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RESEARCH ARTICLE

The times they are a-changin': how venture capital firms change their investment practices under the COVID-19 pandemic

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Abstract This study examines how venture capital (VC) firms have modified their short-term investment practices in response to the COVID-19 crisis. We categorise VCs' investment practices according to their level of visibility to external parties and hypothesise that unobservable investment practices are more likely modified than observable ones, since VC firms must comply with the objectives stated in their contracts with limited partners (LPs), and deviations may be viewed negatively by investors. Changing investment practices may have a negative impact on a VC firm's reputation, but this potential reputational damage could vary along with the reputational capital already possessed by the VC firm and its degree of exposure in a VCs' network. An empirical analysis based on a global survey of VC firms confirms these theoretical presumptions, shedding light on how the industry operates and responds to unique crises such as the COVID-19 pandemic. Specifically, younger and smaller VC firms are found to be more reluctant than larger and older ones to modify observable investment practices. Similarly, VC firms that are more central in a network of investors are also found to be more hesitant to modify observable investment practices.

Plain English Summary How have VC firms adjusted their short-term investment practices in response to the COVID-19 crisis? By distinguishing investment practices based on their visibility to external stakeholders (e.g. limited partners, or LPs), we offer insights into how VCs respond to crises. Our findings indicate that general partners (GPs) are more reluctant to alter structural, stakeholder-visible investment practices compared to those that are less observable. This tendency is especially pronounced among VCs with lower reputational capital, such as younger and smaller firms or those with more at stake reputationally due to their central position within investor networks. This study enhances LPs' and GPs' understanding of how the VC industry may respond under 'stressful conditions', enabling LPs to make more informed resource allocation decisions and providing GPs with a nuanced benchmark of their competitors' practices.

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1 Introduction

COVID-19 has negatively shocked several industrial sectors worldwide, affecting important economic dimensions, from GDP growth to unemployment in several advanced economies (Bartik et al., 2020; Saglietto et al., 2020). Since it was different from most previous crises rooted in macroeconomic or financial problems, the COVID-19 pandemic likely represented, for several economic and financial operators, a 'black swan' to be reckoned with. Directly (and unequivocally) affecting dimensions such as risk and uncertainty, the financial sector has probably been one of the most affected, as many recent contributions on the impact of COVID-19 on the allocation of capital testify (see the recent special issues by Berger et al., 2021 and Duchin & Harford, 2021). Recent studies in financial economics have examined, within the financial sector, policy responses by regulators during the pandemic, as well as the impact of COVID-19 on bank resilience, bank lending activities and stock markets' performance (Bao & Huang, 2021; Beck & Keil, 2022; Duchin & Harford, 2021; Dursun-de Neef & Schandlbauer, 2021; Hasan et al., 2021; Huber et al., 2021; Li & Strahan, 2021; Park & Shin, 2021; Çolak & Öztekin, 2021 among others).

Admittedly, the venture capital (henceforth VC) sector, which we focus on in this study, has not been exempted from the repercussions of the global health crisis. For example, Bellavitis et al. (2022) document a significant decline in VC investments worldwide, which has been more pronounced in early-stage ventures, industries affected more heavily by the pandemic and non-syndicated and international investments. Similar results pointing to an overall decline in VC investments (in terms of both the number of deals and funding amounts) have been obtained by Howell et al. (2020) for the United States of America (US), Brown and Rocha (2020) for the People's Republic of China and Brown et al. (2020) for the United Kingdom (UK).

Although evidence is still scarce in this stream of literature, there is also an increasing interest in a better understanding of how the pandemic has changed the behavioural norms and conducts of VCs' general partners (henceforth GPs). The shock of the COVID-19 pandemic introduced a new source of uncertainty for VC investors (Baker et al., 2020; Gompers et al., 2021; Kuckertz et al., 2020), the nature of which differs substantially from the type VCs are typically used to manage (e.g. the uncertainty related to the quality of the entrepreneurial team, the market potential of the technology and the sustainability of the business). Indeed, the performance of the entire VC sector is, to some extent, also endogenous to how operators can recognise the need for changes in practices (and embrace them once identified) to face the uncertainty introduced by the COVID-19 crisis. In this vein, we ground on the analysis of Gompers et al. (2021), which examines survey answers from a large sample of VC firms to investigate how the pandemic has affected their investment decisions. According to the authors, VCs have slowed their investment pace to about 70% of their regular activity, dedicating more time to portfolio ventures during the pandemic. The crisis has negatively affected 48% of portfolio companies, having just a small negative impact on their funds' internal rates of returns (IRRs). The authors conclude resilience has characterised the VC industry overall during the pandemic crisis.

We provide a more detailed picture on a global scale of which VCs' investment practices[1] have been subject to intensive changes and which have not and the possible underlying reasons behind these differences. More specifically, we categorise different VC investment practices based on their degree of visibility, i.e. investment practices that are more or less 'observable' to external stakeholders, most notably limited partners (henceforth LPs). Investment practices such as the chosen geographic focus or the investment stage are classified as observable; conversely, unobservable investment practices are not evident beyond the VC firms' boundaries. These latter include selection criteria and monitoring practices. We investigate which characteristics make VCs more or less 'sensitive' to change based on the degree of

[1] Our focus is on short-term changes of the investment behaviour of VC firms. In this case, the literature has also used the term 'practice'. We will predominantly use this latter term but, at the same time, we consider 'investment behaviour' as synonymous.

observability of every single behaviour. Thus, dissecting the overall effect of VCs' responses to the crisis's outbreak through investment practices with different degrees of visibility allows us to gain more nuanced insights into how VCs with different characteristics might react differently to future adverse shocks.

To this aim, we conducted a survey between May and October 2021, targeting all the VC managers with an available email address reported on the Preqin database. The survey aimed to identify changes in investment behaviour along the deal funnel following the COVID-19 outbreak.

Our econometric results show that relatively more structural and 'observable' (to stakeholders) investment practices have been less modified than relatively 'unobservable' investment practices. Moreover, relying on the literature on reputational capital in VC financing (Dimov et al., 2007; Gompers, 1996; Hsu, 2004; Pollock et al., 2015; Sørensen, 2007), we show that VCs who are less endowed with reputational capital are more reluctant to make changes into 'observable' practices. We interpret this behaviour with the relatively superior risk of facing negative judgements by stakeholders (i.e. LPs). In fact, relatively younger and smaller firms are found to change 'observable' practices less often than more mature and larger firms do, while no significant differences are traceable in 'unobservable' investment practices across VC firms of different typologies. Consistently, we also find that, *ceteris paribus*, the most central VCs in the investor network, due to their greater exposure to negative consequences in terms of reputational capital, are more likely to *stay the course* compared to non-central VC firms when 'observable' investment practices are at stake.

These findings broaden our understanding of how the COVID-19 pandemic and other possible dramatic shock crises may change the VC industry, whose importance in terms of capacity to generate and fuel successful start-ups is undisputed (see Korteweg & Sensoy, 2023).[2] In doing so, we offer an interesting interpretive lens as to why some VCs embarked more often than others on certain types of changes in investment behaviours. Thus, this study increases the insights of LPs and GPs into how the VC industry might react under 'stressful conditions', allowing the former to make more informed decisions on how to allocate their financial resources and the latter to have a more nuanced benchmark of their competitors' practices. More specifically, we report that in response to a crisis or an exogenous shock, GPs may change their investment practices, taking into account their own reputational capital. This is especially true for young and small VC firms, which still have to build reputational capital (or whose reputational capital, if built, is probably more fragile), and for central VC firms, which face greater risks in terms of reputational damage.

The remainder of the paper is organised as follows. The next section illustrates our theoretical framework and formulates a series of research hypotheses. Section 3 introduces the data, variables and model we use in our analysis. Section 4, relying on the concept of reputational capital, presents our insight analysis on whether or not the realisation of 'observable' vs. 'unobservable' changes in practices may depend on specific characteristics of VCs. In Sect. 5, we carry out some robustness checks. Section 6 provides additional evidence. Section 7 concludes.

2 Theoretical background

VC investing implies that GPs are responsible toward LPs they raise money from in maintaining investment styles and processes that are consistent over time and that match the objectives stated when contracts were signed (Bellavitis et al., 2023). Acting inconsistently with respect to the stated investment practices can potentially affect the risk/return profile of investors' portfolios, damage future possibilities of fundraising (in line with the 'grandstanding hypothesis' by Gompers, 1996), and it is generally viewed unfavourably by investors (Buzzacchi et al., 2015; Cumming et al., 2009). This phenomenon is known as 'style drift' and has been a topic of investigation in prior studies (Buzzacchi et al., 2015; Cumming et al., 2009; Johan et al., 2014; Koening and Burghof, Forthcoming; Lahr & Trombley, 2020).

The emergence of a new and unexpected economic uncertainty following the outbreak of

[2] 'The five largest public companies in the US as of August 2020—Apple, Amazon, Microsoft, Alphabet (Google) and Facebook—were all VC backed in their early days' (Korteweg & Sensoy, 2023, p. 274).

COVID-19 potentially implies the need for changes in the investment practices adopted by VCs, which is, however, not affecting all the industry uniformly. Investment practices can be broadly classified as follows: (i) 'observable', referring to investment approaches that are to a large extent structural, and, as such, clearly identifiable by the VCs' LPs (e.g. the investment stage, the geographical investment focus); (ii) 'unobservable', referring to investment approaches which VCs can adjust without being fully perceived by LPs (e.g. involving selection, monitoring, adding value activities).[3] We argue that, during the period of economic turmoil following the COVID-19 crisis, VCs tend to shy away from changing their observable and structural investment practices in order to comply with the objectives stated in the limited partnerships agreements and not to encounter difficulties in raising new funds from new investors or additional resources from current investors. In fact, a change in observable investment practices is undesirable for LPs, who construct their portfolio's expected risk profile based on the fund's anticipated style. A deviation from stated objectives clearly alters an investor's risk profile in a way that was not initially conceived and may drive LPs to divert their strategic asset allocation targets.

Instead, changes in investment practices that are unobservable to outside investors could be undertaken more confidently by GPs. The pre-investment screening of funding opportunities, post-investment monitoring and advising (Gompers & Lerner, 2001; Kaplan & Strömberg, 2001) are among the actions that might require thought-out reactions and adaptations from VCs in the wake of the new circumstances imposed by the pandemic and are in any case not subjected to the negative backlashes of LPs' judgement, given their opacity to external observers. These predictions lead us to advance the following initial hypothesis:

H1. Following the COVID-19 outbreak, VCs have been less likely to adopt changes in their observable investment practices

However, the implications of changing observable investment practices may be associated with specific VC characteristics. Grounding on the consolidated evidence that VCs' decisions are strongly affected by reputational effects (Dimov et al., 2007; Hsu, 2004; Pollock et al., 2015; Sørensen, 2007), we argue that the costs of changing observable investment practices may be more pronounced for those VCs that would be more exposed in terms of any damage to reputational capital that this change might entail, or for which the possible damage might prevent reputation building in the first place.

An organisation's reputation is a 'social approval' asset (Pollock et al., 2015) that derives its value from how external 'observers' perceive or assess the organisation itself based on its track record of past activities and performance (Barnett et al., 2006; Sorenson, 2014). VC firms need to build and maintain their reputation in the eyes of investors (i.e. LPs). Establishing a reputation with LPs by providing them with consistent and sizeable returns on their investments is fundamental for raising capital for new funds (Gompers, 1996) and negotiating more attractive contracts in shorter time frames (Gompers & Lerner, 1999). Thus, the reputation of VC firms is an important intangible asset to build and take care of once obtained (Chou et al., 2013; Dimov et al., 2007). More reputable VC firms tend to select better quality ventures (Sørensen, 2007), and ventures prefer more reputable VC firms and are ready to pay a premium for their affiliation (Hsu, 2004). We argue that VCs that are less endowed in terms of reputational capital—i.e. younger and smaller firms—could be more reluctant, compared to their larger and older VC counterparts, to adopt changes in their observable investment practices in order not to jeopardise the consent of LPs about their activity, thus preventing reputation building or its consolidation. In turn, LPs may give more credit (and so more room to manoeuvre) to GPs who have proven their ability in the past (and so have already built or consolidated their reputational capital). In addition, younger and smaller firms might also have burdensome covenants on their investment activity imposed in limited partnership agreements

[3] Changes in 'observable' and 'unobservable' investment practices have an inevitable component of exogeneity and can, at least partly, be dictated by external conditions (for example, COVID has made it more difficult to move around and meet in person). Our theorising focuses on the endogenous component of the change in a given investment practice (in response to exogenous conditions). Consistently, our empirical model controls for exogenous effects.

(Gompers & Lerner, 1999, 2002). We, therefore, put forward the following hypothesis:

H2. Following the COVID-19 outbreak, younger and smaller VCs have been less likely to adopt changes in their observable investment practices than older and larger VCs

In the previous two hypotheses, we argued that older and larger VCs, having already established reputational capital, should be less reluctant to adopt changes in their observable practices compared to their younger and smaller counterparts. However, the impact of reputational loss also varies across VCs, potentially deterring some VCs from making changes in observable investment practices. We argue that VCs in central network positions, regardless of their size and age, are more concerned about potential reputational losses than peripheral actors. Reputation takes time to develop, and building a reputation involves resources and time-consuming activities. VC firms build their reputation over time by carefully selecting the right ventures to invest in, coaching and closely monitoring them over their development trajectory and ensuring a sufficiently high successful exit rate. Since building and maintaining a high reputation is costly, VCs will do whatever is possible to keep their reputation unaltered and, when possible, even augment it. In fact, a prominent VC firm will incur considerable costs if its reputation is damaged. Everything else being equal (e.g. regardless of their age and size), VCs occupying central positions in their network are also the most exposed to the negative consequences of a potential loss in reputational capital. A drop in reputation for a central VC, because of their high connectedness and visibility, will diffuse within the network (i.e. the VC industry) more rapidly, potentially exposing the VC to the scrutiny of more LPs. To avoid such a dynamic, central VCs have the incentive to avoid changes that are visible outside the boundaries of the firm. Accordingly, we expect they will be more reluctant than not central VCs to engage in changes concerning observable investment practices for fear of reputational damages. Hence, our third and last hypothesis:

H3. Following the COVID-19 outbreak, more central VCs have been less likely to adopt changes in their observable investment practices than non-core VCs

3 Methodology and data

3.1 Survey design

To investigate VC firms' reactions after the COVID-19 outbreak, we conducted a survey between May and October 2021. The survey design is close to Gompers et al. (2021), but we asked respondents to compare their pre- and post-COVID-19 practices. We designed survey questions to measure a change in VCs' practice rather than obtaining information on the pre- or post-COVID-19 investment behaviour. For example, we did not include questions aimed at characterising a particular investment practice before and after the COVID-19 outbreak. On the contrary, we asked whether and how a particular practice changed after the COVID-19 outbreak. We discussed survey design with academics and industry experts and adjusted the format, style and language of survey questions accordingly. We circulated a first draft of the survey among a few professionals working in different VC firms to reduce ambiguity. This procedure gave us three complete trials and provided precious feedback.

The survey was administered through Qualtrics to a mailing list of VC firms retrieved from the Preqin database. In order not to exclude any false negative instance, our target included all private equity firms with an available email address, and we did not include any geographical criterion, hence addressing the survey to respondents located in different geographical regions. Overall, this resulted in a list of 7122 professional investment firms (i.e. private equity and VCs). We included an initial question to filter off investment firms that do not consider themselves VCs. Any respondent who did not identify itself as an investment firm was removed from our analysis.

The first wave of emails was sent in May 2021. The timing of the survey is after the first two waves of COVID-19 (Mathieu et al., 2020). By May 2021, with the notable exception of the Popular Republic of China, most countries worldwide had already relaxed the lockdown measures (Mathieu et al., 2020), and there were the first shreds of evidence of a decrease in uncertainty (Oldeweme et al., 2021). Accordingly, the answers provided by respondents refer to the

so-called *new-normal period*. We offered all respondents a full report with aggregated survey results to incentivise survey participation.

We went through five reminder waves—until October 2021—for those who had not completed the survey. We tested for nonresponse bias by comparing the respondents of our initial waves with those of our last waves, under the typical assumption that the latter are similar to non-respondents, given the need for an additional stimulus to convince them to participate (Armstrong & Overton, 1977; De Rassenfosse & Fischer, 2016). We did not find significant differences within these groups, especially regarding the COVID-19 impact measurements at the portfolio business level and other significant characteristics like age and size.

We collected 949 unique firm responses (for a response rate of 13.32%). VC firms that responded are representative of the professional investor population for a series of characteristics, including firm ownership and vintage year of the firm. At the same time, respondents are statistically larger than the contacted population, measuring firm size as the financial amount managed by the focal VC firm. While the sample offers good global coverage, it is geographically representative of the African and Oceanic continents; it is over-represented for the European and South American continents and under-represented for the Asian and North American continents. Therefore, we recommend caution when interpreting our results, especially concerning small VC firms operating in these latter geographical contexts. Of the total 949 responses, we considered 506, those that indicated they were venture capital firms. By construction, our survey excludes VC firms that did not survive the COVID-19 outbreak since our research aims to observe the changes in investment practices caused by the shock in its immediacy.

3.2 Descriptive statistics on VC firms' characteristics

This section presents preliminary descriptive statistics on the surveyed VC firms.

In Table 1, we report VC firm-level statistics. The vast majority of companies are independent VCs (86%, IVCs), while the rest are predominantly corporate VCs (9%, CVCs) and, to a lesser extent, bank-affiliated VCs (2%, BVCs) and government VCs (2%, GVCs). The majority of firms are located in the EU (46%, *European* HQ), with the UK (8%), France (6%) and Germany (5%) as the most represented countries. This distribution is coherent with the market composition in this area (Bertoni et al., 2015). Almost one-third of VC firms are located in North America (29%, *North American* HQ). Asia is the third continent most represented (16%, *Asian* HQ). Over one-third of the VC firms have a domestic focus (38%), while 24% of VC firms focus on cross-border investments. The remaining 38% of the VC firms have no specific geographical focus. Interestingly, a significant share

Table 1 Descriptive statistics of variables retrieved from the survey

	Of which	*N*	%
VC typology			
Independent VC (IVC)		437	86%
Captive VC		69	14%
	BVC	12	2%
	CVC	48	9%
	GVC	9	2%
Total		*506*	*100%*
Geographical location			
Asian HQ		81	16%
	India	26	5%
	Singapore	13	3%
European HQ		228	46%
	France	31	6%
	Germany	23	5%
	Italy	13	3%
	Netherlands	17	3%
	Spain	13	3%
	UK	41	8%
North American HQ		144	29%
	US	134	27%
HQ in other continents		45	9%
Total		*498*	*100%*
Geographical focus			
Domestic		193	38%
Cross-border		122	24%
Both		191	38%
Total		*506*	*100%*
Predominant impact of COVID-19 on portfolio			
Positive or null		293	63%
Negative		173	37%
Total		*466*	*100%*

Table 2 Changes in observable investment practices and relative adoption rate

Variable	Definition	*N*	%
Increasing domestic focus	Dummy (variable; hereafter we omit the reference to 'variable') taking value 1 for VC firms that answered 'Yes', 0 for 'No' to the question (which was only posed to those that had declared a cross-border or mixed focus before COVID-19): '*Since the COVID-19 outbreak, has your venture capital firm reduced cross-border venture capital investments in favour of a more domestic focus?*'	297	10%
Diversification of stages	Dummy taking value 1 for VC firms that increased the number of stages in which they invest in the post-COVID-19 outbreak, 0 for the others This dummy has been computed by looking at the responses to the question: '*Which stage of the company did you use to/do you currently target?*'	506	8%
Postponement of exits	Dummy taking value 1 for VC firms that answered 'Yes', 0 for 'No' to the question: '*Has COVID-19 impacted your exit decisions in terms of postponement of some exits that were pre-scheduled?*'	483	42%

of VC firms indicated that COVID-19 had negligible or positive effects on their portfolio start-ups. The variable *Positive or null impact of COVID-19* is equal to one if at least half of the portfolio companies were positively affected or unaffected by COVID-19, which suggests that in almost two VC firms out of three (63%), the share of portfolio companies negatively affected by the pandemics was below 50%.

3.3 Changes in observable vs. unobservable investment practices

To test our hypotheses, we analyse the changes after the COVID-19 outbreak in the different phases of the deal: deal sourcing, investment selection, valuation and exit. More specifically, we distinguish between VC investment practices that are observable vs. unobservable to external stakeholders (e.g. LPs).[4] We consider decisions on the investment stage, the geographical investment focus of the VC firm and the timing of the exit to be *observable*. Changes related to these latter decisions imply a change in a VC's course of actions and, as such, are clearly identifiable by LPs. Table 2 reports the definition and descriptive statistics for these changes in observable investment practices.

Summary statistics in Table 2 indicate that only 10% of VC firms increased their domestic focus, and only 8% reacted to the COVID-19 crisis by increasing the number of stages in which they decided to invest. The percentage increases when considering the postponement of exit, with 42% of the VC firms indicating that after the COVID-19 crisis, they decided to postpone at least one exit.

In juxtaposition with observable practices, we classify those practice domains related to internal management within the VC firm as (relatively) *unobservable*. These investment practices include the evaluation process and the coaching and monitoring of the investment, which are hardly observable outside the VC firm. In other words, changes in unobservable investment practices refer to those changes in the investment approaches that VCs can adjust without being fully perceived by LPs.

Table 3 reports the definition of changes in unobservable investment practices and descriptive statistics.

Following the COVID-19 shock, VC firms indicated a diffused use of unobservable practices at various stages. One-third of respondents reported an increased effort in deal sourcing, screening, structuring and closing. The increase in the effort was most pronounced in post-investment activities (46%), which is preponderantly due to an increase in interaction with the start-up portfolio's management (33%), e.g. for operational guidance activities and to help them in raising new capital. The increase in effort is also relevant in pre-investment activities, such as deal sourcing (34%), deal screening (29%) and deal structuring (22%).

Summarising, these descriptive statistics provide preliminary support to our first hypothesis (H1) which states that, on average, VC firms have been

[4] The operationalisation of 'observable' and 'unobservable' investment practices proposed here has been unanimously validated through specific feedback from several venture capitalists and industry professionals. We thank a reviewer for having suggested us this important check, which forms the basis of our empirical exercise.

Table 3 Changes in unobservable investment practices and relative adoption rate

Variable	Definition	*N*	%
Increasing effort in deal sourcing/origination	Dummy taking value 1 for VC firms that indicated an increase in the effort required for deal sourcing/origination, 0 for the others This dummy has been computed by looking at the responses to the question: *'Has deal sourcing/origination been remarkably impacted after the COVID-19 outbreak in terms of effort required? Select if the overall effort required is increased/remained unchanged /decreased'*	506	34%
Increasing effort in deal screening/selection	Dummy taking value 1 for VC firms that indicated an increase in the effort required for deal screening/selection, 0 for the others This dummy has been computed by looking at the responses to the question: '*Has deal screening/selection been remarkably impacted after the COVID-19 outbreak in terms of effort required? Select if the overall effort required is increased/remained unchanged /decreased'*	506	29%
Increasing effort in deal structuring	Dummy taking value 1 for VC firms that indicated an increase in the effort required for deal structuring, 0 for the others This dummy has been computed by looking at the responses to the question: '*Has deal structuring been remarkably impacted after the COVID-19 outbreak in terms of effort required? Select if the overall effort required is increased/remained unchanged /decreased'*	506	22%
Increasing effort in post-investment activities	Dummy taking value 1 for VC firms that indicated an increase in the effort required in post-investment activities, 0 for the others This dummy has been computed by looking at the responses to the question: '*Have post-investment activities (i.e. monitoring, support, follow-ones) been remarkably impacted after the COVID-19 outbreak in terms of effort required? Select if the overall effort required is increased/remained unchanged /decreased'*	506	46%
Increasing effort in deal closing/exit	Dummy taking value 1 for VC firms that indicated an increase in the effort required for deal closing/exit, 0 for the others This dummy has been computed by looking at the responses to the question: *'Has deal closing/exit been remarkably impacted after the COVID-19 outbreak in terms of effort required? Select if the overall effort required is increased/remained unchanged /decreased'*	506	33%
Increasing managers interactions	Dummy taking value 1 for VC firms that indicated an increase in the interactions with managers of portfolio companies, 0 for the others This dummy has been computed by looking at the responses to the question: '*On average, how frequently do you actively interact with the management of your portfolio's companies pre and post COVID-19 outbreak?'*	483	33%

less likely to adopt changes in observable practices, while they were more likely to pursue changes in practices characterised by a lower degree of outward visibility. In other words, on average, VCs seem to avoid changing their observable investment practices. This result is consistent with the idea that VCs try to remain loyal to the objectives stated in the LPs' agreements and, thus, avoid a possible detrimental effect on their reputational capital that, in turn, may lead VCs to experience difficulty in raising new funds or calling on additional amounts from current investors. The extent to which this initial finding may depend on the different characteristics of VC firms, in terms of their varying levels of reputational capital or potential exposure to reputational backlashes will be the subject of a more in-depth econometric analysis in Sect. 4.

3.4 Independent and control variables

We collected additional VC firm-level information related to the funds managed and the deals performed from Preqin. Complete data on the variables

Table 4 Descriptive statistics of independent and control variables used in the models

Variable	Obs	Mean	p25	p50	p75	Std. dev	Min	Max
Firm age (ln)	3335	2.38	1.79	2.40	2.94	0.75	0.00	5.11
Firm size (ln)	3335	4.28	3.63	4.35	4.99	1.09	0.04	7.67
Network centrality (ln)	3335	3.44	2.30	3.56	4.62	1.59	0.00	7.48
European HQ (d)	3335	0.48	0.00	0.00	1.00	0.50	0.00	1.00
North American HQ (d)	3335	0.28	0.00	0.00	1.00	0.45	0.00	1.00
Asian HQ (d)	3335	0.16	0.00	0.00	0.00	0.36	0.00	1.00
Captive (d)	3335	0.14	0.00	0.00	0.00	0.34	0.00	1.00
Early Stage Focus	3335	0.42	0.21	0.43	0.60	0.27	0.00	1.00
Healthcare Focus (d)	3335	0.12	0.00	0.00	0.00	0.32	0.00	1.00
IT Focus (d)	3335	0.39	0.00	0.00	1.00	0.49	0.00	1.00
No Industry Focus (d)	3335	0.40	0.00	0.00	1.00	0.49	0.00	1.00
Positive or null impact of COVID-19 (d)	3335	0.66	0.00	1.00	1.00	0.48	0.00	1.00

used in the main econometric analyses of this study were available for 388 VC firms out of 506 total respondents.[5] Therefore, our final sample consists of 388 VC firms and is not statistically different from the total number of respondents when comparing the variables shown below. Table 4 reports the descriptive statistics of the independent and control variables used in the models.

The variable *Firm age* represents the difference between the year of the survey submission (2021) and the firm vintage year (in logs). The average is 14 years (median 11 years). The first quartile reaches 6 years, confirming that most of our sample has pre-COVID-19 experience; moreover, only eight (around 2%) firms were born since 2019.

The variable *Firm size* represents the average fund size managed by the focal VC firm (in logs). The average firm size is 123 M$ (median 77 M$).

The variable *Network centrality* is measured as the VC firm's degree of centrality in the co-investment network, i.e. the number of different previous co-investors of the focal VC firm (in logs). The average number of different co-investors is 87 (median 33). These numbers suggest that VC firms in our sample have, on average, relevant experience in terms of the number of investments and frequently recur to syndication.

The variable *Early Stage Focus* is measured as the percentage of the past deals performed by the focal VC represented by start-ups in the first 3 years of their life.

To control for VC firms specialised in the healthcare sector, we include the dummy variable *Healthcare Focus*, which equals one for VC firms that conducted more than 50% of their total deals in start-ups operating in this industry. Similarly, we control for the focus on information technology (IT). Finally, the dummy variable *No Industry Focus* indicates VC firms without a strong specific sectoral focus, meaning none of the industrial sectors they invest in have deals that exceed 50% of their total investments. Results shown in Table 4 indicate that 12% and 39% of VC firms focused their investments on the healthcare and the IT industries, respectively, while 40% do not have a specific focus.[6]

Descriptive statistics of the *European HQ*, *North American HQ*, *Asian HQ*, *Captive* and the *Positive or null impact of COVID*-19 variables in Table 4 do not statistically differ from the sample's descriptive statistics reported in Table 1.

[5] Incidentally note that some analyses related to robustness checks and additional evidence in Sects. 5 and 6 may be based on a smaller number of firms.

[6] According to Preqin, few VC firms—less than 10%—focus on industries such as Business Services, Energy & Utilities and Telecoms & Media. None of these industries exceed 2% of the distribution. They represent the counter-factual in our regressions regarding the industry dimension.

4 Econometric analysis

The unit of analysis of our study is a change into an investment practice. More specifically, our dependent variable takes value one if the practice *i* has been changed by VC firm *j*. For each of the 388 VC firms for which information was available, our sample includes multiple entries, one per practice under investigation. The final dataset includes 3335 observations.[7]

We follow the literature on decision-level data (e.g. Colombo & Delmastro, 2004; Graham et al., 2015) by constructing a panel where each VC firm is repeated by the number of investment practices under investigation. We employ a Probit regression model with a random effects estimator to test our three hypotheses with robust standard errors.[8] This approach helps avoid drawing invalid conclusions if residual variation differs across decisions (see Allison, 1999) and allows us to consider that the decisions made by the same firm are not independent. To test the first hypothesis (H1), we rely on the dummy variable *Observable practice*, which equals one when practice *i* is observable, while zero in the other cases. We also include the other independent variables related to VC firms' characteristics—i.e. *Firm age*, *Firm size* and *Network centrality*—and the control variables described in Sect. 3.2. The correlation matrix of the variables included in our model is reported in Table 5.

In Table 6, we show the results of our first main econometric models. Model I reports the model with the sole variable of interest; in model II, we add our control variables, while in model III, we report the full-fledged model, including the independent variables related to VC firms' characteristics—i.e. *Firm*

Table 5 Correlation matrix of the independent and control variables used in the models

	Variable	1	2	3	4	5	6	7	8	9	10	11
1	Firm age (ln)	1.00										
2	Firm size (ln)	0.20 *	1.00									
3	Network centrality (ln)	0.36 *	0.25 *	1.00								
4	European HQ (d)	0.13 *	0.12 *	0.05 *	1.00							
5	North American HQ (d)	0.00	−0.06 *	0.21 *	−0.60 *	1.00						
6	Asian HQ (d)	−0.14 *	−0.05 *	−0.10 *	−0.42 *	−0.27 *	1.00					
7	Captive (d)	0.10 *	0.10 *	0.09 *	0.07 *	−0.12 *	0.08 *	1.00				
8	Early Stage Focus	−0.16 *	−0.37 *	0.13 *	−0.06 *	0.12 *	0.01	−0.03	1.00			
9	Healthcare Focus (d)	0.08 *	0.02	0.10 *	−0.03	0.10 *	−0.02	−0.07 *	−0.04 *	1.00		
10	IT Focus (d)	−0.04 *	−0.13 *	0.22 *	0.03	0.04 *	−0.07 *	0.01	0.24 *	−0.29 *	1.00	
11	No Industry Focus (d)	0.13 *	0.14 *	−0.08 *	0.04 *	−0.09 *	0.04 *	0.04 *	−0.17 *	−0.30 *	−0.65 *	1.00
12	Positive or null impact of COVID-19 (d)	−0.09 *	0.04 *	0.08 *	−0.02	0.06 *	−0.04 *	−0.05 *	0.07 *	−0.09 *	0.11 *	−0.01

* indicate significance levels at 0.05. The number of observations is 3335

[7] Through our survey we asked information about nine investment practices, namely the ones showed in Tables 3 and 4. Some respondents, however, did not provide information for all the nine investment practices. To avoid any possible censoring problem, in the main analyses, we considered only respondents who answered all questions, i.e. 388 VC firms. The number of observations does not amount exactly to 3492 (i.e. 388 multiplied by 9) because the question on the increase on domestic focus was not shown to investors who had indicated in earlier questions that they were not cross-border investors (see also footnote no. 10).

[8] It is noteworthy that, as discussed by Verbeek (2017) and Wooldridge (2020), specifying robust standard errors is equivalent to clustering the errors by the variable defining the panel—in this case, the VC firm.

Table 6 Baseline estimations for changes in investments practices

Model	I		II		III	
Observable practice (d)	−0.391	***	−0.392	***	−0.392	***
	(0.06)		(0.06)		(0.06)	
Firm age (ln)					0.045	
					(0.05)	
Firm size (ln)					−0.034	
					(0.04)	
Network centrality (ln)					−0.016	
					(0.03)	
European HQ (d)			−0.335	***	−0.310	**
			(0.12)		(0.13)	
North American HQ (d)			−0.194		−0.164	
			(0.14)		(0.15)	
Asian HQ (d)			−0.041		−0.015	
			(0.14)		(0.15)	
Captive (d)			−0.053		−0.046	
			(0.12)		(0.12)	
Early Stage Focus			−0.329	**	−0.356	**
			(0.14)		(0.09)	
Healthcare Focus (d)			−0.276	*	−0.270	
			(0.16)		(0.17)	
IT Focus (d)			−0.047		−0.037	
			(0.13)		(0.14)	
No Industry Focus (d)			0.065		0.069	
			(0.13)		(0.14)	
Positive or null impact of COVID-19 (d)			−0.166	**	−0.152	*
			(0.08)		(0.08)	
Constant			−0.041		−0.015	
			(0.14)		(0.15)	
No. of obs	3335		3335		3335	
No. of companies	388		388		388	

Standard errors in brackets. Significance level: *p-values < 10%, **p-values < 5%, ***p-values < 1%

age, *Firm size* and *Network centrality*. In line with hypothesis H1, all our models confirm a negative and statistically significant coefficient (p-value < 0.001) of the dummy variable *Observable practice*, indicating that the likelihood of a change is lower (−11.33%, p-value 0.000) for an observable investment practice.

To test the second and third hypotheses (H2 and H3), we add one by one the interactions between the three selected characteristics and the dummy variable, *Observable practice*. Results are reported in Table 7.

Model IV introduces the interaction between *Observable practice* and *Firm age*; model V contains the interaction between *Observable practice* and *Firm size*, while model VI presents the interaction between *Observable practice* and *Network centrality*. Lastly, model VII incorporates all these interactions.

In line with our second hypothesis (H2), the interaction between the observability of investment practices and the VC age is positive and statistically significant, thus indicating that older VC firms are more likely to resort to changes in observable practices. In other words, the negative association between *Observable practice* and the dependent variable becomes weaker when the VC age increases. Figure 1 provides a graphical representation of the probability of changing observable or unobservable practices for different values of VC age for the model in column VII, where graphical analysis is typically

Table 7 Estimations for changes in investment practices with interactions

Model	IV		V		VI		VII	
Observable practice (d)	−0.664	***	−0.804	***	−0.272	**	−0.922	***
	(0.20)		(0.24)		(0.14)		(0.29)	
Firm age (ln)	0.015		0.045		0.044		0.008	
	(0.06)		(0.05)		(0.05)		(0.06)	
Observable practice (d)×firm age (ln)	0.114						0.140	*
	(0.08)						(0.08)	
Firm size (ln)	−0.034		−0.059		−0.034		−0.062	
	(0.04)		(0.05)		(0.04)		(0.05)	
Observable practice (d)×firm size (ln)			0.096	*			0.104	*
			(0.05)				(0.06)	
Network centrality (ln)	−0.015		−0.015		−0.006		0.005	
	(0.03)		(0.03)		(0.03)		(0.04)	
Observable practice (d)×network centrality (ln)					−0.035		−0.074	*
					(0.04)		(0.04)	
European HQ (d)	−0.310	**	−0.311	**	−0.310	**	−0.313	**
	(0.13)		(0.13)		(0.13)		(0.13)	
North American HQ (d)	−0.165		−0.165		−0.164		−0.169	
	(0.15)		(0.15)		(0.15)		(0.15)	
Asian HQ (d)	−0.015		−0.014		−0.015		−0.015	
	(0.15)		(0.15)		(0.15)		(0.15)	
Captive (d)	−0.047		−0.046		−0.046		−0.047	
	(0.12)		(0.12)		(0.12)		(0.12)	
Early Stage Focus	−0.357	**	−0.356	**	−0.356	**	−0.357	**
	(0.16)		(0.16)		(0.16)		(0.16)	
Healthcare Focus (d)	−0.272		−0.270		−0.270		−0.273	
	(0.17)		(0.17)		(0.17)		(0.17)	
IT Focus (d)	−0.037		−0.036		−0.036		−0.037	
	(0.14)		(0.14)		(0.14)		(0.14)	
No Industry Focus (d)	0.068		0.069		0.070		0.068	
	(0.14)		(0.14)		(0.14)		(0.14)	
Positive or null impact of COVID-19 (d)	−0.152	*	−0.152	*	−0.152	*	−0.152	*
	(0.08)		(0.08)		(0.08)		(0.08)	
Constant	−0.015		−0.014		−0.015		−0.015	
	(0.15)		(0.15)		(0.15)		(0.15)	
No. of obs	3335		3335		3335		3335	
No. of companies	388		388		388		388	

Standard errors in brackets. Significance level: *p-values < 10%, **p-values < 5%, ***p-values < 1%

recommended in the analysis of interaction effects, given the non-linear nature of Probit models (e.g. Hoetker, 2007).

The likelihood of changing an observable practice is equal to 16.85% for younger VC firms (i.e. when age is at the 10th percentile of the distribution), while the probability of changing an unobservable one is 32.54%. The difference between the two probabilities is statistically significant at the 1% significance level. On the other hand, for older VC firms (i.e. when age is equal to the 90th percentile), the likelihood of changing observable investment practices is 25.93%, while the probability of changing unobservable ones is 33.16%. The difference is not statistically

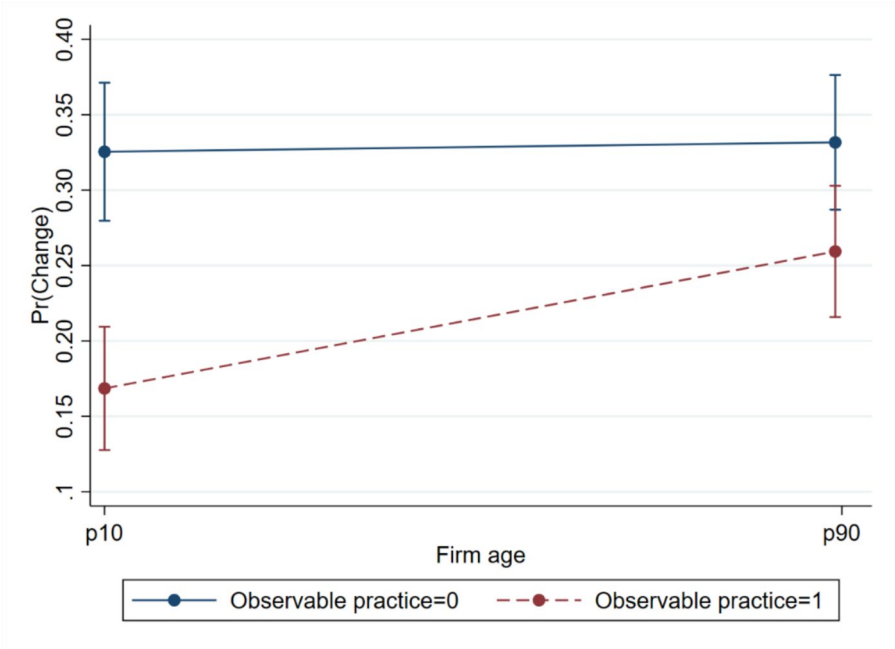

Fig. 1 Predictive margins of *Observable practice when Firm age* takes values corresponding to its 10th and 90th percentile with 90% Cls

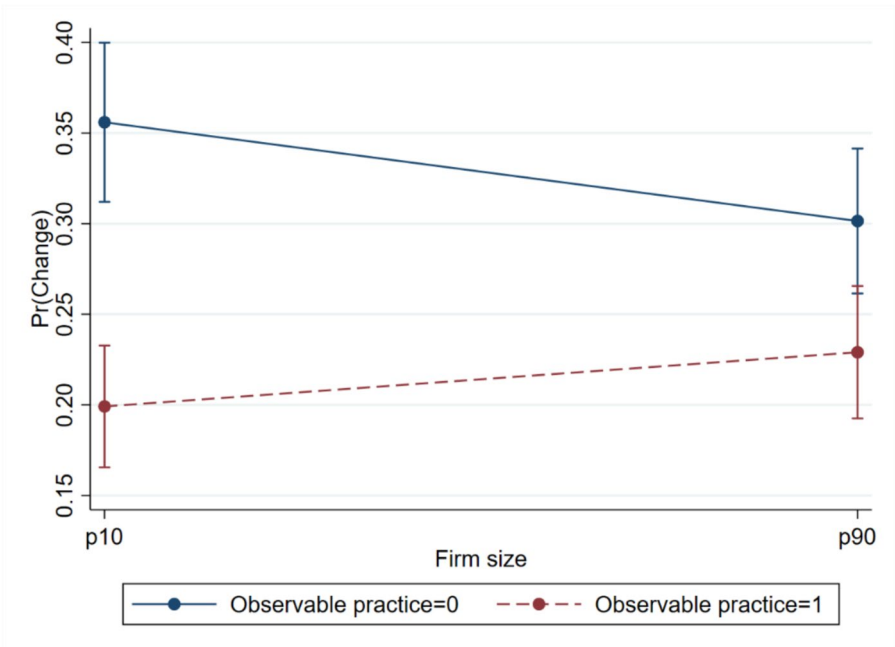

Fig. 2 Predictive margins of *Observable practice when Firm size* takes values corresponding to its 10th and 90th percentile with 90% Cls

significant: i.e. if a VC firm is sufficiently old, there are no differences in the likelihood of changing an observable or an unobservable practice. In other terms, this result confirms that younger VC firms are significantly more reluctant than older VC firms to change observable investment practices vis-à-vis unobservable ones.

The second hypothesis is also confirmed by looking at the interaction of the variable *Observable practice* with the variable *Firm size*, which is positive

and statically significant in models V and VII. As expected, larger VCs are more likely to resort to changes in observable practices.

Estimating the adjusted predictions as reported in Fig. 2 for the model in column VII, the likelihood of changing an observable practice is equal to 19.91% for smaller VC firms (i.e. when size is at the 10th percentile of the distribution), while the probability of changing an unobservable practice for the same category of firms is 35.59%. The difference is statistically significant at the 1% significance level. Conversely, for larger VC firms (i.e. when size is equal to the 90th percentile), the likelihood of changing observable investment practices is 22.90%, while the probability of changing unobservable ones is 30.15%. The difference is not statistically significant: i.e. if a VC firm is sufficiently large, there are no differences in the likelihood of changing an observable or an unobservable practice. In other terms, this result confirms that smaller VC firms are significantly more reluctant than larger VC firms to change observable investment practices vis-à-vis unobservable ones.

The third hypothesis (H3), which is about the lower probability for more central VCs to adopt changes in observable investment practices after the COVID-19 pandemic, is supported (model VII). In fact, the coefficient of the variable capturing the interaction between practice observability and VC centrality is significantly negative; consequently, central firms are less likely to pursue changes in observable practices.

Estimating the adjusted predictions as reported in Fig. 3 for the model in column VII, the likelihood of pursuing an *Observable practice* is equal to 18.09% for more central VC firms (i.e. when *Network centrality* is at the 90th percentile of the distribution), while the probability of changing an unobservable practice is 33.17%, with the difference statistically significant at the 1% significance level. In contrast, for less central VC firms (i.e. when *Network centrality* is equal to the 10th percentile), the likelihood of modifying observable investment practices is 25.14%, while the probability of changing unobservable ones is 32.57%. The difference is not statistically significant: i.e. less central VC firms have no preference to change unobservable rather than observable practices. Said differently, these results confirm that, *ceteris paribus*, more central VC firms are more reluctant than less central VC firms to change observable investment practices compared to unobservable ones.

Regarding control variables, our models suggest that European VC firms and VC firms with a stronger early stage focus are less likely to resort to changes in investment practices. Similarly, VC firms with less impacted portfolios are less likely to change.

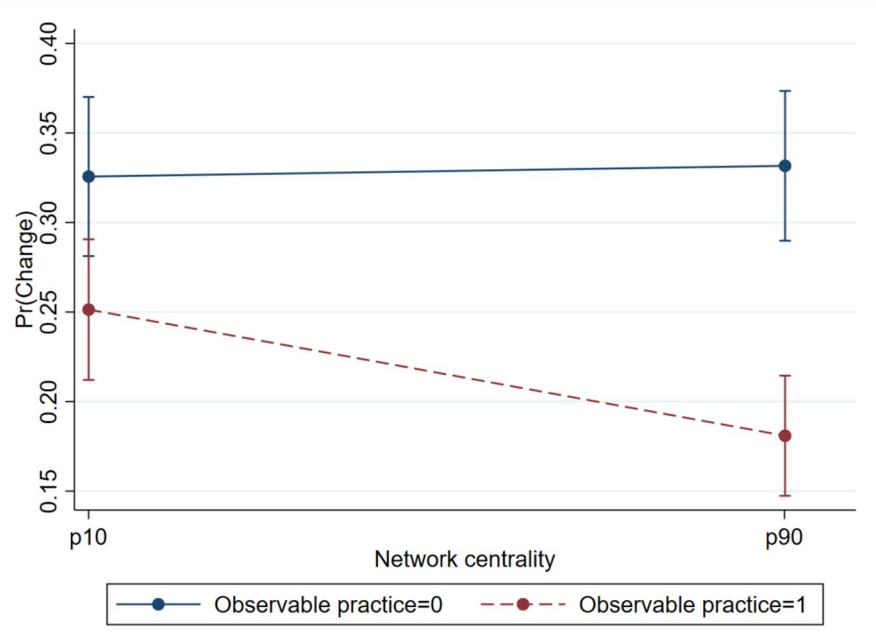

Fig. 3 Predictive margins of *Observable practice when Network centrality* takes values corresponding to its 10th and 90th percentile with 90% Cls

This control reinforces the underlying theory that firms that have been less impacted are less likely to make changes of any kind to avoid being penalised by the market. In line with the recent literature on the impacts of COVID-19 on VCs (Bellucci et al., 2023; Gompers et al., 2021), VC type does not appear to influence investment behaviour after COVID-19.

5 Robustness checks

5.1 Policy indexes

The pandemic has led countries to respond with health, social and economic measures. Among the most noteworthy efforts to track policies implemented by governments are the works of Cheng et al. (2020) and Hale et al. (2021). This source of heterogeneity can influence our result. We conduct a robustness check that considers the measures undertaken by different governments. In order to map the impact of government measures on companies, we use the 'business restrictions' index created by Kubinec et al. (2021) as one of the six indices[9] resulting from the fusion of the two databases many of the authors worked on: the Oxford COVID-19 Government Response Tracker (OxCGRT) (Hale et al., 2021) and the COVID-19 Government Response Event Dataset (CoronaNet) (Cheng et al., 2020). Both databases have been used in numerous scientific articles, including studies in economics (e.g. Aristei & Gallo, 2023; Birhanu et al., 2022; Brodeur et al., 2021; Chen et al., 2021; Dheer et al., 2021; Haug et al., 2020; Koçak et al., 2022; Stephan et al., 2023). The index represents the intensity of labour restriction policies in more than 180 countries from 1 January 2020 to the end of April 2021. The index takes into account 26 variables from the Oxford database, including restrictions on financial activities and transport, and 13 from CoronaNet, including social distance to the workplace, the possibility of face-to-face meetings and the inability to go to the office. The index is a standardised percentage of the weight of each policy that highlights the conditions under which certain work activities can operate. Positive and negative signs are considered since a policy may restrict or enable work. In practice, the index results from the number of restrictions put in place on a given day in a given country (Kubinec et al., 2021). We construct a dummy equal to one if the country has an average index above the median. Furthermore, we consider the VC firm's propensity to invest in national deals by using a dummy that is equal to one if the percentage of previous domestic deals in Preqin is equal to or more than 50%. The interaction between these two variables tests whether VC firms focusing more on domestic deals are more affected by more stringent policy restrictions.

Table 8 shows the results of the models, including this interaction. Model R_I tests the H1, adding the abovementioned interaction in model III—Table 6. Model R_II and model R_III test the H2, adding the abovementioned interaction in models IV and V—Table 7, respectively. Model R_IV tests the H3, adding the abovementioned interaction in model VI—Table 7. Lastly, model R_V jointly tests the hypotheses, adding the abovementioned interaction in model VII—Table 7. Results confirm our research hypotheses and document that Europe-based VC firms reacted less without distinction on the policy stringency.

Our results are robust to several different ways of controlling this restriction index. First, we change the control variable using a dummy that considers the maximum level of policy restriction instead of the average. Secondly, we measure the instability of the restriction through the standard deviation. We calculate both measures using a dummy, taking value one if the country is above the median. Lastly, we build a variable that is the sum of the three dimensions (persistence, peak and instability), obtaining similar results. In addition, we use an alternative index presented by Hale et al. (2021), the stringency one. As said, all these checks yield results similar to those presented in Table 8.

5.2 Other robustness tests

We developed further tests to corroborate the results. First, we employ a pooled OLS estimator instead of the random effects one, by clustering errors at strategy level. Second, we repeat the same OLS regression, but with the clusterisation of errors at the company

[9] The others are 'use of individual protections', 'health monitoring', 'health resources', 'school restrictions' and 'social distancing'.

Table 8 Robustness test: estimations for changes in investment practices with the introduction of the interaction between the domestic focus and the Business Restriction Index

Model	R_I		R_II		R_III		R_IV		R_V	
Observable practice (d)	−0.377	***	−0.636	***	−0.783	***	−0.243	*	−0.889	***
	(0.06)		(0.20)		(0.24)		(0.14)		(0.29)	
Firm age (ln)	0.050		0.022		0.050		0.050		0.014	
	(0.06)		(0.06)		(0.06)		(0.06)		(0.06)	
Observable practice (d)×firm age (ln)			0.108						0.137	*
			(0.08)						(0.08)	
Firm size (ln)	−0.029		−0.029		−0.054		−0.029		−0.057	
	(0.04)		(0.04)		(0.05)		(0.04)		(0.05)	
Observable practice (d)×firm size (ln)					0.094	*			0.104	*
					(0.05)				(0.06)	
Network centrality (ln)	−0.007		−0.007		−0.007		0.004		0.014	
	(0.03)		(0.03)		(0.03)		(0.03)		(0.04)	
Observable practice (d)×network centrality (ln)							−0.039		−0.077	**
							(0.04)		(0.04)	
Restricted country (d)	−0.053		−0.052		−0.053		−0.053		−0.053	
	(0.15)		(0.15)		(0.15)		(0.15)		(0.15)	
Domestic focus (d)	0.124		0.124		0.125		0.124		0.125	
	(0.12)		(0.12)		(0.12)		(0.12)		(0.12)	
Restricted country (d)×domestic focus (d)	0.210		0.210		0.210		0.210		0.210	
	(0.13)		(0.13)		(0.13)		(0.13)		(0.13)	
European HQ (d)	−0.357	***	−0.358	***	−0.359	***	−0.358	***	−0.361	***
	(0.13)		(0.13)		(0.13)		(0.13)		(0.13)	
North American HQ (d)	−0.211		−0.212		−0.212		−0.211		−0.217	
	(0.16)		(0.16)		(0.16)		(0.16)		(0.16)	
Asian HQ (d)	−0.028		−0.028		−0.028		−0.029		−0.029	
	(0.15)		(0.15)		(0.15)		(0.15)		(0.15)	
Captive (d)	−0.042		−0.043		−0.042		−0.042		−0.043	
	(0.12)		(0.12)		(0.12)		(0.12)		(0.12)	
Early Stage Focus	−0.371	**	−0.372	**	−0.371	**	−0.372	**	−0.372	**
	(0.16)		(0.16)		(0.16)		(0.16)		(0.16)	
Healthcare Focus (d)	−0.285		−0.287		−0.286		−0.285		−0.288	
	(0.18)		(0.18)		(0.18)		(0.18)		(0.18)	
IT Focus (d)	−0.032		−0.033		−0.032		−0.031		−0.032	
	(0.14)		(0.14)		(0.14)		(0.14)		(0.14)	
No Industry Focus (d)	0.054		0.052		0.053		0.055		0.053	
	(0.14)		(0.14)		(0.14)		(0.14)		(0.14)	
Positive or null impact of COVID-19 (d)	−0.154	*	−0.155	*	−0.155	*	−0.155	*	−0.155	*
	(0.08)		(0.08)		(0.08)		(0.08)		(0.08)	
Constant	−0.028		−0.028		−0.028		−0.029		−0.029	
	(0.15)		(0.15)		(0.15)		(0.15)		(0.15)	
No. of obs	3299		3299		3299		3299		3299	
No. of companies	384		384		384		384		384	

Standard errors in brackets. Significance level: *p-values < 10%, **p-values < 5%, ***p-values < 1%

level. Third, we run main analyses (and these other robustness checks) by also adding fixed effects at the country level. The findings produced after all these model adjustments are qualitatively comparable to those shown in Sect. 4.

6 Additional evidence

We believe that a strength of our survey is the possibility of obtaining detailed information about each practice decision in isolation. In this section, we report the analysis for each practice decision. We employ a series of Probit regression models with robust standard errors to explore which practice change has been more affected by our independent variables of interest. As dependent variables, we resort, one by one, to the variables capturing changes in practices introduced in Sect. 3.3. We also introduce two additional controls to consider the non-independence between changes in these models. Specifically, we introduce the control *Other observable changes* for changes in another observable practice, compared to the one under investigation. In other terms, this dummy is equal to one if the VC firm has made at least one change in another observable practice besides the focal one. In addition, the control *Unobservable changes* is added to control when the VC firm has pursued at least one change in an unobservable practice. Similarly, we introduce the control *Other unobservable changes* for changes in another unobservable practice (with respect to the one studied). Thus, this dummy is equal to one if the VC firm has made at least one other change in another investment practice besides the focal one. In addition, the control *Observable changes* plays an analogous (but opposite) role to the control *Unobservable changes* in the former regression, so it has the value of one if the VC firm has undertaken at least one change in an observable investment practice.

We report the results of the models on changes in observable practices in Table 9,[10] while Table 10 refers to unobservable ones.

[10] The number of observations in the first practice is lower than in the others for two reasons: first, the related question was not shown to investors who had indicated in earlier questions that they were not cross-border investors (as shown in Table 2); second, the 'captive' control is omitted due to collinearity, resulting in the exclusion of captive investors responses from the model.

In line with our second hypothesis (H2), *Firm age* is positively and significantly correlated to the adoption of changes shown in Table 9, thus indicating that older firms are more likely to resort to changes in observable practices, such as an increase in domestic focus and postponement of exit. The probability of increasing the domestic focus is equal to 1.90% for younger VC firms (i.e. when *Firm age* is at the first quartile of the distribution), while for older VC firms (i.e. when *Firm age* is equal to the third quartile), the probability of increasing domestic focus is equal to 7.00%, where the difference is statistically significant at the 5% significance level. Regarding the of postponement of exit, the probability is equal to 36.92% for younger VC firms, whereas for the older ones, it is 46.21%. Again, the difference is statistically significant at the 5% significance level. Conversely, no significant effects are found in the unobservable investment practices, as reported in Table 10.

The positive coefficient of *Firm size* for stage diversification indicates that larger VC firms are more likely than smaller ones to change this observable practice. The probability of diversifying the stage after the COVID-19 outbreak for smaller VC firms is equal to 4.59% (i.e. when *Firm size* is at the first quartile of the distribution), while for larger ones is 7.44% (i.e. when *Firm size* is equal to the third quartile), with the difference being statistically significant at the 5% significance level. Conversely, when we focus on changes in unobservable investment practices, as reported in Table 10, the coefficients become not statistically significant anymore or statistically negative—as for the effort in deal sourcing/origination and in the post-investment activities—confirming that younger and smaller VC firms did not behave differently than their older and larger counterparts in changing their unobservable investment practices immediately after the COVID-19 outbreak or, at worst, they were more prone to change. These results, taken together, confirm our H2: smaller and younger VC firms have been less likely to embark on changes in observable practices.

Our third hypothesis (H3) focuses on VC centrality. Results in Table 9 related to changes in observable practices indicate that an higher network centrality is significantly associated with an increased domestic focus and a postponement of the exits. The probability of increasing the domestic focus is equal to 5.24% for less central VC firms (i.e. when *Network centrality* is at the first quartile of the

Table 9 Additional evidence: estimations for changes in specific observable practices

Dependent variable	Increasing domestic focus		Diversification of stages		Postponement of exits	
Firm age (ln)	0.558	**	−0.212		0.207	**
	(0.23)		(0.15)		(0.10)	
Firm size (ln)	−0.156		0.179	**	0.046	
	(0.14)		(0.09)		(0.07)	
Network centrality (ln)	−0.175	*	0.114		−0.103	*
	(0.10)		(0.09)		(0.05)	
European HQ (d)	4.236	***	−0.317		−0.432	*
	(0.44)		(0.35)		(0.26)	
North American HQ (d)	5.269	***	−0.064		−0.442	
	(0.44)		(0.38)		(0.28)	
Asian HQ (d)	4.830	***	0.316		0.018	
	(0.43)		(0.37)		(0.29)	
Captive (d)	-		−0.636	*	−0.092	
	(.)		(0.34)		(0.20)	
Early Stage Focus	−0.324		−0.242		−0.662	**
	(0.62)		(0.42)		(0.29)	
Healthcare Focus (d)	0.758		−0.450		−0.341	
	(0.69)		(0.58)		(0.31)	
IT Focus (d)	1.015	*	0.283		0.028	
	(0.57)		(0.41)		(0.26)	
No Industry Focus (d)	1.245	**	0.345		0.213	
	(0.58)		(0.39)		(0.25)	
Positive or null impact of COVID-19 (d)	−0.321		−0.038		−0.171	
	(0.25)		(0.20)		(0.14)	
Other observable changes (d)	0.045		0.259		0.203	
	(0.26)		(0.21)		(0.21)	
Unobservable changes (d)	0.556	*	0.188		0.361	**
	(0.29)		(0.25)		(0.16)	
Constant	0.045	***	0.259	***	0.203	
	(0.26)		(0.21)		(0.21)	
No. of obs	200		388		388	

Estimates are derived from Probit models with robust standard errors. The dependent variables are dummy variables referring to changes in observable investment practices, as illustrated in Table 2. Standard errors in brackets. *, ** and *** indicate significance levels at 0.10, 0.05 and 0.01, respectively

distribution), while for more central VC firms (i.e. when *Network centrality* is equal to the third quartile), the probability of increasing domestic focus is equal to 2.50%. Regarding the of postponement of exit, the probability is equal to 46.11% for less central VC firms, whereas for the more central ones, it is 36.89%, with the difference being statistically significant at the 5% significance level. Conversely, no significant effects are found in the unobservable investment practices, as reported in Table 10. Following H3, VCs occupying central positions in their network are the ones that appear most reluctant to engage in changes concerning observable investment practices.

7 Conclusions

This study investigates from both a theoretical and an empirical point of view if and to what extent a dramatic crisis such as the one represented by the outbreak of COVID-19 could change the investment practices that VC firms put in place in the short run. By categorising these investment practices according to their different degree of visibility to external eyes, we hypothesise that unobservable investment practices are more likely modified than observable ones. As a matter of fact, GPs are responsible toward LPs, which implies that investment styles should comply with the

Table 10 Additional evidence: estimations for changes in specific unobservable practices

Dependent variable	Increasing effort in deal sourcing/ origination	Increasing effort in deal screening/ selection	Increasing effort in deal structuring	Increasing effort in post-investment activities	Increasing effort in deal closing/exit	Increasing managers interactions
Firm age (ln)	0.052	0.006	−0.029	−0.022	0.133	−0.087
	(0.10)	(0.10)	(0.12)	(0.11)	(0.10)	(0.10)
Firm size (ln)	−0.177 **	−0.041	0.052	−0.158 **	0.020	0.037
	(0.07)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)
Network centrality (ln)	0.020	−0.050	−0.033	0.038	−0.041	0.005
	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)
European HQ (d)	−0.021	0.056	−0.312	−0.652 **	0.180	0.242
	(0.26)	(0.27)	(0.27)	(0.28)	(0.27)	(0.27)
North American HQ (d)	0.117	0.226	−0.067	−0.699 **	0.192	0.531 *
	(0.29)	(0.29)	(0.29)	(0.30)	(0.29)	(0.29)
Asian HQ (d)	−0.066	0.204	−0.538 *	−0.226	0.383	0.186
	(0.29)	(0.30)	(0.31)	(0.32)	(0.29)	(0.31)
Captive (d)	0.078	−0.194	0.286	0.098	0.184	0.228
	(0.20)	(0.23)	(0.21)	(0.19)	(0.20)	(0.20)
Early Stage Focus	−0.064	−0.058	0.164	−0.533 *	−0.464	0.368
	(0.29)	(0.31)	(0.32)	(0.28)	(0.33)	(0.28)
Healthcare Focus (d)	0.090	0.316	0.236	−0.260	−0.418	−0.085
	(0.33)	(0.32)	(0.34)	(0.31)	(0.34)	(0.34)
IT Focus (d)	0.041	0.195	−0.348	0.031	−0.170	0.094
	(0.27)	(0.27)	(0.30)	(0.26)	(0.29)	(0.29)
No Industry Focus (d)	0.392	0.188	−0.053	−0.085	−0.311	0.129
	(0.26)	(0.26)	(0.28)	(0.25)	(0.27)	(0.28)
Positive or null impact of COVID-19 (d)	0.012	−0.099	0.278 *	−0.110	−0.184	−0.155
	(0.15)	(0.15)	(0.16)	(0.15)	(0.15)	(0.15)
Observable changes (d)	0.115	0.387 **	0.182	0.204	0.265 *	0.438 ***
	(0.14)	(0.15)	(0.16)	(0.14)	(0.15)	(0.15)
Other unobservable changes (d)	1.001 ***	1.447 ***	0.920 ***	1.087 ***	1.149 ***	0.794 ***
	(0.18)	(0.25)	(0.20)	(0.16)	(0.19)	(0.17)
Constant	−0.852 *	−1.789 ***	−1.548 ***	0.472	−1.360 **	−1.717 ***
	(0.51)	(0.55)	(0.55)	(0.49)	(0.54)	(0.56)
No. of obs	388	388	388	388	388	388

Estimates are derived from Probit models with robust standard errors. The dependent variables are dummy variables referring to changes in unobservable investment practices, as illustrated in Table 3. Standard errors in brackets. *, ** and *** indicate significance levels at 0.10, 0.05 and 0.01, respectively

stated objectives in contracts, where departures are typically regarded negatively by investors (Buzzacchi et al., 2015; Cumming et al., 2009). At the same time, VC firms present different profiles in terms of reputational capital and exposure to possible reputational backlashes of a change in the investment practice pursued. We hypothesise that relatively younger and smaller VC firms would be more reluctant than their older and larger counterparts to change observable investment practices. Analogously, this reluctance to modify observable investment practices could also characterise, *ceteris paribus*, VCs that are more central in a network of investors since they are more exposed than non-central ones. Based on information gathered through an extensive global survey of the world's population of VC firms, the empirical

analysis largely confirms our theoretical reasoning, giving us new insights into how the VC industry operates and responds to 'black swan'-type crises. We show that significant differences arise in the LP-GP relationship depending on GPs' characteristics and the observability of their strategies: beneath average results, considerable variance does exist, which we clarify to better understand the diverse responses of entrepreneurial finance to crises. In doing so, our study highlights the soundness of the 'reputational capital' lens in interpreting the whole VC context (e.g. Gompers, 1996) even in periods of dramatic stress, and in doing so, it increases the information set of all stakeholders—including LPs and GPs—on how different type of actors will respond in practice to these types of shocks. Consistently, our study raises awareness of potential sub-optimal decisions in response to crises by GPs who aim to avoid jeopardising their reputation in order to maximise their remuneration in both current and future VC funds. Given the GPs' compensation structure, which consists primarily of management fees and carried interest, and the limited duration of VC funds, maintaining and enhancing reputational capital is essential to increasing their returns. Since GPs' compensation depends directly or indirectly on successful fundraising, any deviation from expected practices can jeopardise their reputation and future earnings. Therefore, when exogenous conditions necessitate changes, GPs are concerned about safeguarding their reputational capital. As a follow-up question, future work could thoroughly investigate 'new normal' syndications and contracts between LPs and GPs and between GPs and invested companies, and investigate how the reputational capital of GPs may influence the contractual terms. An additional research question could further explore the determinants of change at the investment practices level. In particular, our analysis categorises investment practices into two groups—observable and unobservable—and compares them but does not examine which specific practices are more likely to change within each group. Future research could address this aspect by investigating how the availability of information during a crisis influences the tendency to change one practice over another. In addition, further mechanisms that may influence investor behaviour could be investigated, such as the lack of financial resources or human capital. In fact, opportunities for change, but more importantly, the different directions of these potential changes, can be somehow limited or influenced by significant factors, not only financial ones, but also, for example, the characteristics of the human capital of the GPs. Analysing how these letter characteristics may impact a firm's decisions during a crisis could clearly provide a useful advancement to the competence-based view of the firm (Colombo & Grilli, 2005). Finally, in this study, we do not explore in detail how GPs supported their portfolio companies during the pandemic; future research questions could use this event to investigate the added value of having a VC investor during an important crisis.

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Data Availability The data that support the findings of this study have been collected through a survey. Restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available.

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