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ASSESSING THE ROLE OF VENTURE CAPITAL AND PRIVATE EQUITY INVESTMENT IN FINANCING INNOVATIONS IN GREEN TECHNOLOGY

Key points:

- *Innovations in green technologies (greentech) are essential to drive the net-zero transition through advances such as clean vehicles, energy efficiency, and renewable energy. Greentech firms, often small businesses or start-ups, may face significant financing challenges despite their strong growth potential. Consequently, venture capital and private equity (VCPE) investors have become key financial backers of these firms. Their total investments in these firms are estimated to have grown by an average of 22% per year over the past decade, reaching US$494 billion in 2023. This increase in VCPE investments coincides with a rapid increase in greentech innovations, reflected by an estimated average annual growth of 12% in greentech patents over the same period, with greentech firms in the Asia-Pacific region being the largest contributor.*

- *In this context, this study examines how VCPE investment drives greentech innovations. Beyond addressing the challenges of financing greentech companies, we assess the contribution of non-financial support from VCPE investors, such as technological expertise, managerial skills, and industry experience. We also investigate potential barriers to VCPE investment and discuss policy implications for addressing these challenges. The findings offer insights into how to strengthen Hong Kong's role as an international green finance centre.*

- *Our empirical results indicate that, relative to greentech firms without VCPE investment, VCPE investment contributed an additional annualised growth of 1.7% in the number of greentech patents for their investees from 2013 to 2023. The innovation gains are estimated to be greater when VCPE investors provide additional non-financial support, such as access to new experts and leadership changes, or when the investment is made by VCPE investors with experience investing in greentech firms. In addition, the results show that the operational efficiency of greentech firms is boosted by VCPE investment and non-financial support.*

- *However, VCPE investors are found to be relatively reluctant to invest in lesser-known greentech firms despite their strong potential, possibly due to a lack of information. To*

address this issue, the public sector could play a role in identifying and investing in promising but lesser-known firms, thereby enhancing their visibility and attractiveness to VCPE investors, as our results suggest that every dollar of public investment in these firms would lead to about $0.2 of VCPE investment.

- *In summary, our findings suggest two policy implications for addressing the challenges of financing greentech innovations. First, it would be beneficial to encourage greater participation from VCPE investors, particularly those with experience investing in greentech firms, as they could provide both financing and non-financial support to drive the innovation capabilities and operational efficiency of their investees. Second, the public sector should take the lead in identifying and investing in promising but lesser-known greentech firms, helping them attract more private capital and unlock their growth potential.*

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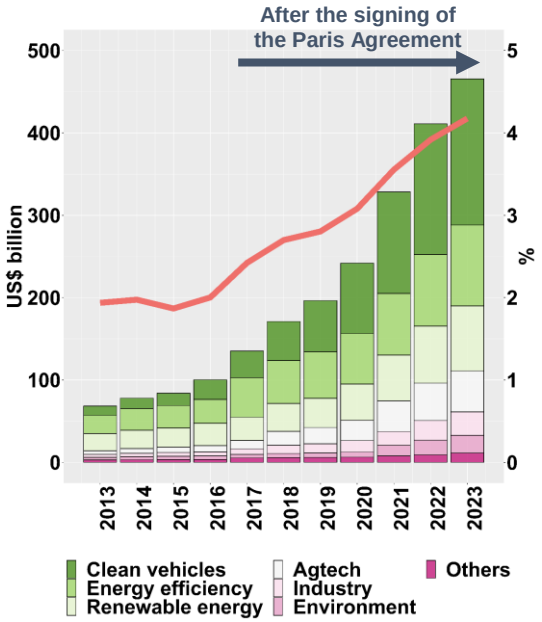
1. INTRODUCTION

Innovations in green technologies (greentech) are essential to drive the net-zero transition through advances such as clean vehicles, energy efficiency, and renewable energy. Greentech firms, often small businesses or start-ups, may face significant financing challenges despite their strong growth potential. Consequently, venture capital and private equity (VCPE) investors have become key financial backers of these firms. Their total investments in these firms are estimated to have grown by an average of 22% per year over the past decade, reaching US$494 billion in 2023 (Chart 1). This increase in VCPE investments coincides with a rapid increase in greentech innovations, reflected by an estimated average annual growth of 12% in greentech patents (Chart 2).

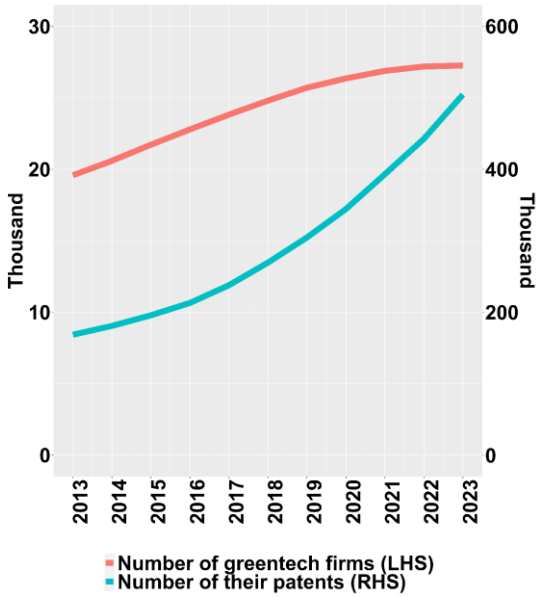
Chart 1: Size and share of VCPE investments in greentech firms



Notes:

1. Each bar (left y-axis) represents the cumulative amount of VCPE investments in greentech firms for the respective year, with the colour indicating the corresponding greentech category;
2. The curve (right y-axis) represents the cumulative amount of VCPE investments in greentech firms, expressed as a percentage of the cumulative amount of VCPE investments across all firms.

Chart 2: Number of greentech firms and their patents



Notes:

1. The curves represent the number of greentech firms in our sample (red curve) and the number of their patents (blue curve) over the years;
2. The left y-axis corresponds to the number of greentech firms (red curve), while the right y-axis corresponds to the number of patents (blue curve). Both are expressed in thousands.

Sources: Preqin Ltd., S&P Capital IQ, and HKMA staff estimates

In this context, this study examines how VCPE investment drives greentech innovations. Besides addressing the challenges of financing greentech companies, we assess the contribution of non-financial support from VCPE investors such as technological expertise, managerial skills, and industry experience. We also investigate potential barriers to VCPE investment and discuss policy implications for addressing these challenges. The findings offer insights into how to strengthen Hong Kong's role as an international green finance centre.

This study is structured as follows. Section 2 provides an overview of greentech firms, their innovations, their VCPE investments, and potential barriers to these investments. Section 3 discusses our empirical findings. Section 4 concludes the study and discusses its policy implications.

2. THE GLOBAL LANDSCAPE OF THE GREENTECH SECTOR

This section describes the global landscape of greentech firms (Section 2.1), their innovations (Section 2.2), their VCPE investments (Section 2.3), and potential barriers to these investments (Section 2.4) in our sample.

2.1. Greentech firms

Using data from Preqin Ltd. and S&P Capital IQ, our sample included 27,266 greentech firms from around the world. We categorised a firm as a greentech firm if one of these databases classify its industry as clean technology, climate technology, clean energy, electric and hybrid vehicles or agricultural technology (AgTech).[1] We also collected firm-level information, including EBITDA margin, age, number of employees, and executive committee composition from both databases.

As shown in Chart 2, the number of greentech firms is estimated to have increased gradually by 3% each year, from 19,586 in 2013 to 27,266 in 2023. In geographical term, this steady growth was mainly attributed to the Eurozone, the United States, the United Kingdom, Mainland China and India, which contributed around 24%, 18%, 14%, 11%, and 6% respectively to this the decade-long growth.

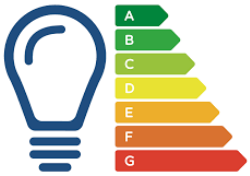
[1] Some studies use alternative databases and identify greentech firms based on their business description, such as Ambrois et al. (2023).

Chart 3: Definition of seven greentech categories

(1) Renewable energy
(33% of the total)

Solar, wind, geothermal, marine, biomass, renewable fuels, waste-to-energy, fuel cells

(2) Energy efficiency
(23% of the total)



Energy storage, management and efficiency, grid tech, semiconductors, fuel efficiency, construction, heating and lighting

(3) Clean vehicles
(11% of the total)

Electric and hydrogen cars, electric vehicle infrastructure, electrification of freight transport, car sharing, public transportation, fleet management, sustainable logistics

(4) AgTech
(9% of the total)

Agricultural technology, food systems, crop efficiency, agricultural chemicals, meat alternatives

(5) Industry
(4% of the total)

Chemicals, mining, materials, clean production and manufacturing

(6) Environment
(7% of the total)

Water, waste and recycling, land use and forestry, air quality, carbon capture

(7) Others
(13% of the total)

Energy and environmental consulting and other clean technology services and products.

Based on industry, we grouped greentech firms into seven categories, namely (1) renewable energy, (2) energy efficiency, (3) clean vehicles, (4) AgTech, (5) industry, (6) environment, and (7) others, as detailed in Chart 3.[2] From our sample, renewable energy was the largest category, accounting for around 33% of the greentech sector by the end of 2023,[3] followed by energy efficiency and clean vehicles, accounting for around 23% and 11% of the sector, respectively.

2.2. Greentech innovations

Furthermore, we collected all patent documents of greentech firms from the World Intellectual Property Organization (WIPO) PATENTSCOPE, which provides access to 116.7 million patent documents, including 4.9 million published international patent applications, from participating regional and national offices.[4] As mentioned in Section 1, the number of patents filed by greentech firms (hereafter referred to as 'greentech patents') is estimated to have almost tripled from 168,543 in 2013 to 504,586 in 2023, with an annualised growth rate of 12%.[5]

In geographical term, greentech firms based in the Asia-Pacific (APAC) region accounted for about half of the number of greentech patents in our sample in 2023, followed by 30% and 19% for firms based in Europe and the Americas, respectively (Chart 4).[6] By industry, clean vehicles, energy efficiency and renewable energy were the main drivers of overall growth, contributing around 30%, 23%, and 15%, respectively (Chart 5).

[2] We grouped the greentech firms in our sample into seven categories with reference to de Haan Montes et al. of the European Investment Fund (2023). According to their classification, they distinguish greentech firms in clean vehicles (i.e. electric and hydrogen cars, electric vehicle infrastructure, electrification of freight transport) and mobility (car sharing, urban mobility solutions, public transportation, fleet management and sustainable logistics). For simplicity, we combined them into a single category: clean vehicles.

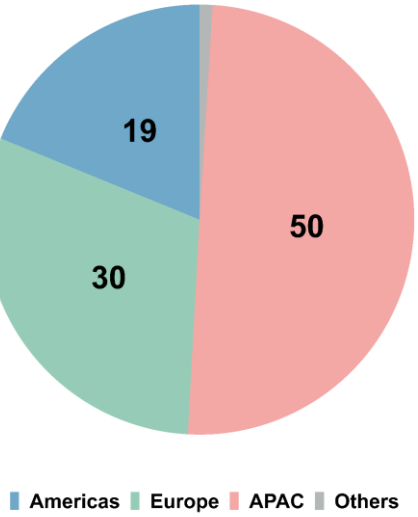
[3] This figure was calculated based on the number of greentech firms.

[4] This includes the Patent Cooperation Treaty, the African Regional Intellectual Property Organisation, the Eurasian Patent Organisation, the European Patent Office, the Patent Office of the Cooperation Council for the Arab States of the Gulf, and 70 jurisdictions.

[5] According to the WIPO IP Statistics Data Centre (2023), the decade-long growth of greentech patents was significantly faster than that of global patents at around 3% per year over the same period.

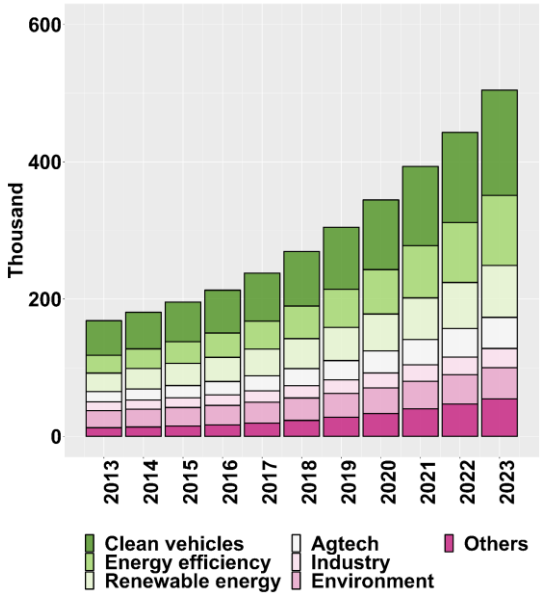
[6] The global patent filing landscape was also dominated by the APAC region in 2022, which accounted for around 68% of the total, followed by Europe and the Americas with 10% and 20%, respectively (WIPO, 2023).

Chart 4: Regional share of greentech patents at the end of 2023



Notes:
1. The pie chart represents the regional share of greentech patents by the end of 2023; and
2. The figures were calculated based on the number of these patents.

Chart 5: Number of greentech patents, by industry



Note:
1. Each bar represents the number of patents filed by greentech firms in the respective year, with the colour indicating the respective greentech category.

Sources: PATENTSCOPE, Preqin Ltd., S&P Capital IQ, and HKMA staff estimates.

2.3. VCPE investment in greentech firms

As mentioned in Section 1, VCPE investment in the greentech sector has grown rapidly since the signing of the Paris Agreement in 2016. This growth has been particularly pronounced in key greentech industries such as clean vehicles, energy efficiency, and renewable energy (Chart 1). Consequently, the proportion of VCPE-invested greentech firms has increased steadily, reaching 22% in 2023, up from 14% just before the Paris Agreement (Chart 6).[7]

In addition to providing financial backing, VCPE investors often offer a diverse range of non-financial assistance to their greentech investees, such as sharing their technological expertise and managerial skills. For instance, they may bring in relevant experts to their investees' executive committees[8] or make changes to key leadership positions, such as replacing incumbent chief executive officers (CEOs) or co-founders.[9] Beyond these personnel adjustments, VCPE investors can leverage

[7] This figure was calculated based on the number of greentech firms.
[8] See Gorman and Sahlman (1989), Suchard (2009) and Hochberg (2012).
[9] See Lerner (1995), Hellmann (1998), Bruton et al. (1997), Bruton et al. (2000) and Baker and Gompers (2003).

their industry experience gained from prior investments in similar firms to provide valuable advice to their investees.[10]

In Section 3.1, we empirically examine the types of support provided by VCPE investors to their greentech investees. In Section 3.2, we assess whether and to what extent VCPE investors contribute to the growth of their greentech investees and distinguish between the impacts of their financial and non-financial support. To the best of our knowledge, these areas are rarely explored in previous studies.[11]

2.4. Potential barriers to VCPE investment in greentech firms

Despite VCPE investors' growing interest in greentech firms, their investment patterns vary considerably. Our analysis indicates that VCPE investors are relatively reluctant to invest in lesser-known greentech firms, possibly due to a lack of information about them.[12] These lesser-known firms include (a) those headquartered in different jurisdictions from those of VCPE investors (Chart 7) and (b) firms that have never received VCPE investments (Chart 8). Regardless of the classification approach used, lesser-known firms capture a relatively small share of VCPE investments in the greentech sector.[13]

However, the investment preferences of VCPE investors may lead to inefficient allocation of capital in the greentech sector, particularly if lesser-known firms have great potential for green innovations but ultimately fail to secure the necessary support from these investors to survive and grow. To address this challenge, the public sector could play a crucial role by identifying and investing in these promising but lesser-known greentech firms. Theoretically, such investments would send a strong signal that the public sector recognises their growth potential, thereby enhancing their visibility and attractiveness to potential VCPE investors.[14]

[10] See Gonzalez-Uribe (2014).

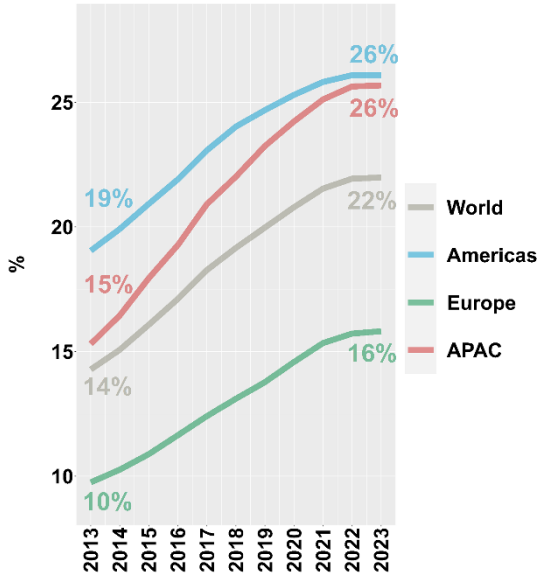
[11] Previous studies, such as Lerner et al. (2011), Bruton et al. (2010), Popov and Roosenboom (2009), and Mollica and Zingales (2007), document the positive impacts of VCPE investment on small businesses and start-ups, but rarely focus on the greentech sector or distinguish between the contributions of their financial and non-financial support.

[12] Howell (2020) also argues that lesser-known firms are less likely than other firms to obtain external financing from venture capital investors. Their chances could be enhanced by winning venture competitions to gain reputation.

[13] Previous studies such as Cornelli et al. (2024) also classify lesser-known firms using the same approach.

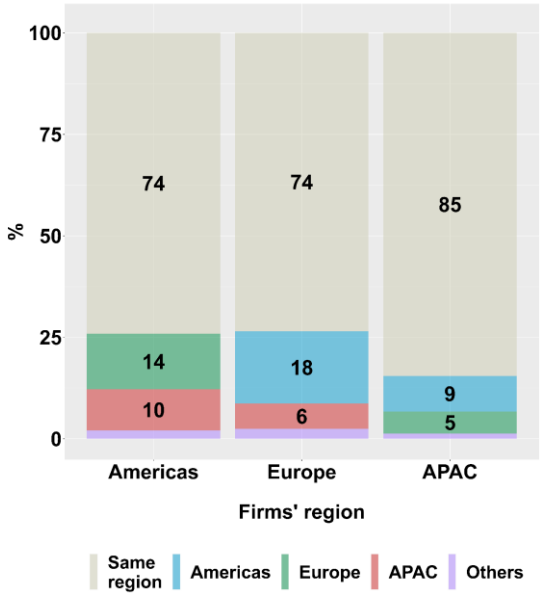
[14] Previous studies also document the impacts of other government policies on VCPE investment. For example, Cornelli et al. (2024) show that VCPE investment increases after firms enter regulatory sandboxes, as VCPE investors would perceive these firms as reputable and guaranteed by the regulator that they are viable and innovative. Lerner (1999), Howell (2017), Islam et al. (2018) and Shinkle and Suchard (2019) argue that government grants convey a credible signal of the scientific and technical merits of the awarded firms and therefore encourage VCPE investment in these firms.

Chart 6: Share of VCPE-invested greentech firms



Notes:
1. Each curve represents the share of VCPE-invested greentech firms, with the colour indicating the firms' respective region;
2. The figures were calculated based on the number of firms;
3. The figures on the left and right represent the shares at the end of 2013 and 2023, respectively.

Chart 7: Share of VCPE investors in greentech firms in 2023, by region

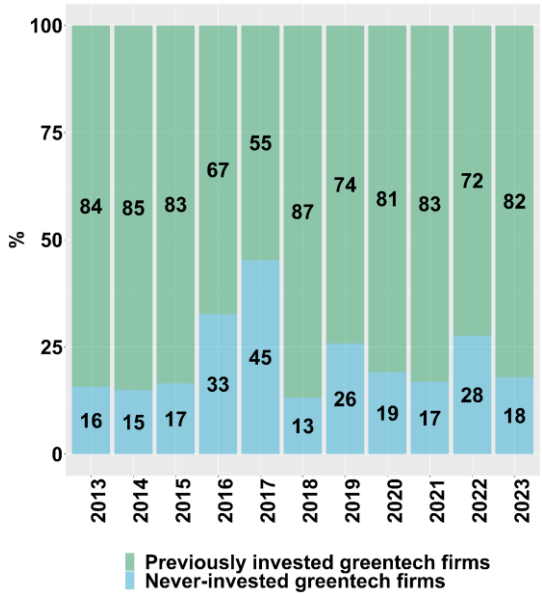


Notes:
1. Each stacked bar represents the share of VCPE investors in greentech firms, with the colours indicating the proportion of investors from different regions;
2. The figures were calculated based on the number of VCPE investors.

Sources: Preqin Ltd., S&P Capital IQ, and HKMA staff estimates.

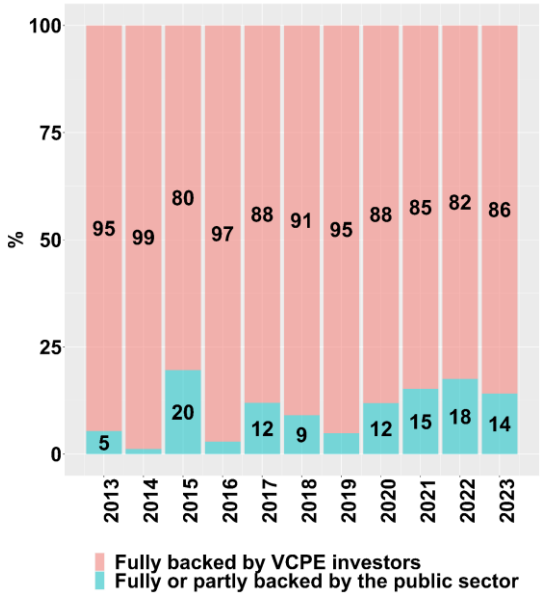
Indeed, the public sector has become increasingly active in investing in greentech firms in recent years. According to available data, 135 government agencies and sovereign wealth funds have invested in 412 greentech firms globally, either independently or in partnership with VCPE investors. These investments accounted for around 14% of all greentech investments in 2023, while the majority of greentech investments came solely from VCPE investors (Chart 9). In Section 3.3, we empirically investigate whether public investment can help greentech firms attract additional VCPE investments.

Chart 8: Share of greentech investments, by investee type



Notes:
1. Each stacked bar represents the share of VCPE investments in previously invested greentech firms (green portion) and in never-invested greentech firms (blue portion) for the respective year;
2. The figures were calculated based on the amounts invested.

Chart 9: Share of greentech investments, by investor type



Notes:
1. Each stacked bar represents the share of greentech investments coming only from VCPE investors (red portion) and coming partly or fully from the public sector (blue portion) in the respective year;
2. The figures were calculated based on the amounts invested.

Sources: Preqin Ltd., S&P Capital IQ, and HKMA staff estimates.

3. EMPIRICAL RESULTS

This section empirically examines the types of support provided by VCPE investors to their greentech investees (Section 3.1), whether VCPE investors drive the growth of their investees relative to non-investees (Section 3.2), and whether public investment in greentech firms encourages VCPE investment, particularly in lesser-known firms (Section 3.3).

3.1. What types of support do VCPE investors provide to greentech firms?

It is well established that VCPE investors provide financial support to their greentech investees, with their investment in these firms estimated at US$494 billion in 2023, as shown in Chart 1. In addition to financial backing, VCPE investors often offer various forms of non-financial support to their greentech investees. By analysing the personnel changes in investees' executive committees, our analysis

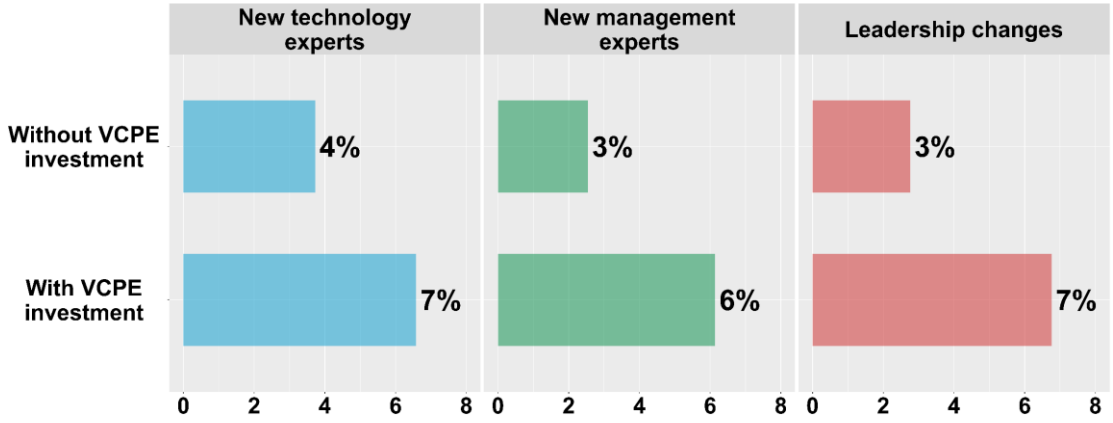
reveals the following trends after investees received VCPE investments in a given year:

a) *New technology experts*: The probability of new technology experts joining these investees[15] later in the year would notably increase to an estimated 7%, up from 4% during the pre-investment period (blue bars, Chart 10);

b) *New management experts*: The probability of new management experts joining these investees[16] later in the year would double to an estimated 6%, compared with 3% in the pre-investment period (green bars, Chart 10); and

c) *Leadership changes*: The probability of leadership changes in these investees[17] later in the year would more than double to an estimated 7%, compared with 3% in the pre-investment period (red bars, Chart 10).

Chart 10: Estimated probabilities with and without VCPE investment



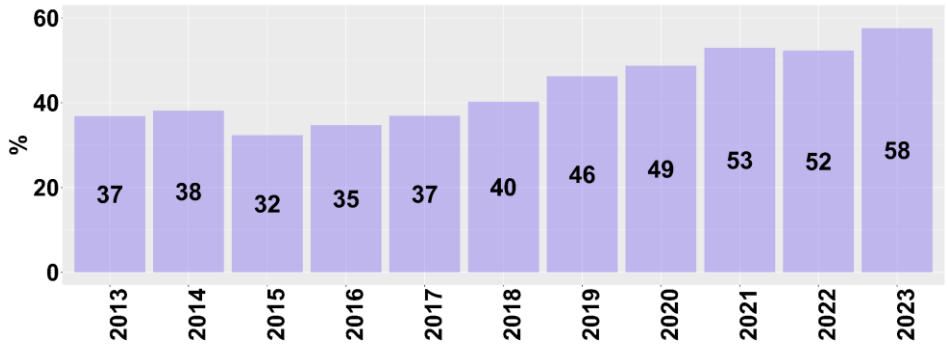
Notes:
1. Each bar represents the estimated probability that the event specified in the header will occur following VCPE investments earlier in the year (lower bars) or during the pre-investment period (upper bars);
2. The methodology for estimating these probabilities is detailed in Annex 1;
3. The differences between the probabilities represented by the upper and lower bars are statistically significant at the 10% level.

Sources: Preqin Ltd., S&P Capital IQ, and HKMA staff estimates.

[15] This includes all new executives responsible for research and development, engineering, information technology, artificial intelligence, machine learning and other science-related functions.
[16] This includes all new executives responsible for operations, production, supply chain, logistics and manufacturing.
[17] This includes the departure of the CEO or any co-founder from the investees.

Additionally, VCPE investors may act as knowledge intermediaries, disseminating their industry experience to their investees.[18] This is particularly the case among investees in the same greentech category, where knowledge is likely to be more transferable. Our analysis indicates that the share of greentech investments coming from VCPE investors who had previously invested in other firms in the same greentech category, referred to as 'experienced VCPE investors', increased sharply to 58% of the total market in 2023, compared with just 37% a decade ago (Chart 11).

Chart 11: Share of greentech investments coming partly or fully from experienced VCPE investors



Notes:
1. Each bar represents the share of greentech investments coming partially or fully from experienced VCPE investors in the respective year;
2. The figures were calculated based on the number of VCPE investment deals in greentech firms.

Sources: Preqin Ltd., S&P Capital IQ, and HKMA staff estimates.

3.2. Do VCPE investors drive the growth of greentech firms?

VCPE investors may drive the growth of greentech firms in two main ways. First, they may enhance the innovation capabilities of their investees by sponsoring scientific research and sharing technological expertise. Second, they may improve the operational efficiency of their investees by funding hardware upgrades and providing managerial skills. To assess the impacts of VCPE investors on the growth of greentech firms, we measured the innovation capabilities of these firms using the number of patents filed and their operational efficiency using the EBITDA margin. These metrics are compared between VCPE investees and non-investees with similar characteristics in Sections 3.2.1 and 3.2.2.[19]

[18] Gonzalez-Uribe (2014) argues that venture capitalists could diffuse knowledge among their investees by showing that firms' patent citations increase after receiving venture capital investments, particularly citations made by other firms also invested by the same venture capital investor. In the context of this study, knowledge diffusion is a likely event among greentech firms that receive investments from the same VCPE investors and in the same category.

[19] We matched each greentech investee only with non-investees that share the same headquarters, belong to the same greentech category, and are closest in age. See Annexes 2 and 3 for details.

3.2.1. Innovation capabilities of greentech firms

VCPE investors could significantly enhance the innovation capabilities of their greentech investees. Our empirical results indicate that the annualised growth of 22% in VCPE investments, as mentioned in Section 1, contributed to an additional annualised increase of 1.7% in the number of patents filed by these investees between 2013 and 2023, relative to non-investees (grey bar, Chart 12). This innovation gain is significant when compared with the annualised growth of 12% in the total number of greentech patents over the same period, as shown in Section 2.2.

Moreover, this innovation gain may be greater if VCPE investors provide technological support to their investees by (a) introducing new technology experts into their investees' executive committee or (b) changing their leadership, as confirmed in Section 3.1. Our analysis estimates that this technological support increased the innovation gain attributed to VCPE investments by between 1.8% and 2.1% over the sample period. Specifically, if greentech firms received VCPE investments in a given year and either:

a) *New technology experts*: If new technology experts joined these investees later in the year, the annualised growth in their number of patents due to VCPE investments would increase to 1.8% (blue bar, Chart 12) from 1.7%[20]; or

b) *Leadership changes*: If the leadership of these investees changed later in the year, the annualised growth in their number of patents due to VCPE investments would increase to 2.1% (red bar, Chart 12) from 1.7%.

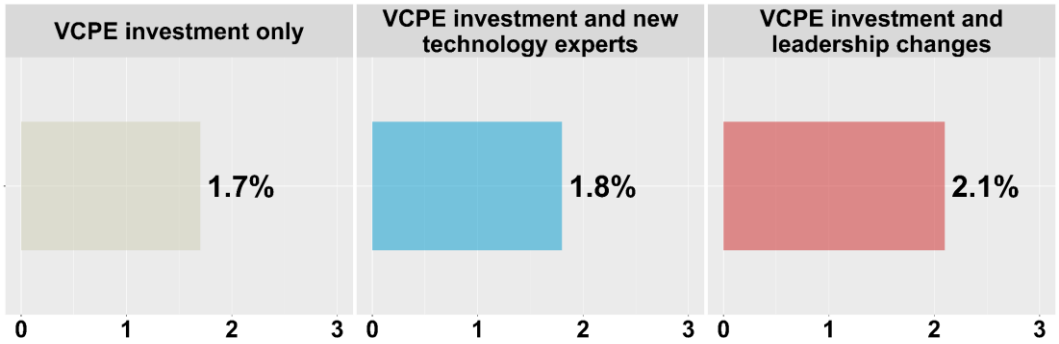
These results indicate that greentech investees can leverage advanced technologies and innovative ideas provided by technology experts and new leaders to enhance their own innovation capabilities.

Furthermore, our findings confirm the conjecture that experienced VCPE investors are better equipped than their less experienced counterparts to enhance the innovation capabilities of their greentech investees. This advantage may arise from their ability to share their industry experience accumulated through previous investments in other firms in the same greentech category. Specifically, our empirical results show that investments by experienced VCPE investors contributed considerably to the increase in the number of patents filed by their investees during

[20] To ensure robustness, our empirical results confirm that the positive impact of VCPE investment on the growth of greentech patents is not significantly influenced by the arrival of management experts. This finding is intuitive, because management experts may not be directly related to the innovation capabilities of greentech firms.

the sample period, in contrast to the muted impact of their less experienced counterparts.[21,22] These findings highlight the crucial role of experienced VCPE investors in driving greentech innovations.

Chart 12: Estimated impacts of VCPE investment on the annualised change in the number of patents filed by investees between 2013 and 2023



Notes:

1. Each bar represents the estimated overall impact of VCPE investment (grey bar), the impact of VCPE investment with new technology experts (blue bar), and the impact of VCPE investment with leadership changes (red bar) on the annualised growth in the number of patents filed by investees between 2013 and 2023, relative to non-investees;
2. These impacts were estimated by multiplying the estimated impacts of each percentage increase in VCPE investment, with or without new technology experts or leadership changes, by the annualised growth rate of 22% in VCPE investment from 2013 to 2023. The methodology for estimating these impacts is detailed in Annex 2;
3. These estimates, as well as the differences between the estimate represented by the grey bar and those represented by the other bars, are statistically significant at the 10% level.

Sources: Preqin Ltd., S&P Capital IQ, and HKMA staff estimates.

3.2.2. Operational efficiency of greentech firms

In addition to enhancing their investees' innovation gain, VCPE investors may significantly improve their operational efficiency. Based on available data,[23] we estimate that the annualised growth of 22% in VCPE investments, as mentioned in Section 1, contributed to an annualised increase of 3.2 percentage points (ppts) in the EBITDA margin of these investees between 2013 and 2023 (grey bar, Chart 13). This efficiency gain is substantial when compared with the median annual change of 4.2

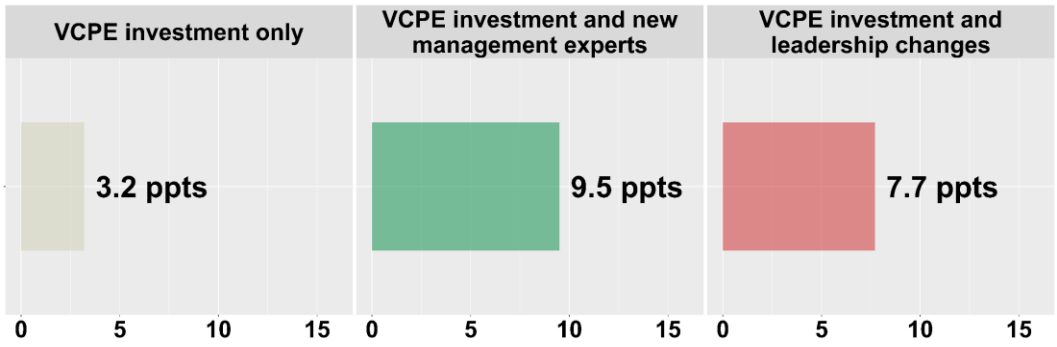
[21] The methodology and results are presented in Annex 3. The estimated impact of VCPE investment by experienced VCPE investors is statistically significant at the 10% level.

[22] The estimates presented in Section 3.2.1 may be confounded by the unobserved ability of VCPE investors to identify promising greentech firms, as documented in Hellmann and Puri (2000) and Engel and Keilbach (2007), rather than being solely due to their ability to nurture these firms. This endogeneity bias was addressed by using instrumental variable (IV) estimation, as detailed in Annexes 2 and 3.

[23] EBITDA margin data were not available for most of greentech firms in our sample. Consequently, our regression was based on a small subset of greentech firms, detailed in Annex 2. Readers should interpret these results with caution.

ppts in EBITDA margins across our full sample of greentech firms over the same period.

Chart 13: Estimated impacts of VCPE investment on the annualised change in the EBITDA margin of investees between 2013 and 2023



Notes:
1. Each bar represents the estimated overall impact of VCPE investment (grey bar), the impact of VCPE investment with new management experts (green bar) and the impact of VCPE investment with leadership changes (red bar) on the annualised change in the EBITDA margin of investees between 2013 and 2023, relative to non-investees;
2. The above impacts were estimated by multiplying the estimated impacts of each percentage increase in VCPE investment, with or without management experts or leadership changes, by the annualised growth rate of 22% in VCPE investment from 2013 to 2023. The methodology for estimating these impacts is detailed in Annex 2;
3. These estimates, as well as the differences between the estimate represented by the grey bar and those represented by the other bars, are statistically significant at the 10% level.

Sources: Preqin Ltd., S&P Capital IQ, and HKMA staff estimates.

Additionally, this efficiency gain could widen if VCPE investors provided managerial support to their investees by (a) introducing new management experts into their investees' executive committee or (b) changing their leadership, as confirmed in Section 3.1. Our empirical results suggest that this managerial support notably increased the efficiency gain attributed to VCPE investments between 7.7 ppts and 9.5 ppts over the sample period. Specifically, if investees received VCPE investment in a given year, and either:

a) *New management experts*: If new management experts joined these investees later in the year, the annualised increase in their EBITDA margin would increase significantly to an estimated 9.5 ppts (green bar, Chart 13) from 3.2 ppts[24]; or

[24] Our empirical results confirm that the positive impact of VCPE investment on the EBITDA margin of greentech firms is not significantly influenced by the arrival of technology experts. This finding is intuitive, because technology experts may not be directly related to the operational efficiency of greentech firms.

b) *Leadership changes*: If the leadership of investees changed later in the year, the annualised increase in their EBITDA margin would increase sharply to an estimated 7.7 ppts (red bar, Chart 13) from 3.2 ppts.[25]

These results suggest that greentech investees can leverage the managerial skills provided by management experts and new leaders to improve their operational efficiency.

3.3. Does public investment encourage VCPE investment in greentech firms?

To address this question, we compared VCPE investments in greentech firms that received public investment with similar firms that did not receive public investment.[26]

Our findings indicate that VCPE investment tends to follow public investment in greentech firms. Specifically, our empirical results show that every dollar of public investment in these firms led to about $0.10 of VCPE investment within the year (grey bar, Chart 14). This finding highlights the positive influence of public investment in stimulating VCPE investment in the greentech sector.

Furthermore, our analysis reveals that the impact of public investment varies significantly depending on the familiarity of greentech firms to VCPE investors. As discussed in Section 2.4, we classified a greentech firm as lesser-known if it is either (a) headquartered in a different jurisdiction from its VCPE investors (referred to as 'foreign-based firms'), or (b) has never received VCPE investments (referred to as 'never-invested firms'). The remaining firms were categorised as better-known firms. Our empirical results suggest that the incremental VCPE investment for lesser-known firms could more than double to a range of $0.22 to $0.23 for every dollar of public investment, in stark contrast to negligible amounts for their better-known counterparts. Specifically:[27]

a) *Foreign-based firms*: For these firms, every dollar of public investment could lead to an average of $0.22 of VCPE investment (blue bar, Chart 14); and

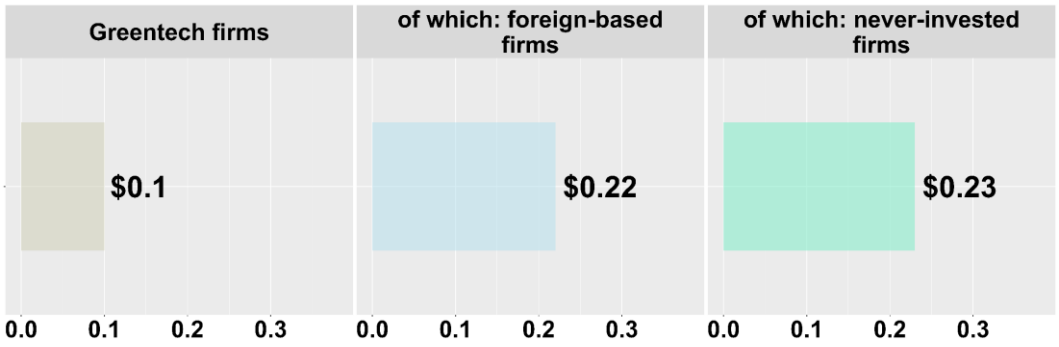
[25] The results presented in Section 3.2.2 may be confounded by the unobserved ability of VCPE investors to identify promising greentech firms, as documented in Hellman and Puri (2000) and Engel and Keilbach (2007), rather than being solely due to their ability to nurture these firms. This endogeneity bias was addressed by using IV estimation, as detailed in Annex 2.

[26] We matched each public investee with non-investees that share the same headquarters, belong to the same greentech category, operate at the same fundraising stage, and are closest in age. See Annex 4 for details.

[27] Conversely, our empirical results indicate that public investment does not follow VCPE investment, as detailed in Annex 4. These findings suggest that public investment 'Granger-causes' VCPE investment for greentech firms.

b) *Never-invested firms*: For these firms, every dollar of public investment could stimulate an average of $0.23 of VCPE investment (green bar, Chart 14).

Chart 14: Estimated amount of VCPE investment for every dollar of public investment in the same greentech firms



Notes:
1. Each bar represents the estimated amount of VCPE investment within the year following every dollar of public investment in greentech firms (grey bar), foreign-based greentech firms (light blue), and never-invested greentech firms (light green);
2. The methodology for estimating these changes is detailed in Annex 4;
3. The estimates represented by the bars, as well as the differences between the estimate shown by the grey bar and those represented by the other bars, are statistically significant at the 10% level.

Sources: Preqin Ltd., S&P Capital IQ, and HKMA staff estimates.

These findings argue for a more proactive role for the public sector in identifying and investing in promising but lesser-known greentech firms from a sustainable development perspective. Such initiatives could facilitate a more efficient allocation of capital within the greentech sector.

Indeed, governments around the world have become increasingly proactive in fostering the development of the greentech sector. For instance, some governments have rolled out regulatory sandboxes that allow greentech firms to conduct pilot trials of their innovations in a controlled environment under regulatory oversight. This approach enables regulators to identify promising candidates among the participants in these sandboxes. In addition, governments may invest in or subsidize promising greentech firms. Hong Kong is no exception to this trend. In its 2024–25 Budget, the Government announced that the Hong Kong Investment Corporation Limited would undertake direct investment and co-investment projects in a number of strategic areas, including greentech. Additionally, the Government established the Green Tech Fund (GTF) in 2020 to provide financial support for research and development projects focused on decarbonising the city and enhancing environmental protection. Since its inception, the GTF has approved funding worth HK$132.5 million for a total of 30

projects, covering areas such as decarbonisation, zero-carbon energy, energy saving and efficiency, green transport, waste management and reduction, and air quality.[28]

4. CONCLUSION

In summary, as global economies strive to achieve carbon neutrality, various clusters of greentech firms have emerged as illustrated by our sample. However, these firms are often small businesses or start-ups that may face significant financing challenges despite their strong growth potential. In light of the increasing frequency and intensity of climate-related risks that have impacted our lives recently, many of us, including policymakers, are interested in understanding how to effectively leverage both market forces and government participation to help these firms bridge their financing gaps and maintain growth. This issue is particularly relevant to Hong Kong as the city seeks to strengthen its role as an international green finance centre.

In this context, this study provides valuable insights. Beyond addressing the challenges of financing greentech firms, VCPE investors often provide non-financial assistance, including technological expertise, managerial skills, and industry experience, to their greentech investees. Both financial and non-financial support can significantly enhance the innovation capabilities and operational efficiency of these firms, underscoring the role of VCPE investors as key contributors to the transition towards a sustainable future. However, VCPE investors are relatively reluctant to invest in lesser-known greentech firms despite their strong potential, likely due to a lack of information. To address this challenge, the public sector could play a key role in identifying and investing in promising but lesser-known firms, as our findings indicate that public investment can enhance their visibility and attractiveness to potential VCPE investors, by signalling public sector recognition of their innovation potential.

These findings also have two important policy implications for addressing the challenges of financing greentech innovations. First, it would be beneficial to encourage greater participation from VCPE investors, particularly those with experience in greentech investments, as they can provide both financial and non-financial support to drive the innovation and operational efficiency of their investees. Second, the public sector may take the lead in identifying and investing in promising but lesser-known greentech firms, helping them attract more private capital and unlock their growth potential.

[28] See the GTF (2024).

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ANNEXES

Annex 1: Estimating the change in the probability of arrival of experts and leadership changes due to VCPE investment

To estimate the change in the probability of (a) the arrival of new technology experts, (b) the arrival of new management experts, or (c) leadership changes due to VCPE investments earlier in the year, we used a sample of greentech firms invested by VCPE investors and estimated the fixed-effects probit model shown in Equation (1):

$$A_{i,t} = Z\left(\beta_1 \times X_{i,t} + Control_{i,t-1} + \theta_{i,t} + \varepsilon_{i,t}\right) \qquad (1)$$

where,

$Z(.)$	=	Cumulative standard normal distribution function
$A_{i,t}$	=	1) Dummy variable equal to 1 if any technology experts join the executive committee of firm i[29] in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise; 2) Dummy variable equal to 1 if any management experts join the executive committee of firm i[30] in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise; or 3) Dummy variable equal to 1 if the CEO or any co-founder departs from firm i in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise.
$X_{i,t}$	=	Log (1 + cumulative amount of VCPE investment in firm i in year t)
$Control_{i,t-1}$	=	Log (1 + age of firm i in year $t-1$)
$\theta_{i,t}$	=	Firm- and year-level fixed effects
$\varepsilon_{i,t}$	=	Residual term

This set-up allowed us to examine the lead–lag relationship between VCPE investment and the arrival of new experts and leadership changes, as $X_{i,t}$ always occurs after $A_{i,t}$ in year t. The coefficient of interest is β_1, which reflects the impact of VCPE investment on the probability that greentech firms acquire new technology or management experts, or experience a change in leadership. A significant and positive β_1 would indicate that VCPE investment increases the associated probability.

[29] This includes all new executives responsible for research and development, engineering, information technology, artificial intelligence, machine learning and other science-related functions.
[30] This includes all new executives responsible for operations, production, supply chain, logistics and manufacturing.

The regression results presented in Table A1 indicate that the arrival of new technology experts (Column 1), the arrival of new management experts (Column 2), and leadership changes (Column 3) are all more likely to occur after VCPE investments, with a statistical significance level of 1%. Considering the average cumulative amount of VCPE investment across the greentech investees in our sample between 2013 and 2023, we computed the average changes in the probabilities of these events due to VCPE investment.

Table A1: Regression results of Equation (1)

Dependent variable: $A_{i,t}$	Arrival of new technology experts	Arrival of new management experts	Departure of the CEO or any co-founder
	(1)	(2)	(3)
$X_{i,t}$	0.016***	0.021***	0.024***
Average change in the probability of $A_{i,t}$	+ 2.85 ppts	+ 3.60 ppts	+ 4.00 ppts
VCPE-invested firms	2,854	2,854	2,854
Number of observations	25,403	25,403	25,403

Note: *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.
Source: HKMA staff estimate.

Annex 2: Estimating the impact of VCPE investors on the innovation capabilities and operational efficiency of greentech firms

To estimate the impact of VCPE investment on (a) the innovation capabilities and (b) operational efficiency of greentech firms, both with and without the non-financial support from VCPE investors, we used a matched sample of 4,998 greentech firms receiving VCPE investment and 7,762 non-investees with similar characteristics. Based on the matched sample, we constructed a panel dataset at the firm-year level from 2013 to 2023 and estimated the fixed-effects IV regression model presented in Equations (2)–(4):

$$Y_{i,t+1} = \beta_1 \times X_{i,t} \times A_{i,t} + \beta_2 \times X_{i,t} \times (1 - A_{i,t}) + \beta_3 \times A_{i,t} + Control_{i,t} + \theta_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$X_{i,t} \times A_{i,t} = \sigma_1 \times IV_t \times A_{i,t} + \sigma_2 \times IV_t \times (1 - A_{i,t}) + \sigma_3 \times A_{i,t} + Control_{i,t} + \theta_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$X_{i,t} \times (1 - A_{i,t}) = \sigma_1 \times IV_t \times A_{i,t} + \sigma_2 \times IV_t \times (1 - A_{i,t}) + \sigma_3 \times A_{i,t} + Control_{i,t} + \theta_{i,t} + \varepsilon_{i,t} \quad (4)$$

where,

$Y_{i,t+1}$ = 1) Log (1 + cumulative number of patents of firm i in year $t + 1$); or
2) EBITDA margin of firm i in year $t + 1$.

$X_{i,t}$ = Log (1 + cumulative amount of VCPE investment in firm i in year t)

$A_{i,t}$ =
1) Dummy variable equal to 1 if any technology experts join the executive committee of firm i[31] in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise;
2) Dummy variable equal to 1 if any management experts join the executive committee of firm i[32] in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise; or
3) Dummy variable equal to 1 if the CEO or any co-founder departs from firm i in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise.

$Control_{i,t}$ = 1) Log (1 + age of firm i in year t); and
2) All of the following variables if not chosen as $A_{i,t}$:

[31] This includes any new executives responsible for research and development, engineering, information technology, artificial intelligence, machine learning and other science-related functions.
[32] This includes any new executives responsible for operations, production, supply chain, logistics and manufacturing.

a) Dummy variable equal to 1 if any technology experts join the executive committee of firm i in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise;

b) Dummy variable equal to 1 if any management experts join the executive committee of firm i in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise; and

c) Dummy variable equal to 1 if the CEO or any co-founder departs from firm i in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise.

$\theta_{i,t}$ = Firm- and year-level fixed effects

$\varepsilon_{i,t}$ = Residual term

IV_t = The growth rate of global insurance corporations and pension funds (ICPFs)' total assets in year t

The coefficients of interest are β_1 and β_2, which reflect the impacts of VCPE investment with and without non-financial support from VPCE investors, respectively. We addressed potential endogeneity bias through IV estimation. Specifically, we predicted $X_{i,t} \times A_{i,t}$ and $X_{i,t} \times (1 - A_{i,t})$ in Equations (3) and (4) and entered the predicted values into Equation (2) to estimate the coefficients of interest. This approach requires that IV_t be an instrument for $X_{i,t}$. We selected the annual growth rate of total assets of global ICPFs as IV_t because it potentially satisfies certain conditions.[33] First, IV_t influences $X_{i,t}$ because the growth of ICPFs, which are key limited partners of VCPE investors,[34] may induce them to invest more in these VCPE investors, thereby potentially increasing VCPE investments in the greentech sector. Second, IV_t is unlikely to directly affect $Y_{i,t+1}$ because the growth of global ICPFs is not directly related to the innovation capabilities and operational efficiency of greentech firms.[35, 36]

Although we matched 4,998 VCPE greentech investees with 7,762 non-investees, some firms were excluded from the regression due to the unavailability of some variables, leaving a total of 10,526 matched firms for Equation (2), when $Y_{i,t+1}$ is calculated as Log (1 + cumulative number of patents of firm i in year $t + 1$). For the same equation, when $Y_{i,t+1}$ is the EBITDA margin of firm i in year $t + 1$, the

[33] The use of total assets of ICPFs as an IV for VCPE investment is well documented in the literature, notably by Gonzalez-Uribe (2014) and Mollica and Zingales (2007). Other IVs for VCPE investment are used in the literature, such as regulatory changes affecting the investment behaviour of ICPFs, as documented in Popov and Roosenboom (2009).

[34] See Wong et al. (2024), IOSCO (2023), and Aramonte and Avalos (2021).

[35] From our sample, the observed correlation between $Y_{i,t+1}$ and IV_t is very close to zero.

[36] The regression results remain largely robust when using the number of global initial public offerings as an alternative IV instead of the growth rate of total assets of global ICPFs. This alternative IV is discussed in Guo and Jiang (2013).

number of matched firms decreased to 1,879, primarily due to the unavailability of EBITDA margin data for most of the matched firms.

Table A2: Regression results of Equations (2), (3) and (4)

Dependent variable: $Y_{i,t+1}$	Log (1 + patents)			EBITDA margin		
	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)
First-stage:						
R^2 for $X_{i,t}$	0.83			0.85		
R^2 for $X_{i,t} \times A_{i,t}$		0.64	0.66		0.68	0.70
R^2 for $X_{i,t} \times (1 - A_{i,t})$		0.81	0.80		0.85	0.85
Second-stage:						
$X_{i,t}$	0.078***			0.144***		
$X_{i,t} \times A_{i,t}$		0.080***	0.093***		0.434*	0.349*
$X_{i,t} \times (1 - A_{i,t})$		0.063***	0.076***		0.191**	0.129*
Wald test: β_1 - β_2		0.017*	0.017*		0.243*	0.220*
$A_{i,t} = 1$ if:	--	Arrival of technology experts	Departure of the CEO or any co-founder	--	Arrival of managem-ent experts	Departure of the CEO or any co-founder
Number of matched firms	10,526	10,526	10,526	1,879	1,879	1,879
Number of observations	99,553	99,553	99,553	12,641	12,641	12,641

Note: *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.
Source: HKMA staff estimate.

The regression results presented in Table A2 indicate that greentech firms have a higher level of patent output (Column 1a) and EBITDA margins (Column 2a) after VCPE investments, which is statistically significant at the 10% level. The positive impact of VCPE investment increases further after the arrival of technology experts (Column 1b) or management experts (Column 2b), or the departure of the CEO or any co-founder (Columns 1c and 2c) later in the year. By multiplying the estimated impacts of VCPE investment in Table A2 by the annualised growth of 22% in VCPE greentech investment from 2013 to 2023, we computed the annualised

increases in the number of patents and EBITDA margins of greentech firms due to VCPE investment over the same period.[37]

[37] The business scale of greentech firms may significantly influence their innovation capabilities or operational efficiency. Although this factor was partially controlled by firm-level fixed effects, it was not fully accounted for in the regression results presented in Table A2, as these data were unavailable for most of the matched firms. If we also controlled for their business scale, measured by the number of employees, the number of matched firms included in the regression for Equation (2) would be significantly reduced to 2,919, when the dependent variable is Log (1 + cumulative number of patents of firm i in year $t + 1$) and to 994 when the dependent variable is the EBITDA margin of firm i in year $t + 1$. Nevertheless, our results remain robust even with this adjustment.

Annex 3: Estimating the impact of industry experience shared by VCPE investors on the innovation capabilities of greentech firms

To estimate this impact, we used the same panel data at the firm-year level and estimated a variant of Equations (2)–(4), represented by Equations (5)–(8):

$$Y_{i,t+1} = \beta_1 \times X_{i,t} \times N_{i,t} + \beta_2 \times X_{i,t} \times \left(1 - N_{i,t}\right) + \beta_3 \times N_{i,t} + Control_{i,t} + \theta_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$N_{i,t} = \sigma_1 \times IV_t^1 + \sigma_2 \times IV_t^2 + \sigma_3 \times IV_t^1 \times IV_t^2 + Control_{i,t} + \theta_{i,t} + \varepsilon_{i,t} \quad (6)$$

$$X_{i,t} \times N_{i,t} = \sigma_1 \times IV_t^1 + \sigma_2 \times IV_t^2 + \sigma_3 \times IV_t^1 \times IV_t^2 + Control_{i,t} + \theta_{i,t} + \varepsilon_{i,t} \quad (7)$$

$$X_{i,t} \times \left(1 - N_{i,t}\right) = \sigma_1 \times IV_t^1 + \sigma_2 \times IV_t^2 + \sigma_3 \times IV_t^1 \times IV_t^2 + Control_{i,t} + \theta_{i,t} + \varepsilon_{i,t} \quad (8)$$

where,

$Y_{i,t+1}$ = Log (1 + cumulative number of patents of firm i in year $t + 1$)

$X_{i,t}$ = Log (1 + cumulative amount of VCPE investment in firm i in year t)

$N_{i,t}$ = Dummy variable equal to 1 if firm i is invested in year t by any VCPE investors who had invested in any other greentech firms in the same category in earlier years, or 0 otherwise

$Control_{i,t}$ =
1) Log (1 + age of firm i in year t);
2) Dummy variable equal to 1 if any technology expert joins the executive committee of firm i in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise;
3) Dummy variable equal to 1 if any management expert joins the executive committee of firm i in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise; and
4) Dummy variable equal to 1 if the CEO or any co-founder departs from firm i in year t after the final round of VCPE investment in firm i earlier that year, or 0 otherwise.

$\theta_{i,t}$ = Firm- and year-level fixed effects

$\varepsilon_{i,t}$ = Residual term

IV_t^1 = The growth rate of global insurance corporations (ICs)' total assets in year t

IV_t^2 = The growth rate of global pension funds (PFs)' total assets in year t

The coefficients of interest are β_1 and β_2, which reflect the impacts of VCPE investments by experienced VCPE investors and their less experienced counterparts, respectively. We used two IVs, denoted by IV_t^1 and IV_t^2, as instruments for the two endogenous variables in Equation (5), namely $X_{i,t}$ and $N_{i,t}$. Both IVs satisfy the conditions that they can influence $X_{i,t}$ and $N_{i,t}$ but are not directly related to $Y_{i,t+1}$.

The regression results presented in Table A3 indicate that greentech firms filed a higher number of patents after investments by experienced VCPE investors than by their less experienced counterparts, which is statistically significant at the 5% level. This suggests that experienced VCPE investors can better increase the innovation capabilities of their greentech investees than their less experienced counterparts, likely by sharing industry experience accumulated through previous investments in other greentech firms in the same category.

Table A3: Regression results of Equations (5), (6), (7) and (8)

Dependent variable: $Y_{i,t+1}$	Log (1 + patents)
	(1)
First-stage:	
R^2 for $N_{i,t}$	0.24
R^2 for $X_{i,t} \times N_{i,t}$	0.26
R^2 for $X_{i,t} \times (1 - N_{i,t})$	0.73
Second-stage:	
$X_{i,t} \times N_{i,t}$	0.553**
$X_{i,t} \times (1 - N_{i,t})$	0.004
Wald test: β_1 - β_2	0.549**
Number of matched firms	10,526
Number of observations	99,553

Note: *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.
Source: HKMA staff estimate.

Annex 4: Estimating the impact of public investment on VCPE investment in the same greentech firms

To estimate the impact of public investment on VCPE investment in the same greentech firms, we used a matched sample of 329 greentech firms receiving public investment and 705 non-public investees with similar characteristics. Based on this matched sample, we constructed a panel data at the firm-VCPE investor-year level from 2013 to 2023 and estimated the two fixed-effects regression models shown in Equations (9) and (10):

$$Y_{i,j,t+1} = \beta_1 \times X_{i,t} \times V_{i,j,t} + \beta_2 \times X_{i,t} \times \left(1 - V_{i,j,t}\right) + \beta_3 \times V_{i,t} + Control_{i,t} + Y_{i,j,t} + \theta_{i,j,t} + \varepsilon_{i,j,t} \quad (9)$$

$$X_{i,t+1} = \alpha_1 \times Y_{i,j,t} \times V_{i,j,t} + \alpha_2 \times Y_{i,j,t} \times \left(1 - V_{i,j,t}\right) + \alpha_3 \times V_{i,t} + Control_{i,t} + X_{i,t} + \theta_{i,j,t} + \varepsilon_{i,j,t} \quad (10)$$

where,

$Y_{i,j,t+1}$ = Log (1 + amount of investment in firm i from VCPE investor j in year $t + 1$)

$X_{i,t}$ = Log (1 + amount of public investment in firm i in year t)

$V_{i,t}$ =
1) Dummy variable equal to 1 if firm i is based in a different jurisdiction from that of VCPE investor j, or 0 otherwise;
2) Dummy variable equal to 1 if firm i has never been invested by VCPE investor j in year t, or 0 otherwise; or
3) Dummy variable equal to 1 if firm i is younger than three quarters of the matched sample in year t, or 0 otherwise.

$Control_{i,t}$ = Log (1 + age of firm i in year t)

$Y_{i,j,t}$ = Log (1 + amount of VCPE investment in firm i from VCPE investor j in year t)

$\theta_{i,j,t}$ = Firm-, VCPE investors- and year-level fixed effects

$\varepsilon_{i,t}$ = Residual term.

Both equations provide a standard framework for testing whether $X_{i,t}$ 'Granger-causes' $Y_{i,j,t+1}$. From a statistical perspective, this will be established if the estimated β_1 and β_2, which reflect the impact of public investment on VCPE investment in lesser-known and better-known greentech firms, respectively, are positive and statistically significant. In contrast, the estimated α_1 and α_2, which reflect the impact of VCPE investment on public investment in lesser-known and better-known greentech firms, respectively, are expected to be statistically non-significant. We classified a greentech firm as lesser-known if it is (a) foreign-based

from VCPE investor j's perspective, (b) has never received VCPE investment, or (c) is relatively young compared with matched greentech firms; otherwise, the firm is classified as better-known.[38]

Although we matched 329 public investees with 705 non-investees, some firms were excluded from the regression due to the unavailability of some variables, leaving a total of 823 matched firms for Equations (9) and (10).

Table A4: Regression results of Equations (9) and (10)

Dependent variable	$Y_{i,j,t+1}$			$X_{i,t+1}$		
	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)
$X_{i,t} \times V_{i,j,t}$	0.30***	0.29***	1.02***	--	--	--
$X_{i,t} \times (1 - V_{i,j,t})$	0.01	-0.07	0.08***	--	--	--
Wald test: β_1 - β_2	0.29***	0.36***	0.94***	--	--	--
$Y_{i,j,t} \times V_{i,j,t}$	--	--	--	0.00	-0.00	0.02
$Y_{i,j,t} \times (1 - V_{i,j,t})$	--	--	--	0.00	0.01	0.00
Wald test: α_1 - α_2	--	--	--	0.00	-0.01	0.02
$V_{i,j,t} = 1$ if:	Foreign-based firms	Never-invested firms	Relatively young firms	Foreign-based firms	Never-invested firms	Relatively young firms
Number of matched firms	823	823	823	823	823	823
Number of VCPE investors	3,681	3,681	3,681	3,681	3,681	3,681
Number of observations	43,653	43,653	43,653	43,653	43,653	43,653

Note: *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.
Source: HKMA staff estimate.

The regression results presented in Table A4 indicate that public investment in lesser-known greentech firms 'Granger-causes' VCPE investment in the same firms over a year, as the β_1 estimate is significant and positive while the α_1 estimate

[38] Although we did not observe that VCPE investors are generally reluctant to invest in relatively young greentech firms in our sample, we continued to classify lesser-known and better-known greentech firms by age for robustness tests. This approach follows that used by Cornelli et al. (2024), who examine the impact of regulatory sandboxes, rather than public investment, on VCPE investment. The classification of lesser-known and better-known firms based on geography and VCPE investment history is also documented in Cornelli et al. (2024).

is statistically non-significant. We then converted the β_1 estimate, namely the estimated impact of each percentage increase in public investment in lesser-known greentech firms on VCPE investment, into the equivalent impact of each dollar increase in public investment.

Regarding better-known greentech firms, our regression results reported in the same table do not strongly support the Granger causal impact of public investment on VCPE investment, as both β_2 and α_2 estimates are statistically non-significant in most cases (Columns 1a–1b). Although the β_2 estimate is statistically significant in one instance (Column 1c), it is much smaller than β_1, indicating that the positive impact of public investment is stronger for lesser-known greentech firms. Finally, we estimated the overall impact of public investment on VCPE investment using a variant of Equation (9) where β_1 and β_2 are combined into a single coefficient.