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ENHANCING R&D IN TAIWANESE SMALL AND MEDIUM ENTERPRISES: AN ANALYSIS OF POST COVID-19 BUSINESS SURVIVAL STRATEGIES

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ABSTRACT

The COVID-19 pandemic significantly impacted businesses, particularly small and medium enterprises (SMEs). Despite numerous setbacks, some SMEs demonstrated resilience by adopting innovative survival strategies, including investment in research and development (R&D). This study investigates the extent of R&D investment among selected SMEs in Taiwan and its role in their survival during the pandemic. Using a mixed methods approach, data was collected through semi-structured questionnaires, with participants representing various SME categories until saturation was achieved. SME proprietors provided insights on how R&D investments contributed to their resilience. The findings indicate that 73.3% of respondents invested directly in R&D and 54.3% reported that R&D investments positively impacted their business survival during the pandemic. The study recommends that SMEs enhance their R&D capabilities by developing staff skills and allocating specific funds for R&D in their budgets to better withstand future disruptions.

Keywords: Research & development, small and medium enterprises, research & innovation, COVID-19.

INTRODUCTION

The COVID-19 pandemic had a profound impact on businesses worldwide, with small and medium enterprises (SMEs) being particularly hard hit. The pandemic is notably remembered for the severe lockdowns on businesses globally (Özoran et al., 2023). Following the outbreak of COVID-19, in Wuhan, China in December 2019, the virus quickly spread across the world causing widespread illness and death (World Health Organization, 2020). In response, Most countries imposed lockdowns, travel restrictions and quarantines, that led to a drastic halt in business activities for most SMEs, resulting in some even collapsing (International Labour Organization, 2020). Many emerging and vulnerable SMEs did not survive the long periods of business inactivity. In Nepal, for example, lockdowns severely weakened the economic and financial stability of enterprises, and the government's support was inadequate (Basnyat & Sharma, 2021).

While most countries experienced diminishing growth rates due to the adverse effects of COVID-19, Taiwan's gross domestic product (GDP) grew by 6.09 percent in 2021 (Nikkei Asia, 2021), marking its highest growth rate since 2010. This growth was driven by rising exports from Taiwan buoyed by high-tech products during a time when the rest of the world was in lockdown. However, the pandemic had varied impacts on different sectors: SMES in the energy sector saw a reduction in consumption, while those in electricity experienced increased demand (Nikkei Asia, 2021). Taiwan is home to several high performing industries, including airlines, electronic components, machine tools, petrochemicals, and automotive parts. Among these, SMEs in the information, communication technology (ICT) and semiconductor sectors managed to prevail and experience increased sales for some of their products despite the pandemic's challenges (Thiruchelvam, 2022).

COVID-19 infections in Taiwan started to escalate in May 2021 (Thiruchelvam, 2022). By 10th November 2022, the Taiwan Centre for Disease Control reported a total of 16,187,394 cases with 5,273,449 confirmed as COVID-19 positive, and 9,893 deaths (Taiwan Center for Disease Control, 2022). Despite these challenging conditions, Taiwan entrepreneurs implemented innovative business strategies to survive, with some SMEs thriving rather than failing. A key survival strategy was increased investment in Research and Development (R&D) (Akpan et al., 2022). According to Doloreux and Frigon, (2020) R&D involves a firm's deliberate efforts to research, gather information, innovate and develop new applications and technical knowledge to boost sales and gain a competitive advantage over other firms. This can include basic, applied or experimental research aimed at discovering new products and procedures, or improving existing ones.

The Government of Taiwan has actively promoted R&D to support and transform SMEs, helping them adapt to the digital economy and international economic and trade conditions. Measures include adopting cloud technology, offering coaching, enhancing manufacturing, encouraging structural innovation and supporting environmental protection (Small and Medium Enterprise Administration, 2021). Other national governments are also increasingly supporting researchers who integrate innovative ideas and practices into SMEs (Bhaskaran, 2006). Thanks to these innovative business interventions, Taiwan SMEs have continued to grow despite the COVID-19 crisis. Although 2020 was a weaker year for Taiwan's SMEs compared to 2019, businesses within this sector grew by 45.5 percent (Thiruchelvam, 2022). This remarkable growth is noteworthy, as Taiwan achieved the highest SME growth among advanced economies such as Australia, Hong Kong, New Zealand, and Singapore (CPA Australia Asia Pacific, 2021).

In Taiwan, a small and medium enterprise (SME) is defined as an enterprise with paid-in capital not exceeding NT$100 million and fewer than 200 regular employees (Small and Medium Enterprise Administration, 2021). By 2019, Taiwan had 1,491,420 SMEs, accounting for 97.65 percent of all enterprises. These SMEs employ over 9,054,000 people, or 78.73 percent of the workforce, an indicator of SMEs as the cornerstone of stability and job creation in Taiwan (Ministry of Economic Affairs ROC, 2022).

Extant literature focuses on how multi-national companies in Taiwan engage in R&D to improve their business, but there is a lack of data on SMEs. This gap underscores the need to conduct a comprehensive study on the extent to which SMEs in Taiwan invest and utilize R&D as a business survival strategy during crises. This study aims to examine the institutional preparedness of SMEs, the state of their R&D infrastructure, the competency of their human resources in R&D, and the attitude of top management towards R&D.

The goal of this study was to investigate the extent to which selected SMEs in Taiwan invest in R&D and how this investment contributed to their survival during the COVID-19 pandemic. The study had four research objectives: (i) to assess the level of R&D investment by SMEs in Taiwan; (ii) to investigate the impact of R&D on the survival of SMEs during the COVID-19 pandemic; (iii) to explore the sources of R&D information used by Taiwan SMEs; and (iv) to recommend strategies for improving R&D practices among Taiwan SMEs.

LITERATURE REVIEW

The COVID-19 pandemic revealed an unprecedented level of vulnerability among SMEs (Basnyat & Sharma, 2021). For SMEs to survive in such crisis environments, they must continually introduce innovative and dynamic business strategies, such as developing new products that resonate with customers. Fast-paced innovation is crucial for the success of SMEs (Kessler et al., 2007). These enterprises frequently introduce innovations to the market, refine their products based on customer feedback, and offer competitive prices (Smith & Reinertsen, 1992). Studies conducted in the U.S. revealed that SMEs are responsible for 50 percent of all innovations and 95 percent of radical innovations (Kessler et al., 2007). Radical innovations have the potential to increase SME sales and significantly improve business performance.

Role of R&D-Conscious Human Resources in SMEs

The government of Taiwan has come up with strategies to support small business start-ups, incubation, and innovation acceleration. Its goal is to create a high-quality entrepreneurial environment in Taiwan. Additionally, the Township Revitalization Project for Small and Medium Enterprises aims to promote industry transformation within townships by enhancing international trade and market expansion through digital innovation (Small and Medium Enterprise Administration, 2021). Transformational leadership within the government plays a crucial role in creating a vision that inspires and encourages the development of innovative ideas among SMEs. Taiwan's transformational leadership approach has been shown to enhance mindfulness, positive performance, self-efficacy, and green performance. (Sun et al., 2006; Chen et al., 2014). Transformational leadership begins with Human Resources (HR) communicating the strategic vision to employees. At this stage, HR focuses on recruiting and retaining an R&D conscious workforce. This workforce implements innovative practices, including the use of eco-friendly principles, improving environmental performance, reducing emissions, minimizing

material use in production and design, cutting costs and waste, and utilizing green raw materials while conserving use of electricity and water (Sun et al., 2006).

The Taiwanese Government has actively promoted R&D in biotechnology while maintaining strict regulations on stem cell therapy. To support this effort, several organizations have been established, including the Institute for Biotechnology and Medicine Industry, the Research Centre for Biotechnology & Medical Policy, and the National Research Program for Biopharmaceuticals. These organisations benefit from tax concessions and are encouraged to invest in the R&D of new pharmaceuticals and other biotech products (Chang, 2016).

R&D SME Infrastructure

The innovation orientation of SME can be assessed by examining their R&D expenditure (Bhaskaran, 2006). For example, SMEs in urbanised China allocate a considerable amount of their expenditure on R&D infrastructure. They invest in developing improved housing tailored to their markets and establish property rights for these facilities that are both institutional and socially attuned to customer needs and aspirations (Sa & Haila, 2021). Government expenditure on R&D infrastructure helps create an entrepreneurial ecosystem that supports SMEs by fostering an environment conductive to ambitious entrepreneurs, innovation, and economic growth (Cavallo et al., 2019).

It is also important to note the substantial investment in collaborative R&D. Strategic alliances may form between firms within the same industry or even between competitors (Harbison & Pekar, 1998). Competing SMEs can collaborate on research and innovation to gain a competitive advantage over large companies (Gnyawali & Park, 2009). Such collaboration typically occurs in international markets and can offer several benefits, including attracting more customers, increasing market share, increasing profits, and extending the lifecycle of new products. However, it is also argued that external sourcing of R&D may slow down innovation in SMEs and act as a barrier to rapid development (Kessler et al., 2007).

Dynamics of the SME Markets

Taiwanese SMEs focus significantly on increasing production volume while simultaneously diversifying their export market. Although marketing costs are relatively lower than the costs of investing in R&D or acquiring specialized knowledge, SMEs that leverage specialized knowledge and information tend to produce superior goods and services. The perceived benefits of these high-quality products and services foster customer loyalty. By investing in R&D, SMEs can continuously improve their products/services and explore new business opportunities thereby improving their overall performance (Siu et al., 2004).

To maximise the effectiveness of R&D, SMEs should build networks with various sources of innovations including government agencies, libraries, universities, research institutions, development corporations and industry partners. For example, in Australia, the government has played a crucial role in linking seafood retail SMEs with R&D networks, institutions and universities. These linkages have facilitated easier access to information and the adoption of innovations. Effective networking enables SMEs to establish closer relationships with government bodies, research and development corporations, universities and industry groups, enabling them to collaboratively and extensively engage in R&D activities (Bhaskaran, 2006).

Technological Collaboration

In Hsinchu *City,* universities and scientific research institutions are actively engaging with SMEs to enhance their performance. Notable institutions involved include the National Chiao Tung University, National Tsing Hua University, Chung Hua University and Yuanpei University. These collaborations have encouraged several scientists and engineers to leave their stable jobs and start their own enterprises that integrate technology with commerce. This synergy has contributed to transforming Hsinchu into a technological innovation hub, often referred to as the Silicon Valley of Taiwan. A similar development is also playing out in Zhongguancun area of the Peoples' Republic of China. However, there are key differences: Hsinchu City focuses on growing SMEs in the manufacturing sector and taps into local affordable labour, whereas Zhongguancun emphasise high-tech startup SMEs and attracts highly skilled university students. Despite these differences, both regions demonstrate that university-SME partnerships foster substantial R&D, which is largely endogenous—driven by self-innovation rather than imitation (Xianping, 2004).

SMEs in Taiwan have been working to cultivate a culture of internal learning and knowledge generation. This culture is supported by rewarding risk-taking, promoting teamwork, empowering employees and institutionalising cross-functional communication (Ellison et al., 1995). Some SMEs have further advanced their R&D efforts by developing requisite competencies in knowledge application and technology exploitation of in-house innovations. It should be noted at this point that the existing literature reviewed has not extensively explored how Taiwanese SMEs engage in R&D to enhance their business operations. This study seeks to address this gap in the literature.

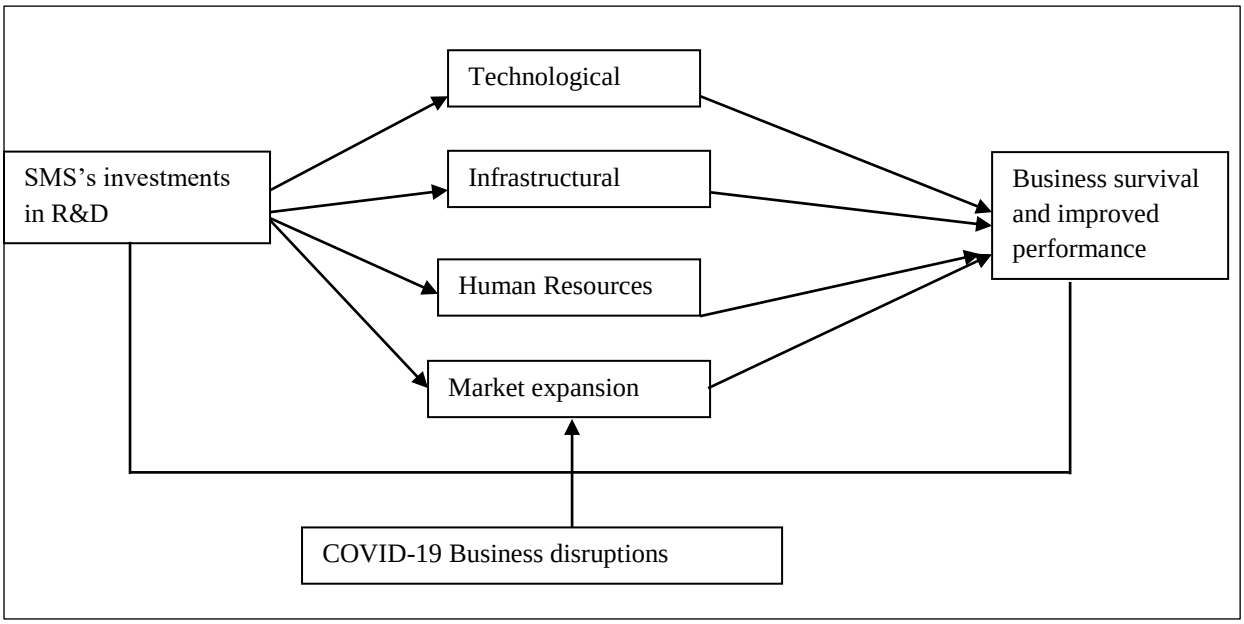
Theoretical Framework

This study is grounded in the Theory of Planned Behaviour (TPB), a standard model adapted from Fishbein and Ajzen's (1975) theory of planned behaviour. The TPB suggests that SMEs are likely to adopt certain research, innovation and development strategies to navigate business crises such as COVID-19. There is a well-established relationship between business survival and behaviour intentions. During a crisis, SMEs may choose to adjust their technology, infrastructure, human resources, as well as market strategies. According to the TPB, while SMEs may plan to modify these four constructs, they may lack precise knowledge about which exact construct or behaviour needs to be adjusted to deliver the desired effect (Tun & Hoang, 2023). Providing SME employees with the required technological tools and ensuring the effective utilisation of these technologies can enhance higher levels of employee creativity and innovation (Adeel et al., 2023). However, Ong (2022) observed that employee behaviour may sometimes become counterproductive and detrimental adversely affecting business operations and survival. In SMEs, such counterproductive work behaviours often manifest as aggression and deviations from planned innovation strategies (Berry et al., 2007; Douglas & Martinko, 2001; Robinson et al., 2013).

Based on the reviewed literature and the TPB model, a conceptual framework was developed to guide this study. Figure 1 illustrates the framework designed to help SMEs thrive during the COVID-19 pandemic or similar crises. SMEs must strategically plan and invest in four key areas: technology, infrastructure, human resources and market/customer satisfaction. An SME that excels in these areas—by advancing technology, establishing robust R&D infrastructure, employing competent staff, and constantly seeking customer feedback to expand its market—will be better positioned to navigate disruptions caused by COVID-19 or any comparable crisis.

Figure 1

Conceptual Framework for Taiwanese SME Investment in R&D



METHODOLOGY

This study employed a mixed-methods approach. Qualitative methods were used for sampling and data collection, while quantitative methods were applied to data collection and presentation of results. The study adopted an interpretive research design, which, according to Schwartz-Shea and Yanow (2011), involves analysing scientific work from a practical perspective. This research design integrates observation, dialogue and close reading within qualitative research. Interpretive researchers aim to make their assumptions explicit. This interpretive design consisted of two steps. The first step involved gathering and qualitatively analysing content related to R&D investments by Taiwanese SMEs, as discussed by Mayring (2019). This process aimed to develop a comprehensive understanding of the arguments Taiwanese SMEs use when investing in R&D. Relevant literature was sourced from Google Scholar and Taylor and Francis database (Huang & Mabon, 2022). The second step entailed distributing online semi-structured questionnaires to research participants to gather their views on R&D investments in SMEs (Febriani & Dewobroto, 2018).

While some scholars criticise single-industry studies for being too narrow, as is the case with this study focusing on Taiwanese SME R&D investments, it is important to recognise that such studies offer greater control over extraneous variations, such as industry-specific characteristics and problems (Bhaskaran, 2006). This study successfully delved into the nuances of R&D investments in SMEs, providing insights that could be replicated in other contexts and potentially generalised to other national and regional SME R&D scenarios.

A purposive sampling method was used to identify SMEs operating within dynamic and innovative environments. The Taiwan government had launched a plan to accelerate the transformation of SMEs across six core strategic areas: information & communications technology, semiconductors, 5G, cybersecurity, biotechnology, healthcare, defence capabilities, green energy and essential goods (Nikkei Asia, 2021). Therefore, the researchers specifically selected SMEs from these

six sectors. The SME proprietors were requested to share how their businesses survived the COVID-19 pandemic through the application of R&D. Additionally, a chain referral method was used, where current research participants recommended other potential study participants (King et al, 1994). To facilitate understanding, the questionnaires were available in both English and Mandarin, enabling respondents to read and answer in either language.

To ensure social distancing, some participants received links complete the online semi-structured questionnaire, while others were interviewed by phone. Further, contact was made through social media platforms such as Line, WhatsApp, Zoom, and Google Meet. Various participants from different categories of SMEs were chosen until data saturation was reached (Sa & Haila, 2021). Data collection was conducted between 15 September and 31 October, 2022, with each questionnaire taking approximately 15 to 20 minutes to complete. The research data was analysed thematically through reduction, presentation, and interpretation (Smith, 2015). The reduction process aimed to reach crucial data to address the main research objectives. Most of the qualitative data was codified and presented in quantitative form.

FINDINGS AND DISCUSSIONS

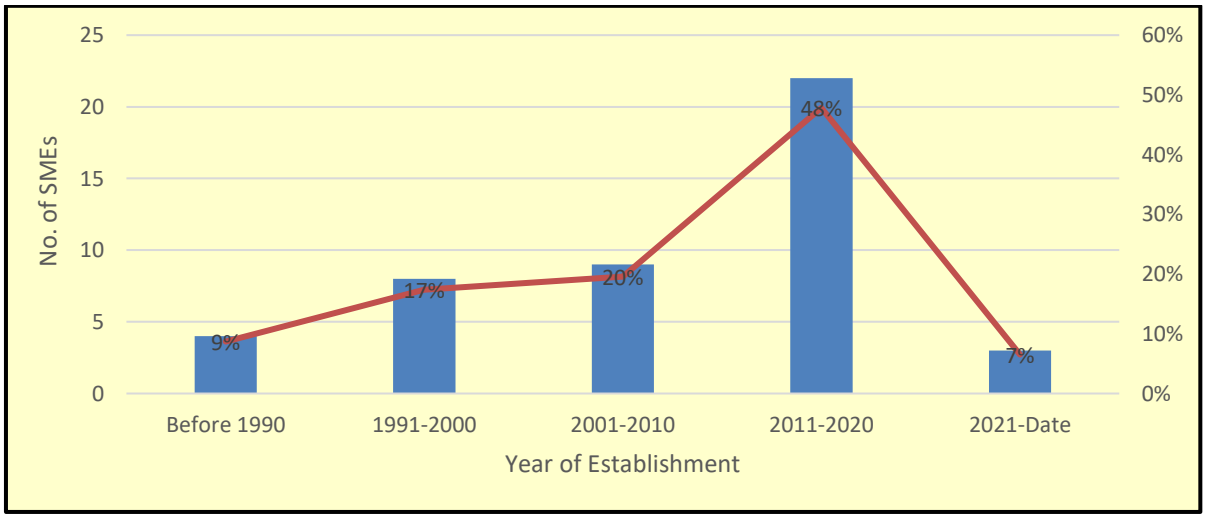
A total of 46 SME proprietors and representatives participated in the study. Data collection continued until saturation was achieved.

Characteristics of Study Participants

The researchers examined the years in which the SMEs were established. As illustrated in Figure 2, the majority 22 SMEs (47.8%), were established between 2011 and 2020. Further analysis of the data revealed that 4 SMEs (8.7%) were set up before 1990, and 8 SMEs (14.4%) were established between 1991 and 2000. Additionally, 9 SMEs (19.6%) were established between 2001 and 2010, with a few established after 2021. Multiple regression analyses were conducted to explore the relationship between R&D adoption and the year of SME establishment. The analysis found no significant relationship (Bhaskaran, 2006).

Figure 2

Year of Establishment of SMEs

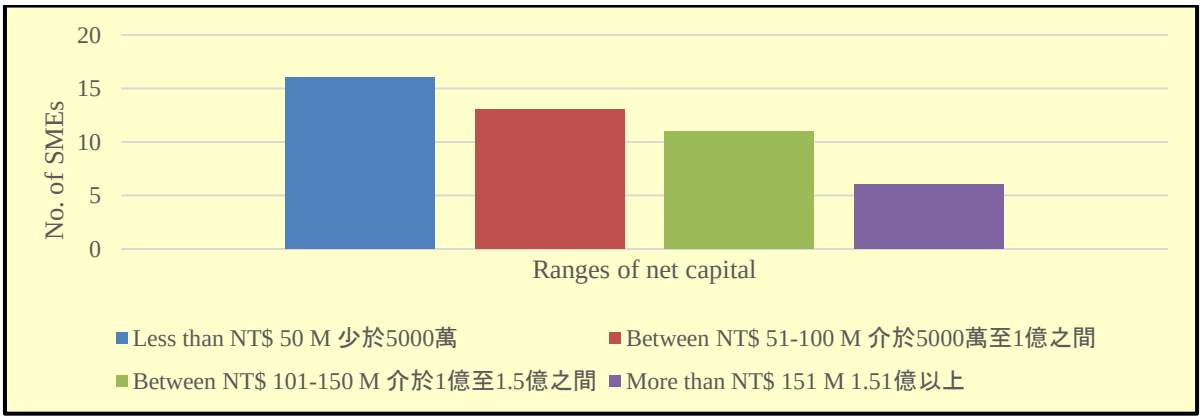


(*Source:* Field data, n=46).

Figure 3 illustrates the distribution of net capital among SMEs. The largest group, comprising 16 SMEs (34.8%), had net capital of less than NTD 50 million. This was followed by 11 SMEs (23.9%) with net capital between NTD 51 and 100 million. Another 11 SMEs (23.9%) had net capital ranging from 101 to 150 million. Only 6 SMEs (13%) had net capital exceeding 151 million.

Figure 3

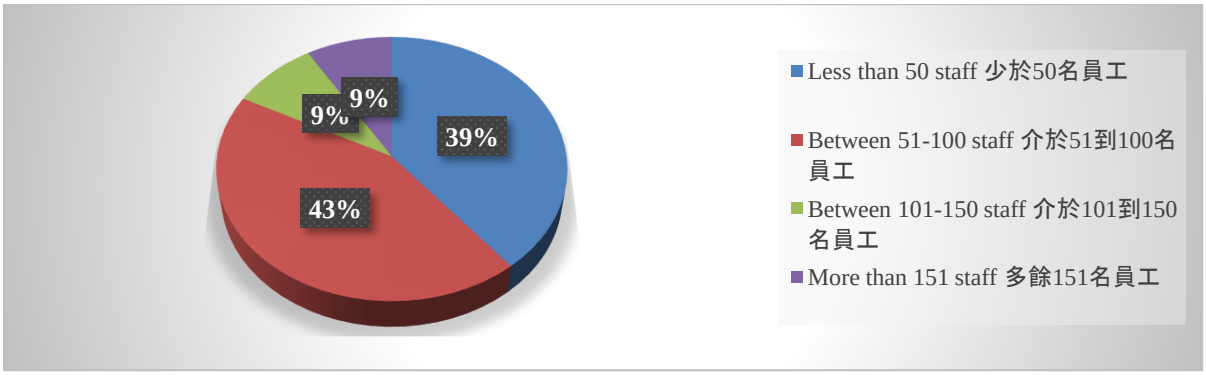
Net Capital of SMEs



A review of staff numbers revealed that majority of SMEs, 20 (43.5%), employed between 51 and 100 staff members, as shown in Figure 4. This was followed by 18 SMEs (39.1%) that employed fewer than 50 staff members. Only 4 SMEs (8.7%) had between 101 and 150 employees, and an equal number had more than 150 workers. Documentary evidence showed that by 1995, over 90% of Taiwan firms were categorised as SMEs with half of these employing fewer than 10 staff members (Ministry of Economic Affairs ROC, 2022). Many of these employees were family members or relatives who often worked for little or no pay (Chen et al., 2014). Historically, Taiwan SMEs prefer lean staffing structures. Further research on SMEs in Taiwan indicated that 656 SMEs (69.4%) had fewer than 30 staff members, 205 SMEs (23.5%) had between 31 and 100 staff members and only 63 SMEs (7.2%) employed more than 100 staff members (Yeh-Yun Lin & Yi-Ching, 2007).

Figure 4

Number of Staff Employees



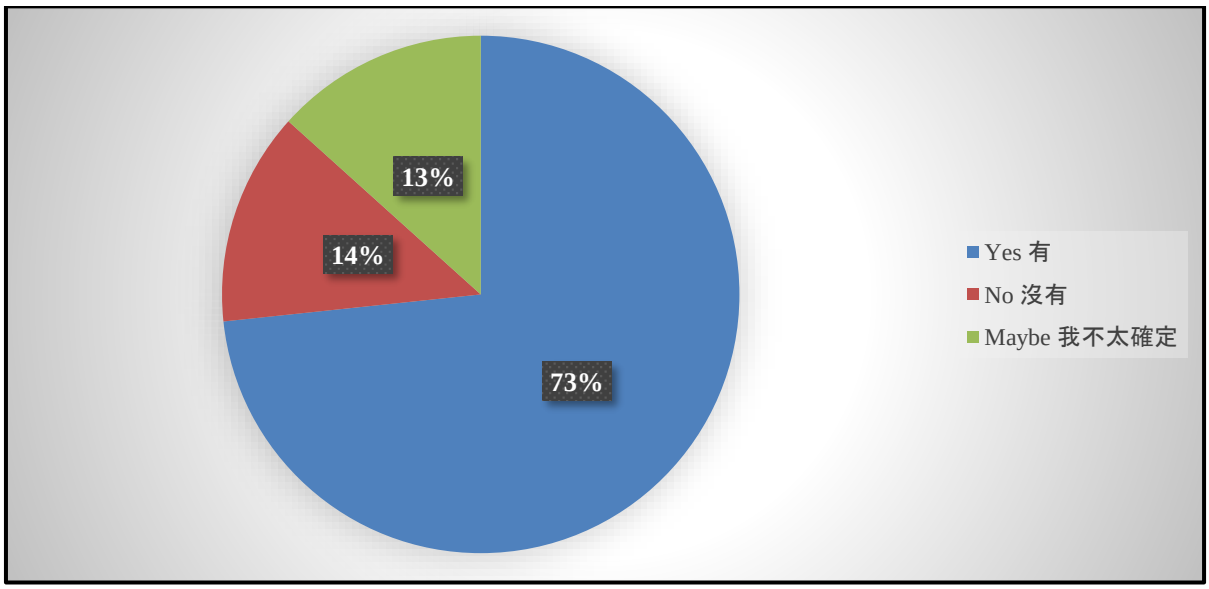
Extent of Investing in R&D

The study participants were asked whether they directly invest funds into R&D. A total of 33 participants (73.3%) indicated that they do, while 6 (13.3%) reported that they do not, and another 6 (13.3%) were unsure, as shown in Figure 5. Previous related studies showed that Taiwanese SMEs often allocate substantial funds to R&D to enhance firm performance, foster innovation and improve operational efficiency (Delios & Beamish, 1999; Hitt et al., 1994; Kotabe et al., 2002).

Even though driving entrepreneurship, economic growth and social development is primarily the public sector's responsibility, various studies show the importance of private sector investment in R&D. This investment is crucial for fostering an innovative economic environment, advancing technology, addressing entrepreneurs' risk aversion, and optimizing R&D resources. Additionally, the provision of R&D soft loans, internal R&D financing, and adjustments to R&D organisational and managerial structures are key areas of focus. For effective R&D investment, both the public and private sectors must collaborate to create flexible policies, support craft innovation, enhance entrepreneurship and ensure continuous communication and exchange between the public and private sector and non-governmental organisations (Vatavu et al., 2021).

Figure 5

Investment in R&D

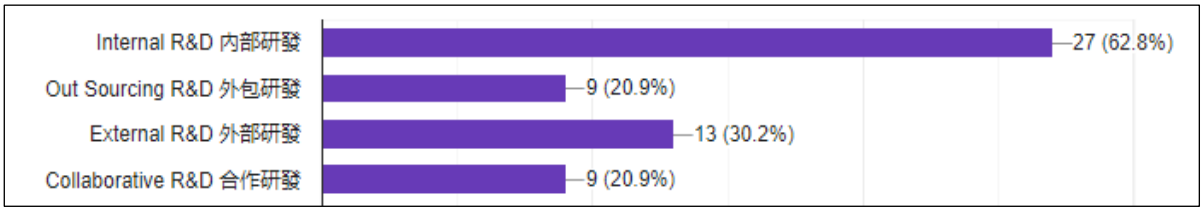


Out of the 73.3 percent of SMEs that invested in R&D, Figure 6 shows that the majority, 27 SMEs (62.8%) focused on internal R&D. The figure also shows that 13 SMEs (30.2%) invested in external R&D while 9 SMEs (20.9%) invested in both outsourcing R&D and collaborative R&D. These findings align with an earlier study on Taiwanese SMEs which found that more than half of the enterprises conducted in-house R&D, while 40 percent outsourced their R&D activities (Yeh-Yun Lin & Yi-Ching, 2007). Between 2002 and 2005, Taiwan SMEs achieved a remarkable 34 percent compound annual growth rate by investing in internal R&D, which provided them with a competitive advantage. However, such closed business models are often challenged by rising R&D costs. To address these challenges, SMEs can benefit from investing in external and collaborative R&D. Joint R&D efforts are complementary, although they can sometimes lead to intellectual property (IP) disputes and

infringements. Partners may encounter issues if they feel that the collaborative R&D is not meeting their expectations in the competitive business environment (Hu & Tsai, 2006).

Figure 6

Categories of R&D Investments by Taiwanese SMEs



Concerning the area of focus for R&D investment, Table 1 shows that nearly a third of the SMEs i.e., 40 SMEs (32.8%) surveyed in the study are actively investing in technological R&D. This is followed by 29 SMEs (23.8%) investing in market presence, and 24 SMEs (19.7%) focusing on R&D infrastructure. The research findings indicate that SMEs in Taiwan are focused on technology and are increasingly leveraging e-commerce to boost online revenue through digital sales, and online payment platforms such as PayPal, Apple Pay and WeChat Pay. Additionally, a significant majority of small Taiwanese businesses are benefiting from investments in social media and cybersecurity (CPA Australia Asia Pacific, 2021). These R&D investments align with TPB and highlight how SMEs are strategically adapting their business practices to navigate the challenges posed by the COVID-19 pandemic.

Table 1

Key Areas of R&D Investment by Taiwanese SMEs

No.	Variable	Frequency	Percentage
1	Technology	40	32.8%
2	Market presence and customer satisfaction	29	23.8%
3	R&D infrastructure	24	19.7%
4	Human resource competence	18	14.7%
5	Green transformation leadership/Environmental sustainability	11	9%
	Total	122	100

Investment in R&D enables SMEs to produce new knowledge, integrate existing and new insights, and enhance various aspects of their operations, including production, branding, marketing and delivery. Further, research by Hu and Tsai (2006) and Li and Hu (2013) highlighted that Taiwanese SMEs used foreign direct investments (FDI) to channel their R&D efforts into achieving technological efficiencies. This FDI not only directly improved technological efficiencies, but also indirectly enhanced production for the global market (Li & Hu, 2013). This aligns with the 46.2 percent of the SMEs in our study that allocate their R&D efforts towards strengthening market presence and enhancing customer satisfaction. Existing literature indicates that SMEs require access to cross-regional knowledge in R&D to avoid the pitfalls of outdated technologies and shrinking markets (Hu et al., 2018).

For instance, the 24 SMEs (19.7%) which focus on R&D infrastructure are working to develop supportive functions and innovative infrastructure, such as partnerships with universities and research

centres, which can drive R&D activities. Successful investment in R&D infrastructure depends on both intra- and inter-subsystem interactions and knowledge flow, promoting collaboration between SMEs and innovation systems (Hu et al., 2018).

It is Interestingly, although it represents a smaller segment, 9 percent of the respondents invest in R&D related to green transformation, renewable energy and environmental conservation. Taiwan's support for the Copenhagen Accord, which aimed to reduce greenhouse gas emissions by at least 30 percent by 2020 (Hu et al., 2013), reflects a broader global trend. As the demand for clean energy rises, driven by the need to address climate change, private-sector involvement—including that of SMEs—is crucial. Even minimal investments in green R&D, if effectively mobilised, can strategically build up to significant private funding for green infrastructure projects. For the world to adhere to the target of limiting temperature rise to below 2 degrees Celsius and to support sustainable development in developing countries through low-carbon economic development, it is crucial for the private, public and global sectors to accelerate their efforts. Governments can further support this by creating enabling environments for SMEs that lower the risks and costs associated with investing in green technology R&D (Hu et al., 2013).

Investment in R&D and COVID-19 Business Survival

A significant proportion of respondents, 39 (84.7%) reported that the COVID-19 pandemic negatively impacted their businesses. In contrast, 5 respondents (10.9%) did not experience any negative impact, while 2 respondents (2.2%) were unsure. Despite the widespread impact, the CPA Australia Asia - Pacific Small Business Survey 2020–2021 revealed that Taiwan SMEs were among the least affected by the pandemic in the Asia Pacific region (CPA Australia Asia Pacific, 2021). This relative resilience was partly attributed to their strong focus on developing new payment technologies and enhancing customer satisfaction.

Table 2

Impact of COVID-19 on Taiwanese SMEs

No.	Variable	Response	Percentage
1	Loss of business sales. 業務及銷售損失	34	58.7%
2	Inability to recover recurrent expenses (rent, salaries and other business). 無法正常支付周期性支出 (租金、工資或其他業務帳單)	22	37.9%
3	Increase in fraud. 欺诈增加	1	1.7%
4	Forced layoffs. 被迫裁员	1	1.7%
	Total	58	100

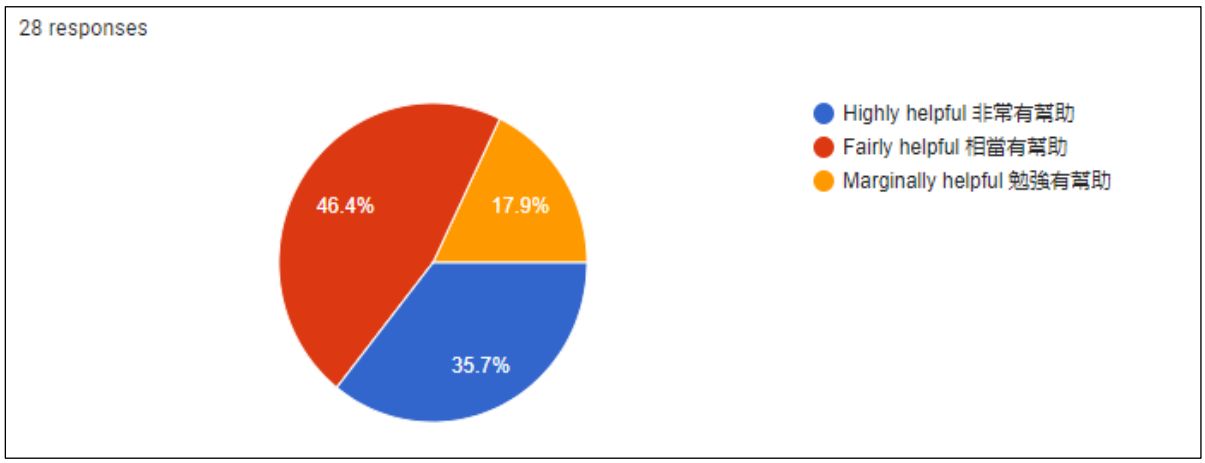
Table 2 shows that the most significant negative impact of COVID-19 was a decrease in business sales, reported by 34 respondents (58.7%). This was followed by difficulties in paying bills, according to 22 respondents (37.9%). Other challenges included increase in fraud and the necessity to lay off valued staff members. Taiwan's SMEs experienced an overall deteriorating economic environment, difficulties in market expansion and rising costs due to the pandemic. The costs of maintaining staff during periods of low or no productivity were particularly detrimental in 2020. In response, these SMEs sought to mitigate these challenges by investing in technology, such as automation, to reduce staffing needs or reallocate staff to perform higher-value tasks (CPA Australia Asia Pacific, 2021).

As to whether investing in R&D had a positive impact on the business survival of Taiwanese SMEs, the field data revealed that 25 respondents (54.3%) believed that investing in R&D positively impacted the survival of Taiwan SMEs. Conversely, 16 respondents (34.8%) were uncertain about the impact while 5 respondents (10.9%) felt that investing in R&D had no positive impact. For Taiwanese SMEs operating in the textile and electronics industries, R&D was considered as key for survival and success. These SMEs developed R&D capabilities, implemented quality control circles, engaged in group learning, and pursued continuous improvement to maintain their business (Chiao et al., 2006). The Government of Taiwan has played a pivotal role in influencing SMEs to invest in R&D during the COVID-19 crisis. The government's influence is evident from increased R&D expenditure in the digitalisation sector (Kotlebova et al., 2020). For instance, the Taiwan government's investment in developing industrial parks has enabled the Industrial Technology Research Institute to incubate approximately 270 innovative SMEs in the industry and technology sector (Vatavu et al., 2021).

SMEs in Taiwan have shown moderate resilience despite the uncertainties caused by COVID-19. A related study revealed that 46 percent of Taiwan SMEs experienced business growth in 2020, with 56 percent of the SMEs reporting growth in 2021 (Thiruchelvam, 2022). To support this growth and bolster RD activities, the Central Bank of Taiwan approved more than NT$400 billion (USD 14.4 billion) in loans to assist SMEs affected by the pandemic (Kuo, 2021). This financial support aimed to enhance SMEs' R&D efforts and ensure that they continue to play a vital role in revitalizing the economy.

Figure 7

Effectiveness off R&D Investment for SMEs during COVID-19 Crisis



Regarding the perceived effectiveness of R&D in aiding SME survival during the COVID-19 crisis, Figure 7 shows that 13 respondents (46.4%) found investing in R&D to be fairly helpful. Another 10 respondents (35.7%) considered it very helpful, while 5 respondents (17.9%) declared that it was marginally helpful. Before the COVID-19 era, Taiwanese SMEs had already been actively engaging in R&D to increase productivity, enhance product quality, lower production costs, develop new products, increase production flexibility and standardise production procedures (Chiao et al., 2006; Small and Medium Enterprise Administration, 2021). As a result, many SMEs were able to navigate the crisis successfully by leveraging pre-existing R&D innovations. According to Liao (2019) the role of R&D in SME management has evolved from focusing on product and service innovation to a more coordinative and supportive role in overall business innovation. R&D now assists SMEs to improve their specific skills and expertise for more effective resource deployment and management.

Table 3 highlights several key benefits SMEs gain from investing in R&D. These include: introducing new innovations to the market (25 respondents, 9.9%), creating economies of scale (23 respondents, 9.1%), increasing return on investment (22 respondents, 8.7%) and promoting product novelty (22 respondents, 8.7%). Other benefits include mitigating business risks, increasing profitability, market segmentation, improved packaging and gaining pricing freedom among others. These findings align closely with existing literature, which highlights similar benefits accruing from R&D investment such as; product and process innovation, improved export performance, competitive advantages, specialized marketing capabilities and standardization (Kotabe et al,.2002; Nassimbeni, 2001). The 20 respondents (7.9%) who stated increased profitability from investing in R&D concur with Yang et al. (2010) who found out that SMEs that invest more heavily in R&D achieved higher profitability. The profitability of innovative SMEs normally surpasses that of non-innovative SMEs, partly due to short-term profit-enhancing effect from patents obtained through R&D (Huang & Hou, 2019).

Table 3

Advantages of R&D Investments for SMEs

No.	Variable	Response	Percentage
1	Introduction of new innovations to the market 將新的想法及創意引入市場	25	9.9%
2	Creation of economies of scale. 創造規模經濟	23	9.1%
3	Increased return on investment. 增加投資回報	22	8.7%
4	Promotion of product novelty. 促進產品新穎性	22	8.7%
5	Enhanced market segmentation. 市場區隔	21	8.4%
6	Increased profitability. 提高收益率	20	7.9%
7	Mitigation of business risk. 降低業務風險	19	7.6%
8	Greater pricing freedom. 得到定價自由	17	6.7%
9	Improvement in packaging. 產品包裝進步	16	6.3%
10	Elicitation of customer feedback. 可以從客戶端得到更多反饋	16	6.3%
11	Registered ownership of innovations (patents, trademarks and licensing). 通過專利、商標和註冊所許可的創新所有權	14	5.5%
12	Compliance with institutional standards. 達到公司的共同標準	12	4.7%
13	Secured long-term viability of the enterprise. 確保企業的長期生存能力	11	4.3%
14	Enhanced brand equity and reputation. 提高品牌資產及聲譽	8	3.2%
15	Improved information security. 改善信息安全	5	1.9%
16	Expanded Internet opportunities. 扩大互联网机会	2	0.8%
	Total	253	100

Investment in R&D indeed offers numerous benefits for SMEs, enhancing services, production, marketing and delivery, as noted by over 40 percent of respondents in the study (Hu et al., 2018). Additionally, SMEs with management training in R&D tend to show higher innovation levels, leading to more patents and trademarks, as indicated by 15 respondents (5.5%). Effective R&D investment enables SMEs to introduce new products, implement technological changes in both processes and products and develop new prototypes, culminating in the creation and registration of new intellectual properties for SME (Xie et al., 2013).

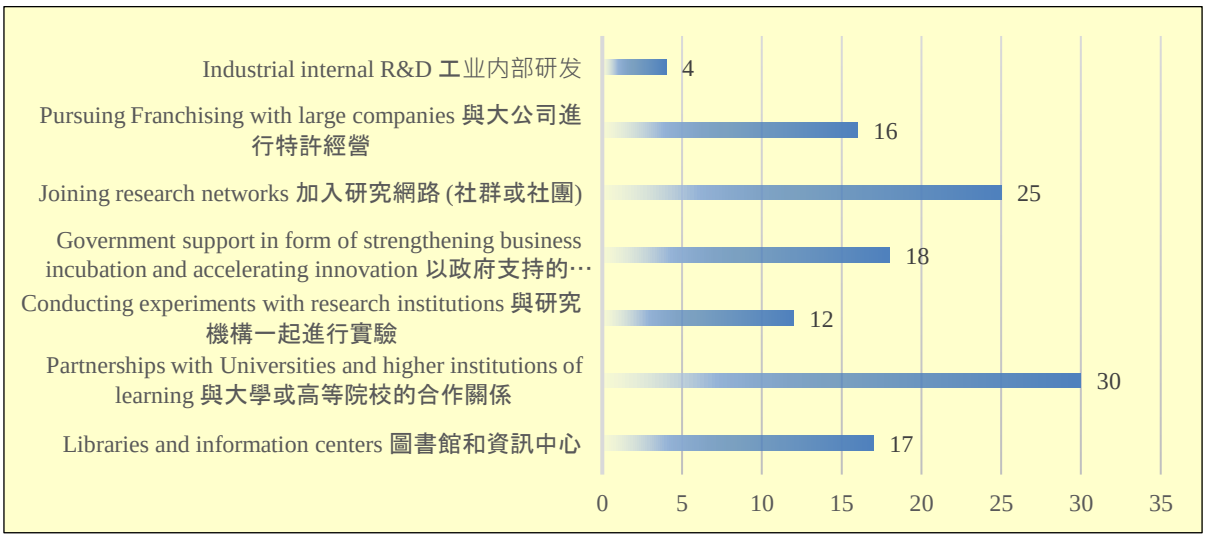
Sources of R&D Information

Febriani and Dewobroto (2018) noted that SMEs often struggle to identify the exact sources of R&D information and the quality of researchers who can address their challenges. Figure 8 illustrates the

various sources of R&D information available to Taiwanese SMEs. The top three sources identified by respondents were: (i) Partnerships with universities and institutions of higher education: 30 respondents (24.6%) favoured this approach. (ii) Joining research networks: 25 respondents (20.5%) preferred this method. (iii) Conducting experiments with research institution and the government: Both categories were supported by 18 respondents (14.8%). The Taiwanese government plays a crucial role in supporting R&D for SMEs and is dedicated to advancing domestic industrial technology. Government support includes budgeting and subsidizing SME R&D expenditure for industrial technology. The Ministry of Economic Affairs (MOEA) specifically focuses on the competitiveness of the SME domestic industry. The government further funds SMEs to outsource joint R&D efforts, promotes value added innovation and helps secure intellectual property protections, including patents, designs, trademarks and trade secrets (Hu & Tsai, 2006). In Pakistan, government support for SMEs in the Swat valley includes providing R&D information on technology, training, finance, capital and subsidies. These measures aim to foster SME development and enhance business performance (Khan et al, 2020).

Figure 8

SME Sources of R&D Information



However, it should be noted that limited proficiency in a language of communication like English or Mandarin can impede SMEs from accessing R&D information. Additionally, financial constraints and inadequate business and personal networks can exacerbate difficulties in obtaining relevant R&D information, hindering the introduction of innovations within SMEs (Bhaskaran, 2006).

Challenges faced by SMEs Investing in R&D

Table 4 shows that 30 respondents (23.2%) identified rising R&D costs as a significant challenge. Further, 24 respondents (18.6%) pointed to uncertainties in technological developments while 21 respondents (16.3%) mentioned the high-risk nature of R&D investments and innovations. Other challenges include a shortage of resources to invest in R&D (14.7%), lack of support from top management (6.3%), and issues with incompetent R&D consultants (8.5%).

The shortage of resources for R&D, as noted by Chiao et al (2006), is often attributed to limited R&D capabilities. Despite the tax benefits for R&D expenditure in Taiwan, some SMEs find the R&D

reporting procedures complicated and bothersome, leading to underreporting of their actual R&D investments (Chiao et al, .2006). This underperformance in technology can be attributed to the relatively poor short-term returns on R&D investment. According to CPA Australia Asia Pacific (2021), only 31.7 percent of SMEs that invested in R&D in 2020 saw an improvement in profitability.

Further constraints on R&D activities in SMEs include a lack of external innovation partners, limited financial resources, high development risks, and insufficient information on new technologies (Xie et al., 2013). Similar challenges were echoed by the study participants, who identified the shortage of technical R&D experts, together with shortage of financial capital, lack of technical R&D information and the high-cost/risk of innovation as major barriers to R&D (Xie et al., 2010). Further, the problem of incompetent R&D consultants has been highlighted in related studies conducted in Malaysia. Despite entrepreneurship being a core module in higher education institutions, there has been relatively little entrepreneurial activity (GEM, 2017). This is mainly attributed to millennials being less entrepreneurial (Dobson et al., 2017), declining entrepreneurial attitude, and lack of entrepreneurial competence (Benamar, 2016).

Table 4

Challenges Encountered by Taiwanese SMEs in R&D Investment

No.	Variable	Count	Percentage
1	Rising R&D costs. 研發成本提高	30	23.2 %
2	Uncertainty in technological developments. 技術發展的不確定性	24	18.6 %
3	High risk investments associated with innovations. 高風險的創新投資	21	16.3 %
4	Insufficient resources for large-scale innovations. 缺乏投資大規模創新的資源	19	14.7 %
5	Inadequate strategic alliances. 不適當的結盟	14	10.8 %
6	Limited competent consultants for outsourcing. 對於外部採辦(外包)不稱職的顧問	11	8.5 %
7	Lack of support from top management. 缺乏高層管理人員的支持	8	6.3 %
8	Challenges in managing global R&D teams. 挑战全球研发团队的管理	2	1.6 %
	Total	129	100

Strategies for Improving R&D in Taiwan SMEs

Table 5 presents suggestions from study participants on overcoming the challenges faced by SMEs in investing in R&D. The top three suggestions were as follows: (i) institutionalise teamwork and enhance cross-functional communication during R&D activities (21.9%); (ii) foster a culture of internal learning and knowledge generation within SMEs (20.8%) and (iii) develop necessary competencies to effectively leverage technology (17.7%). Additional suggestions included rewarding staff who significantly contribute to R&D, and increasing government support for R&D initiatives in SMEs. Studies indicate a positive and significant relationship between incentivising staff who contribute to R&D and improving business performance in SMEs (Ramli & Senin, 2021). Furthermore, investing in essential R&D infrastructure can enhance process innovations which leads to cost reduction, expanded production capacity and improved quality (Chiao et al., 2006).

Table 5

Suggestions for Overcoming Challenges Faced by Taiwanese SMEs in R&D Investment

No.	Variable	Response	Percentage
1	Institutionalise teamwork, empowerment and cross-functional communication. 將「團隊合作」、「授權許可」及「跨職能溝通」制度化	21	21.9%
2	Foster a climate that encourages internal learning and knowledge generation within SMEs. 營造鼓勵內部學習互相交流知識的氛圍	20	20.8%
3	Build essential competencies in knowledge application and technology exploitation. 在知識應用和技術開發方面建立必要的能力	17	17.7%
4	Implement public policies to assist SMEs with R&D tasks, addressing their resource and staffing constraints. 因為其資源和人員配備有限，所以政府應採取公共政策，協助中小企業完成一些研發任務	15	15.6%
5	Cultivate a culture that rewards risk-taking. 發展與獎勵冒險的企業文化	12	12.5%
6	Consider outsourcing R&D. 研發外包	9	9.4%
7	Develop skills in boundary spanning. 發展有關「跨界溝通」的技能	2	2.1%
	Total	96	100

Requisite competencies in knowledge application and technology exploitation can be developed through re-engineering entrepreneurial education in higher education institutions (HEIs). Multidisciplinary learning environment in HEIs should focus on strengthening experiential learning which focuses on taking calculated business risks to develop R&D entrepreneurial skills. According to Yong (2022), creating an appropriate learning environment and adopting effective pedagogical strategies, which appeal to students' psychological needs, are crucial for nurturing entrepreneurial competencies. These competencies are vital for students who will become future drivers of R&D in SMEs.

A total of 15 respondents (15.6%) suggested that the government implement public policies to assist SMEs with R&D tasks, given their resource and staffing constraints. Despite limited funding, several relevant funds and Acts have been established, including the Air Pollution Fee and Fund, Renewable Energy Development Act, Energy Management Act, Building Act, EIA Act and Air Pollution Control Act. Nonetheless, the Taiwan government should consider developing policies that promote more substantial investments in R&D by SMEs (Hu et al., 2013).

Since SMEs represent majority of the businesses in Taiwan, it is crucial for the government to enhance its support for R&D investments. This support will enable SMEs to create more jobs and contribute to economic development. To achieve this, the government should consider increasing public expenditure on R&D, encouraging the work of R&D experts in universities and research institutions, and facilitating SMEs' access to external R&D resources, an innovative economic environment and specialised R&D human capital (Castaño et al., 2016).

CONCLUSION, LIMITATIONS, IMPLICATIONS, AND FUTURE RESEARCH DIRECTIONS

This study examined the role of R&D investment by Taiwanese SMEs in their survival and performance during the Covid-19 pandemic. It has been established that Taiwanese SMEs invest significantly in R&D to enhance firm performance, foster innovation and improve operational efficiency. These investments aim to advance technology and facilitate market expansion. Taiwan SMEs leverage technology to maximise e-commerce, boost online revenue through digital sales, and utilize various online payment platforms. According to TPB, SMEs are intensifying R&D to enhance production capabilities for the global market. Currently, Taiwanese SMEs have established a strong presence in global markets and are committed to meet the needs of their international customers.

Key benefits of R&D investment for Taiwanese SMEs include: product and process innovation, creation of economies of scale, increased return on investment, promotion of product novelty, improved export performance, competitive advantages, specialized marketing capabilities, and standardization. However, these benefits are countered by challenges such as rising costs of R&D, uncertainty in technological developments, high-risk investments, resource shortages, lack of support from top management, and reliance on incompetent R&D consultants.

Given the significant level of business innovation in Taiwan, which should be reflected in intellectual property protection, SME development institutions and policymakers should leverage on this R&D investment. It is crucial to cultivate more SME start-ups, encourage innovation, and implement policies that support enterprise growth, regardless of disruptions like COVID-19.

Due to constraints in time and human resources, the study encountered several limitations. Researchers were only able to engage with SMES in Taipei. Additionally, one researcher faced language barrier communicating in Mandarin, requiring the service of interpreters. This could have led to potential distortions in the original meaning or context of the discussion. Despite these challenges, the researchers made efforts to address these limitations by engaging professional translators and conducting representative studies.

Looking ahead, SMEs should consider the following recommendations to improve their R&D investment strategies based on the study's findings. It is essential for SMEs to enhance their staff's R&D skills to better navigate future business disruptions like COVID-19. SME proprietors should allocate specific funds for R&D activities when budgeting for their enterprises. Collaboration with competitors can help SMEs create economies of scale, mitigate risks, and leverage resources. Furthermore, SMEs should reward and incentivise staff who actively contribute to R&D efforts. The Government of Taiwan is encouraged to develop a public policy focused on R&D that supports SMEs by providing access to R&D experts. The registration process for patents and other intellectual properties developed by SMEs should be streamlined. Lastly, higher education institutions should strengthen experiential learning in entrepreneurial studies. Universities, colleges, research institutes and libraries should establish linkages with SMEs to provide up-to-date R&D information. Both the public and private sectors should utilise these linkages to enhance innovation financing and implement flexible policies that foster entrepreneurship.

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