist in the COVID-19 period.

Table 2 The T-test of AR and Significant Periods

The significant period of AR	Mean of t-value
T_1, T_2, T_3	-2.853*
T_{16}, T_{19}, T_{22}, T_{24}, T_{25}, T_{27}	-3.78**
T_{68}, T_{69}, T_{79}, T_{82}, T_{85}, T_{87}, T_{90}, T_{96}, T_{99}	-2.21*
T_{105}	-2.76*
T_{117}, T_{118}, T_{121}, T_{124}, T_{125}, T_{127}	-2.32*
T_{129}, T_{133}, T_{135}, T_{136}, T_{139}, T_{141}	3.98**

Note: * at 5% level of significance, ** at 1% level of significance
T_n represents the next n-day of event.

We also picture the cumulative abnormal return, CAR, of ESCO index in Figure 3. Firstly, comparing with other countries all around the world, the similar situations that the most decline happens about on March, 2020 can be observed in CAR. Secondly, due to real business needs for energy efficiency, ESCOs experienced significantly abnormal return drops, just about -7.5%, then rapidly price rebound. After the initial huge impact for several months, the whole ESCO industry recovered gradually and maintain original activities on August, 2020.

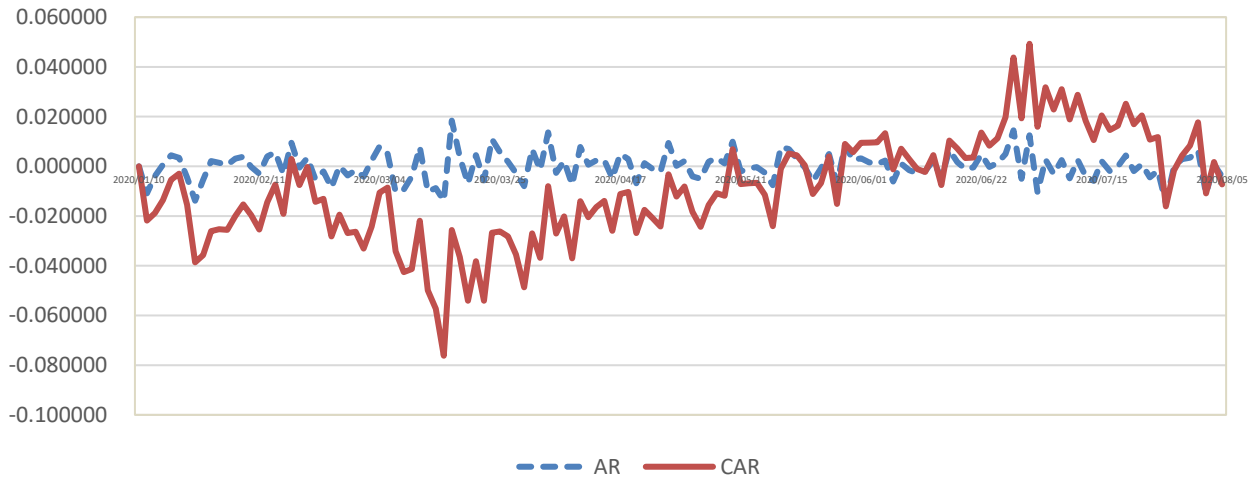

Figure 3 The AR and CAR of ESCO Index in COVID-19 Event

5. ESCO Industrial Survey

Financial event study limits to analyze the price fluctuation of listed companies. For more realizing the influence of products combination, revenue and export of ESCOs due to COVID-19, the industrial survey is executed for unlisted companies. The interviewed companies are 105 in 2019, and 103 in 2020, about 31.02% of the overall ESCOs. The sampling distribution is tested to be consistent with the one of population as shown in Table 1, Section 3.

Table 3 illustrates the overview of the operations of ESCOs in the period of COVID-19. As the observed, the amount of paid-in capital of Taiwan's ESCOs consistently rose in the both-year period. The average value has grown from US$ 8,944.03 K to US$ 9,470.28 K. This shows that the operating scale of ESCO manufacturers has gradually increased and is moving toward large-scale enterprises. The conducted interviews reveal that in recent years, many air-conditional or lightning companies (especially inverter air conditioner or LED supplier) have joined in the energy saving association and provided energy-saving projects to compete in consuming markets. Through this study, the operating activities of the energy-saving projects of surveyed enterprises were collected, and the growth rate and net profits of energy-saving projects can be estimated.

The energy savings brought about by energy efficiency improvements yield a range of benefits, including lower greenhouse-gas emissions and energy consumption. The output value of the whole Taiwan's ESCOs should increase gradually in recent years due to more operators and supports from government theorically. However, the means of annual energy-saving projects value declines significantly as shown in Table 3. The average annual energy-saving projects value is US$ 2,684.38 K in 2019, but US$ 1,860.93 K in 2020. It presents that this pandemic has caused disruptions in many energy-saving projects.

Additionally, the exporting ratios also fell from 40.19% to 33.98%. With independent samples t-test, the hypothesis 2 (H_2) can be confirmed that the value and export ratio of ESCOs significantly decline around COVID-19 event period.

Table 3 The Statistics of Taiwan's ESCOs in 2019 vs. 2020

All energy service companies	Year 2019		Year 2020		T-test
	mean	St. dev.	mean	St. dev.	
Paid-in Capital (US$ 1,000)	8,944.03	12,152.84	9,470.28	12,983.11	0.46
Annual energy-saving projects value (US$1,000)	2,684.38	3,006.85	1,860.93	3,046.54	4.14*
Growth rate (%) of energy -saving projects	0.26	25.68	0.15	23.22	1.26
Net profit (%) of energy-saving projects	9.58	8.96	8.29	10.81	0.27
Saving rate (%)	32.16	14.29	34.60	16.03	1.61
Exporting ratio (%)	40.19	49.26	33.98	47.60	4.09*
No. of samples	105		103		

Energy-saving professional companies	Year 2019		Year 2020		T-test
	mean	St. dev.	mean	St. dev.	
Paid-in Capital (US$ 1,000)	3,692.98	4,670.02	6,470.59	9,635.33	3.82
Annual energy-saving projects value (US$1,000)	5,106.19	6,071.71	3,377.19	4,683.67	0.63
Growth rate (%) of energy -saving projects	12.75	22.21	2.35	23.92	0.58
Net profit (%) of energy-saving projects	12.13	9.81	9.12	14.95	0.29
Saving rate (%)	34.00	14.74	39.00	14.78	0.68
Exporting ratio (%)	50.00	51.30	35.29	49.26	1.79
No. of samples	20		17		

Energy-saving equipment companies	Year 2019		Year 2020		T-test
	mean	St. dev.	mean	St. dev.	
Paid-in Capital (US$ 1,000)	10,777.62	13,281.39	7,837.98	12,091.71	2.00
Annual energy-saving projects value (US$1,000)	1,173.63	1,883.37	843.11	979.44	4.15*
Growth rate (%) of energy -saving projects	-2.91	27.56	-3.97	22.69	1.27
Net profit (%) of energy-saving projects	9.93	9.73	8.68	7.34	2.77
Saving rate (%)	33.18	12.61	38.00	16.27	0.47
Exporting ratio (%)	54.05	50.52	29.41	46.25	6.46**
No. of samples	37		34		

Energy-saving supporting companies	Year 2019		Year 2020		T-test
	mean	St. dev.	mean	St. dev.	
Paid-in Capital (US$ 1,000)	9,523.81	12,893.69	11,518.22	14,294.68	1.41
Annual energy-saving projects value (US$1,000)	2,925.80	8,437.76	1,814.61	2,881.33	3.96*
Growth rate (%) of energy -saving projects	-2.76	24.30	-2.12	23.42	0.22
Net profit (%) of energy-saving projects	8.01	7.57	7.77	11.32	3.46
Saving rate (%)	31.16	15.03	30.60	15.66	0.10
Exporting ratio (%)	28.57	45.64	36.54	48.62	2.85
No. of samples	48		52		

Note: * at 5% level of significance, ** at 1% level of significance, and US1 = NT$28.5.

Fortunately saving rate of enterprises in promoting energy-saving projects has also shown a slight upward trend (from 32.16% to 34.60%) due to technology development. However, the average profitability of the energy-saving

project in 2019 was 9.58%, but the one was only 8.29% in 2020, the data manifest that energy-saving projects are not high-profit business models, and only reasonable rate of return can be obtained.

Taiwan's ESCOs can be separated into three types of business operations, including: energy-saving professional companies, energy-saving equipment companies, and energy-saving supporting companies. This study surveyed 37 (= 20+17) energy-saving professional companies with the main business activities consisting of energy services, and energy-saving projects which account for over 50% of their overall business activities. The next kind is the energy-saving equipment companies which are energy-saving equipment manufacturers themselves promoting their own products turnover. They also play the role of ESCOs, and engage in energy-saving projects. This study surveyed 71 (= 37+34) companies under this type. The third one is classified as energy-saving supporting companies which are general companies, such as telecommunications companies, leasing companies, engineering planning companies, …etc. Because the energy-saving projects are related to other businesses within the companies, they also undertake energy-saving services. A total of 100 (= 48+52) companies surveyed fall under this category.

As shown in Table 3, the characteristics of the energy-saving professional companies in terms of revenue, growth rate, profits and exporting ratio of energy-saving projects slightly show the existence of the negative impacts from COVID-19. Due to small samples, it is hard to conclude significantly.

On the contrary, energy-saving equipment companies acting in energy-saving projects, such as annual value and exporting ratio, significantly show: the declination around COVID-19 period exists. In general, the equipment manufacturers are larger than professional companies in capital. This phenomenon is clearly realized that large companies are easier to internationalize, and the impacts of COVID-19 in export are more than the import. Therefore, the impacts of equipment manufacturers are more obvious than the impacts of other ESCOs group.

As for energy-saving supporting companies, their businesses are rich and diverse. Part of them, as internet software firms, may benefit from COVID-19, the others may severely damage. The whole energy-saving supporting companies in profits and saving rate of energy-saving projects slightly show negative impacts. Nevertheless, the growth rate and exporting ratio rise in COVID-19 period.

As shown in the results above, energy-saving equipment companies suffer the most influence in annual revenue and export, compared with the other groups. Our research can confirm hypothesis 3 (H_3), and conclude that different types of ESCOs are significantly different due to COVID-19.

To observe the annual change of energy saving projects between 2019 and 2020, Figure 4 is depicted with the distribution of various technology types. Energy-saving retrofit engineering is the most common projects with an average ratio of 38.55-41.46%, and it slightly declined in COVID-19 period. Contrarily, the promotion of energy performance guaranteed, and energy-saving equipment leasing in 2020 are completely competitive. This situation may be inferred that the end users of energy-saving equipment suffered financial constraints during infectious disease, and they took more conservative approaches in energy-saving strategy. As for energy share savings contracts, the item is stable from 14.38% to 14.13%. This business model needs multi-year finance from ESCOs. After several years of promotion, almost ESCOs have exhausted their own internal funds for previous share savings projects. They would not like to increase the amounts of share-savings, but prefer to increase the one-time payment energy-saving equipment sales. Therefore, the energy share-savings projects gradually decreased, and the proportion of equipment sales grew slightly.

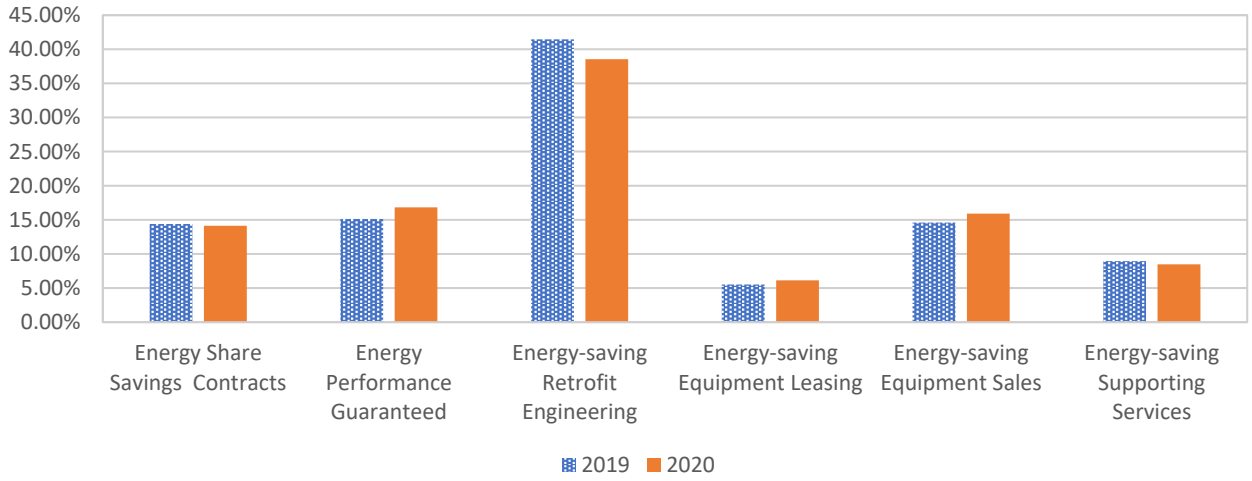

Figure 4 The Technical Proportion of Energy-Saving Projects

During the epidemic period, most governments adopt strict personnel control restrictions. Export is expected to suffer huge shock. Figure 5 shows the proportion of Taiwan's ESCOs exporting areas between 2019 and 2020. Because language, culture and economic development of Chinese market is the closest to the ones of Taiwan. Therefore, China is still the main export partner of Taiwan's ESCOs which accounted for 25.31%-31.83% of the total proportion. It is followed by Taiwan's secondary trade partners in the Southeast Asia, with Vietnam accounting for about 14.84%, and Thailand and Indonesia with 7.34% and 14.84% in 2020, respectively. Exports in other Southeast Asian countries like Philippines and Malaysia are relatively lower with 6.72% to 3.75% in 2020.

It can also be observed from Figure 5 that the export of Taiwan's ESCO to China from 2019 to 2020 is heavily declines. The possible causes should be inferred as the recent opposite political positions between Taiwan and China, and the blocked of international trade caused by the new epidemic.

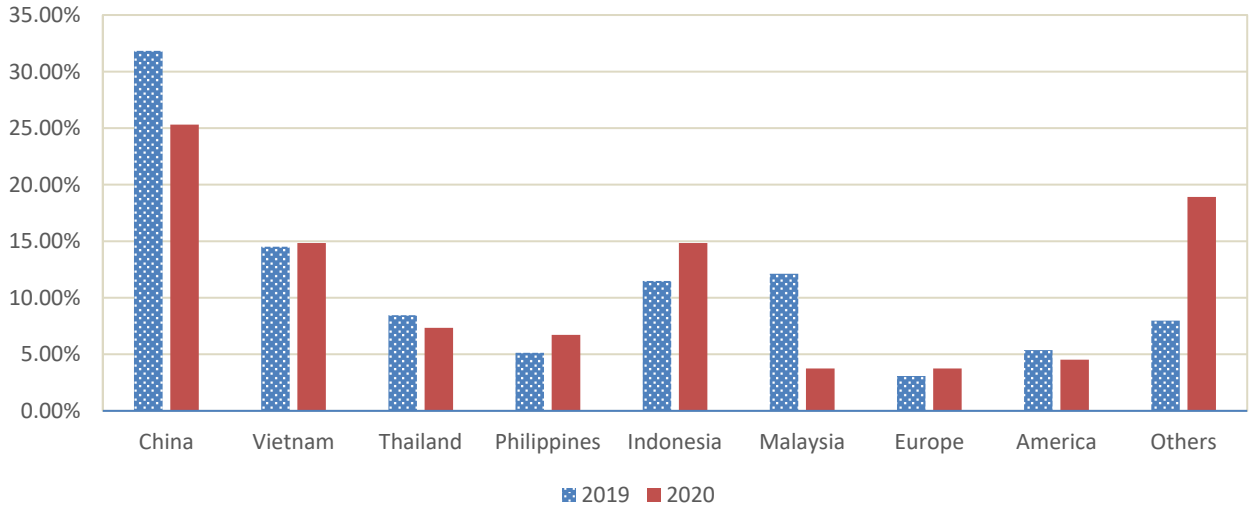

Figure 5 Proportion of Export Regions of Taiwan's ESCOs

In addition, the integrated proportion of countries in Southeast Asia has exceeded 40%. Overall, it has surpassed China's exporting share. However, although the proportion of exports in Southeast Asia has increased,

the exporting distribution and delivery of ESCOs in single country remains little amounts due to diverse languages, complex political situations, and the lack of international free trade agreements. In addition, owing to Taiwan's energy-saving products have gradually obtained international certification in recent years, Taiwan's international output ratios in Europe and other regions including Japan and the Middle East have also risen.

6. Conclusion

The COVID-19 pandemic has caused disruptions in many industries of the world. In numerous countries, although lockdowns are being lifted and workplaces are opening again, the decline of industrial output has been happened in the first half of 2020. We investigate the impact on the Taiwan's ESCO industry. To analyze the internal influences, we propose the methodology of event study integrated with industrial survey. Event study approach heavily relies on daily price fluctuation to estimate the capacity of impact on firm value. The fieldworks in industrial survey are auxiliary used to fill up the shortage of event study in unlisted companies. With the survey, we can estimate the decline of revenue due to COVID-19, and analyze the modification of international ESCO outputs.

In our study, we propose three hypotheses to be tested. On the aspect of event study, the hypothesis 1 is confirmed that Taiwan's ESCOs experienced significantly stock price drops, about 7.5% on March 2020, then rapidly price rebound. After the initial huge impact for several months, the whole ESCO industry recovered gradually original activities in August, 2020. As for industrial survey, the hypothesis 2 is confirmed that the value and export ratio of ESCOs significantly decline around COVID-19 event period. Our research also confirms the hypothesis 3 and conclude that the energy-saving equipment companies suffer the most influence in annual revenue and export, compared with the other groups.

Besides, the promotion of energy performance guaranteed, and energy-saving equipment leasing in 2020 are more competitive. This situation may be inferred that the end users of energy-saving equipment suffered financial constraints during infectious disease, and they took more conservative approaches to save energy. Simultaneously, ESCOs have exhausted their own internal funds for previous share savings projects. They would like to prefer to increase the one-time payment energy-saving equipment sales. Therefore, the energy share-savings projects gradually decreased, and the proportion of equipment sales grew slightly.

ESCOs rebounded after half year period. Their revenue, profit and export ratio have all suffered huge influences. The energy savings brought about by energy efficiency improvements yield a range of benefits. We suggest that the governments around the world have to promote the energy-saving projects executing universally in the COVID-19 period, especially support to energy-saving equipment companies and share saving projects.

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