How venture capitalists decide which new medical technologies come to exist

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Abstract

To encourage the commercial translation of biomedical discoveries, public policies increasingly seek to stimulate the venture capital industry. Very little is known, however, about the way venture capitalists assess the likely benefits new technologies may bring to clinical practice and healthcare systems. Drawing on a five-year fieldwork conducted in Quebec (Canada), which included in-depth interviews and document analysis, we explore why capital investors choose to invest in certain health technology-based ventures and how they influence the innovation process. Our findings clarify how capital investors: first, use market-oriented valuations when they pick and ‘coach’ technology entrepreneurs; second, act to transform and protect their investments; and finally, exert their authority along the technology development process. Current innovation policies should be carefully examined because capital investors’ understanding of the world in which they operate largely determines which health technologies make their way into healthcare systems and which may never come into existence.

Key words: academic spin-offs; medical innovation; venture capital; sociology of innovation; health policy; innovation policy.

1. Capital and new medical technologies

It’s from doctors that the demand [for technology] comes, and the industry tries to produce what doctors want. […] It’s never through direct links with the Ministry of Health. (Health policymaker, Pol5)

By bringing forward the worldview and mandate of those who finance the development of new medical technology, this paper highlights the perplexing absence of health policy considerations in the decisions that give shape to health technology (Sampat and Drummond 2011). We focus our attention on the financing of academic spin-offs, which are small firms created by entrepreneurial academics and clinicians in order to develop and bring a new health technology to market. These emerging firms are actively supported through public policy and are the source of much medical innovation (Chatterji et al. 2008; Grimaldi et al. 2011). Because technology-based spin-offs cannot generate revenues before their core technology reaches the market, the early-stage financing provided by venture capital is crucial (Vohora et al. 2004). It helps move their technology past the ‘valley of death’ to the stage where they can attract a wider spectrum of less specialised investors (Zider 1998; Pierrakis 2010).

While governments are increasingly ‘involved in supporting the financing of innovation and the venture capital industry’ (Duruflé 2010: 15; Fleming 2015; Lerner and Tag 2013), very little is known about the way in which venture capitalists influence technology development and assess the likely benefits new technologies may bring to clinical practice and healthcare systems (Ackerly et al. 2008). Research on venture capital mostly belongs to business and innovation management scholarship and seeks to quantitatively explain the economic performance of an investment portfolio or of the firms supported by venture capital (Amit et al. 1998; Bertoni et al. 2011). This business focus is not entirely surprising considering that many scholars and policy-makers conceive of innovation policy as a tool for delivering a country’s ‘growth agenda’ (European Commission 2013).

Rather, this paper adopts a sociological perspective in order to qualitatively explore how capital investors think about health technology-based ventures, what they consider valuable when investing in healthcare and what empowers their actions along the technology development path. By doing so, our paper contributes to public policy scholarship by critically examining the societal implications of venture capital, which has tangible consequences for patients, healthcare providers and third-party payers.
1.1 What policy-makers expect from venture capital

Public policies in North America and Europe increasingly seek to stimulate the venture capital industry in order to expedite the commercial translation of biomedical discoveries (Lazonick and Tulum 2011). In the UK:

... the dearth of early-stage funding by private providers has prompted several UK government initiatives to improve access to finance for small high-growth firms. (Pierrakis 2010: 7)

Initiatives introduced in the mid-1990s consisted in the creation of funds and ‘a variety of tax incentives to individuals and corporations’ seeking to draw more capital into the venture capital market (Pierrakis 2010: 7). Canada has a ‘strong history of government involvement’ in the life sciences venture capital (Tucker et al. 2011: 332). While it remains hazardous in systems of innovation to attribute a direct effect to specific policy interventions (Hirsch-Kreinsen 2011), the levels of venture capital potentially available to Canadian life sciences companies have more than doubled in the period 2001–10 (Tucker et al. 2011). To help innovative companies to gain easier access to risk financing, the European Horizon 2020 Programme protected up to €320.14 million in 2014. More specifically, the ‘Access to Risk Finance’ program supports counselling on how to make firms more attractive to risk finance, banks and potential investors, and research into business angels, crowd-funding and the potential for pan-European venture capital ‘funds of funds’ (Horizon 2020 2013). The goal, from a policy standpoint, is to ensure that:

Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. (European Commission 2013)

When it comes to fostering the creation of technology-based ventures, different financing tools can be made available (e.g. loans, guarantees, equity finance) and each bears its own set of strengths and limitations (Buchanan et al. 2009; Oakey 2003). For instance, the ‘fund of funds’ approach often allows the venture capital industry to conduct business as it sees fit. Several policy instruments may thus be seen as being ‘hands-off’. Moreover, practices in the venture capital industry are deeply influenced by financial markets and the extent to which certain sectors are perceived as less risky than others from a speculative standpoint. For instance, Fleming (2015) observed that between the 2009 Great Recession in the USA and 2014 the total venture capital invested in ‘all industry sectors increased dramatically, from $20.3 billion to $39.6 billion’ but the amount invested in life sciences during this time ‘shrank as a percentage of total investments, from 35.7 percent to 19.9 percent’ (Fleming 2015: 273) (see Pierrakis 2010 for a discussion of the impact of the dotcom crash on venture capital in the UK).

Venture capital is risky because of the high failure rate and the nature of the investments at play. Venture capitalists commit their resources for a specified period of time to small privately held companies with few tangible assets. Part of the risk arises because the capital is ‘illiquid’ during this period of time (Amit et al. 1998; Buchanan et al. 2009; Styhre 2014). The window of opportunity for a ‘liquidity event’ such as acquisition by another company or an initial public offering—which provides the ability to sell shares to the public—is generally within five years (Tucker et al. 2011; Robinson 2015). These so-called ‘exit’ events enable venture capitalists to recoup their investments and generate a return. Akin to ‘a loan with a 58% annual compound interest rate that cannot be prepaid’, venture capital represents very high-cost capital, but this rate is seen as necessary because most ventures fail (Zider 1998: 135). Indeed, Song et al. (2008) found that only 36% of American ventures created in the period 1991–2000 with more than five employees had survived after four years and this rate fell to 21.9% after five years. The returns from a subset of firms are thus ‘much greater than average to make up for the many expected failures’ and yield, on average, returns above 20% (Ackerly et al. 2008: 69).

Established scholarship on venture capital acknowledges that venture capitalists seek to both pick winners and build them (i.e. foster their growth and success) (Baum and Silverman 2004). Venture capitalists do not simply provide costly financing to a few carefully chosen entrepreneurs, they also engage in ‘value-adding activities’ (Luukkonen et al. 2013). These activities consist of: first, ‘coaching’ the spin-offs by providing the administrative, marketing and strategy support these young firms usually lack; and second, professionalizing their management and facilitating alliances with key third parties within the industry. Thus, to understand how venture capital may shape the kinds of innovation patients, clinicians and health-care systems receive, one needs to examine not only why capital investors choose to invest in certain health technology-based ventures and not others, but also how they engage in the process, interact with entrepreneurial academics and clinicians and influence their technological endeavour.

To structure such a qualitative analysis, we draw on Leonardi and Barley (2010: 39) who underscore that:

... technologies emerge out of on-going negotiations and conflicts between groups with competing interests and visions of what the technology should do.

They suggest paying attention to the power dynamics that become socially institutionalised over time. Guided by the tenets of institutional theory (Scott 2008), this paper explores the cognitive rules shaping capital investors’ worldview (i.e. how they think), the normative rules guiding their decisions (i.e. what they consider valuable) and the regulative rules that enable and constrain their mandate (i.e. what provides power to their actions along the technology development process). This theoretical framework was chosen considering the tendency in innovation policy research to ‘left censor’ technology construction processes (Leonardi and Barley 2010), which reduces our ability to call into question the macro-social dynamics that affect which new technologies come to exist (Lazonick and Tulum 2011).

We describe below the fieldwork from which this paper draws its empirical observations. Our findings then clarify how capital investors: first, use market-oriented valuations when they pick and coach technology entrepreneurs; second, act to transform and protect their investments; and finally, exert their authority along the ventures’ lifecycle (Vohora et al. 2004). Our discussion points out that handling the subtleties associated with the fulfillment of health policy goals is neither part of the capital investors’ mandate, nor of their worldview. Nevertheless, their influence over technology development has tangible consequences for health policy and for clinicians, patients and third-party payers. Hence, current innovation policies that foreground venture capital should be carefully examined because capital investors’ understanding of the world in which they operate shapes in important ways the kinds of innovation that patients, clinicians and healthcare systems receive and the societal benefits one may expect.
2. Methods

Our five-year fieldwork involved a phased approach wherein we gathered a multifaceted corpus of qualitative data. We organised our data collection strategy around five spin-offs that had been established in the mid-1990s and whose core products were in the early stage of commercialisation when our study began in 2008. These spin-offs developed:

- an optical molecular imaging device for diagnosing breast cancer
- a line of cryoablation catheters for the treatment of arrhythmia
- a decision-support software to monitor prolonged labour and help detect birth-related injuries
- a home telehealth solution comprising a set of coordination tools to promote continuity of care for chronically ill patients
- a computer-assisted navigation system to support minimally invasive orthopaedic surgery

These spin-offs were based in Montreal, the largest metropolitan centre in Quebec (Canada), which has established a strong presence in the medical device and pharmaceutical industries (Tucker et al. 2011).

Our fieldwork involved extensive document review, interviews with key informants and focus groups, and was designed to provide both scope and depth to our program of research. Table 1 indicates the research objective underlying each data source we gathered. Interview guides (available upon request) were tailored to generate an in-depth description of the specific role each group of informants plays in technology development and of the expertise, knowledge and judgments underlying this role. Our recruitment approach for all interviews was purposeful and included a mix of snowballing sampling and systematic interviewing, which is appropriate when a small number of individuals hold the positions of interest (Flyvbjerg 2011; Gibbert and Ruigrok 2010). All documents, including the media content, were available electronically and thus were systematically indexed. Both the documents and the interview transcripts were integrated within QDA Miner data analysis software. This very large qualitative data set enabled an in-depth analysis of how various innovation stakeholders interact and contribute to technology development.

This paper draws more heavily on the interviews with capital investors, but it is necessarily informed by what we have learned throughout our research program and analysed in other publications (Lehoux et al. 2013, 2014a,b). The analyses specific to this paper sought to characterise capital investors’ ways of thinking about and valuing technology-based ventures, but also what empowers their actions throughout the process. Our integrated database and mixed coding strategy (Creswell 2013) enabled us to carefully ponder when and how capital investors interact with technology developers and to develop process-oriented analytic categories that were iteratively consolidated (matrix with illustrative quotes available upon request). To generate an understanding that remains closely linked to data (Ferlie et al. 2005), we built on the most salient themes to develop a narrative that unfolds along the lifecycle of venture capital

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<thead>
<tr>
<th>Fieldwork component</th>
<th>Data sources</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Preliminary data collection phase</td>
<td>• Exploratory interviews with CEOs and high-level executives of five spin-offs and with experts in regulatory affairs and technology transfer (n = 11)</td>
<td>Length: 60–120 min. Notes were recorded during and after each interview</td>
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<td>• Electronic documents retrieval, indexing and analysis:</td>
<td>Content retrieved in 2008 from websites of spin-offs; these documents described the activities of spin-offs since their inception (mid 1990s) and addressed their key audiences</td>
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<td>○ press releases (n = 568)</td>
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<td>○ annual reports (n = 21)</td>
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<td>○ promotional documents (n = 23)</td>
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<td>Detailed data collection phase</td>
<td>• Semi-structured interviews with clinicians and scientists who were part of design team and contributed to creation of three spin-offs (n = 9)</td>
<td>Length: 90–120 min Recorded, transcribed verbatim and checked by respondent</td>
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<td>• Semi-structured interviews with capital investors (n = 6)</td>
<td>Length: 35–120 min Recorded, transcribed verbatim and checked by respondent</td>
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<td>• Semi-structured interviews with regulators (n = 3)</td>
<td>Notes were recorded during and after each event</td>
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<td>• Semi-structured interviews with policy-makers (n = 5)</td>
<td>Databases: CBCA and Biblio Branchée All media content in English or French that mentioned spin-offs, their CEOs and products in period 1998–2009</td>
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<td>• Industry events observation [n = 6]</td>
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<td>• Media coverage analysis (n = 814)</td>
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<td>Analysis and debriefing phase</td>
<td>• Scientific and policy-oriented presentations of preliminary findings (n = 14)</td>
<td>Debriefing after event with research team</td>
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<td>• Mixed focus groups with technology developers, clinicians and patient representatives (n = 19)</td>
<td>Three concurrent groups engaged into two structured deliberations, each lasting 60 min Recorded and transcribed verbatim</td>
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investments (Vohora et al. 2004). This process-oriented narrative points out the cognitive, normative and regulative rules that underlie capital investors’ decisions and actions when: first, they assess the value of a ‘deal’; second, build and protect that value; and finally, monetise it in order to recoup their investment.

The Research Ethics Review Board of the University of Montreal approved this study. We conceal the names of the spin-offs, their products, chief executive officers (CEOs) and employees when quoting empirical material (translated from French to English when applicable). Throughout the paper, we indicate quotes from investors by ‘Inv’, those from technology developers by ‘Dev’ and those from policy-makers by ‘Pol’. For our media sources, we use the following notation: printed general business (PGB), and electronic specialised business (ESB).

3. From assessing the value of a deal to monetising value

We describe the process by which capital investors appraise the likely value of technology-based ventures and then, once an investment decision has been made, construct, protect and monetise this value. Their worldview and actions are interpreted in the light of their interactions with technology developers and the regulatory and policy environment.

3.1 Assessing the value of a ‘deal’

Capital investors are exposed on a yearly basis to many technology ventures looking for funding. Only a small portion of them will result in an investment decision (i.e. ‘a deal’). When screening business plans and assessing which ventures may prove the most interesting, capital investors examine the ‘people’ involved as much as the technology and its scientific underpinnings:

We don’t want someone who comes and has a technology that is amazing, and he doesn’t really know the applications. We really want someone who’ll be thinking about how the health system will be in 10 years from now or 15 years from now, because development cycles are rather long, and we’ll ensure that the entrepreneur really has a reflection on that. (Inv4)

The formal appraisal of a potential deal relies on due diligence, a process that mobilises corporate information (i.e. patent submissions, correspondence with regulatory agencies, financial statements) and external experts. Lawyers and accountants scrutinise the corporate soundness of the venture and whether its intellectual protection (IP) strategy is solid. Knowing how to apply for new patents, acquire existing patents or navigate across various IP systems provides a certain ‘freedom to operate’ (Inv4). Catheters used in interventional cardiology are, for instance, frequently associated with lawsuits for infringement of intellectual property and investors need to anticipate whether competitors will put forward an aggressive IP strategy or not. To assess the clinical value of a potential deal, biomedical experts and physicians are asked to comment on the technical and clinical aspects of the technology. While due diligence seeks to reduce the inherent uncertainty, it remains a ‘very mechanistic’ process in which one gathers credible opinions mainly to confirm one’s own judgment (Inv3). Overall, an investment decision remains rather subjective in that:

… it’s a gut feeling that [investors] seek to document as much as possible. (Inv4)

When asked to define what they consider ‘good’ health innovations, respondents evoked criteria that are loosely compatible with a clinical perspective (e.g. addressing ‘medical needs that matter’, catering to a ‘large group of patients’, ‘saving lives’, ‘really improving the patient’s fate’ (Inv3), or supporting ‘patient-centred’ homecare):

I loved the technology presented to us, which allowed one to follow the patient at home and bring plenty of gadgets, equipment, that would keep our people relatively healthy, but at home rather than being parked in hospices. (Inv5)

When prompted about what they considered to be important healthcare system needs and challenges, capital investors mentioned that a new medical device ‘has to bring benefits to the system in terms of productivity and medico-economic terms’ (Inv6) and that information technology would help by ‘cutting back on paper-based bureaucracy’ (Inv5). Cost-control challenges coupled with an ageing population were seen, by some respondents, as ‘superb investment opportunities’ and supporting ventures that may improve efficiency, reduce hospital length of stays and respond to ageing was described as ‘exciting’ (Inv4). The relevance of addressing ‘domestic’ healthcare concerns was, nevertheless, swiftly tossed away: ‘we are aiming at a worldwide market’ and, from this standpoint, the ‘local [healthcare] system challenges [were] of little concern’ (Inv1). For most respondents, not only was the Canadian market seen as too small and much less affluent, but pressures to control healthcare spending in its publicly funded healthcare system were also considered to be impediments (Inv3).

Capital investors made recurrent comparisons with the USA, where the market signals of the for-profit hospitals are seen as easier to interpret:

I think that in the United States it’s perhaps easier, because the typical private hospital in the US has a financial interest in improving its processes and in performing. Here, it’s not the same logic; it isn’t as clear. I’m not saying that our system doesn’t seek improvements, but it’s more difficult. In part I think because of the financial issue, profit isn’t measured the same way. (Inv3)

Such comparisons between Canada and the USA pinpoint the valuation system that characterises capital investors’ worldview. Health technologies are understood like other consumer products in that they prove their value only when they find their market:

… if the best technology in the world doesn’t raise the interest of the client, it isn’t worth much. (Inv4)

Such a market-oriented valuation also implies that the intrinsic value of the technology is not necessarily what matters the most because:

… it’s not always the best technology that makes it first to the finish line. (Inv1)

This racing metaphor does highlight that arriving first on the market has value, even if the technology may not prove the most medically valuable. The metaphor also evokes the thrill, passion and excitement that pervade the work of venture capitalists:

I’d say it is much more difficult not to invest than invest. Because investors are always very excited: we search, everything looks interesting, it’s, in fact, pretty easy to move forward in an investment project, we believe [we’re right]. We all want to have… we do not want to miss the boat… A good transaction; everyone wants to participate in it! […] That’s great, it’s fun! […] When a deal circulates… […] there’s a dynamic to it, and depending on whom you’re talking to, you’ll get different opinions. (Inv3)

Notwithstanding the danger of ‘falling in love with a deal’ ( Inv1), there was a prevalent notion that one is less likely to be mistaken if
other individuals think the same way. In the face of technology development uncertainty, investors love when others love what they love:

Investors are really like sheep, ok? As long as there’s no leader, there won’t be any deal, that’s clear. It always takes what we call a ‘lead.’ But if you say ok, I’m a leader, I’ll do it, I get on board, and then you find yourself alone, that’s a very bad sign. It means that you’re wrong perhaps. And then, if you don’t have someone else who is willing to get on board, who validates your reading of the case, it’s almost impossible to get the deal through. (Inv3)

Such cognitive group cohesion helps build confidence, which is not only pivotal to an investment decision, but also has broader consequences. The judgments interviewees described as partly technical and partly emotional are shaped by the expertise and sensibility of their community, one that is deemed highly credible by other actors. An innovation policy-maker explained, for instance, how the ministry’s funding scheme for technology-based ventures straightforwardly trusts investors’ judgments:

If the investor gives $1, it’s because he has assessed that there was a potential for the technology. For us, this means we don’t need to have big teams in venture capital… We don’t want to go there. We certainly make an initial review of the project to ensure that everything is in order, but we won’t go any further than that. (Pol1)

Not only venture capitalists make binary, life and death decisions for ventures at an early stage but, because of the financial risks involved, these decisions are seen as trustworthy by policy-makers. This assumption implies that public policy supports the development of those technologies that capital investors identify as valuable. Nevertheless, the value of a particular venture is assessed within the purview of an investment portfolio, not that of the public interest. More specifically, to mitigate financial risks, capital investors must ensure that their investments are diversified across sectors (e.g. energy, mining, healthcare) and within particular sectors (e.g. obstetrics, cancer, cardiology). As the senior vice president of a very large Quebec fund stressed in a media interview, depending on one’s portfolio building strategy, certain investment firms may control and shape a large segment of the domestic technology development capacity:

For almost 12 years we have been present in the health sciences, and have invested a total of $700 million in this area during this period. Today, our portfolio includes approximately 40 companies, representing approximately 25% of the industry. (PGB-14)

Overall, through due diligence investors seek to do their homework seriously, teasing out their own gut feelings toward a potential deal as well as those of external experts and peers. Perhaps hoping that this one venture will be a ‘home run’ (Inv3), they make daring, emotion-filled decisions that unlock a lot of money, but which rely on a limited analysis of market-pull dynamics (i.e. what healthcare systems are likely to need and purchase). Nonetheless, as we will see below, this initial decision may not be the one that matters the most because what happens once a deal has been struck proves more important for the purpose at hand:

Like I said, investment decisions are relatively simple to make: we love, or we don’t; we agree, or we disagree. It’s what happens next. It’s what follows that matters. […] I’m not paid to invest. I get paid to generate a return. So it’s not the $1 that I put, but the $10 I’ll be able to get in a few years from now. (Inv4)

3.2 Constructing and protecting value

Once an investment decision is made, investors’ actions are geared at growing and protecting the value of their investment that is in the form of equity (i.e. shares that provide authority over business decisions). They actively seek to ‘construct’ value by making deliberate efforts to gather and assemble the key resources that ventures need in order to grow.

As an investor, I should give access to, or seek to use my contacts and my investor power—as I represent X billion or X hundreds of millions— in order to give the company access to resources that normally would not be opened to discuss or work with it because it’s a small company. As an investor with deep pockets, I should be able to provide access to resources. I call this macro management; providing resources, providing help, opening doors. (Inv1)

It is through transformative actions that economic value can be ‘constructed’. The terms sheet—a document explaining the ownership stake, controls and investment protections—firmly structures how entrepreneurs and investors interact because it connects the expected returns on investment (ROI) to the milestones a venture must meet over a pre-defined period of time (e.g. animal studies, clinical trials, regulatory approval). When asked why investors would wish to be closely involved in the decisions made by technology developers, one respondent explained the logic at play:

Smaller the company is, the more investors want to be involved. Not on the bench, we understand, but you know… if there’s a decision to make, like ‘a study should be done again.’ Wait a minute: a study should be repeated? Why? It wasn’t part of our plan. And how much it will cost to redo this study? That’s $200,000! No, we can’t. If we put 200,000, we will have to refinance sooner than expected, and if we refinance faster than expected, we won’t have the value we want. […] You, as an investor, you’ve set your deal like, you put your money at time zero and in 18 months we’ll have this; in 24 months we will have this; and in 36 months we will have this, and this we think will be worth x. (Inv3)

The mathematical logic above highlights the importance of an agreed upon timeframe where time matters because technology-based ventures are ‘cash-burning companies’ that ‘are not profitable’ until they can market their products (Inv6). Informed by the expert appraisals gathered during the due diligence, capital investors scrutinise whether the venture will progress swiftly enough, that is within the agreed upon timeframe and without too many unforeseen challenges. For instance, purchasing a patent is described in a business news report both as a protective strategy and a major ‘leap forward’:

[spin-off] would eventually have developed this technology, but buying it now is ‘almost certainly a defensive-type move. It means you can’t be sued now by the guys who own this patent portfolio, and it can also make it difficult for somebody else to use the same technology as you’re using.’ Licensing the optical molecular imaging patents of [name], who recently gained a spot on [spin-off’s] scientific advisory board, also helps it accelerate product development, Piccioni [business analyst at BMO Nesbitt Burns] said. (ESB-1)

Capital investors have the power to influence the progress of a venture directly through its Board of Directors since they obtain a seat when they invest. When asked whether and how they intervene on technology-specific decisions, one respondent explained:

Let me give you an example: I’m developing a new computer program, I have an indication for imaging, well, I have breast cancer,
prostate cancer, brain cancer. Good. But I have limited budgets, I must prioritise over time. The investor will get involved because sometimes we’ll ask for external reports and say well I’d rather like you to go in the brain because there’s less competition, or I’d rather… We’ll intervene, but we’ll do so in concert with the company. (Inv1)

What ‘in concert with’ the company means remains a matter of perspective. For the technology developers we interviewed, capital investors do not really care about the problem-solving challenges, design optimization and technical debugging technology development entails: ‘all they want is their return’ (Dev1). Nonetheless, capital investors affect the design priorities of technology developers by monitoring closely the progress of their R&D activities:

We’re very accountable of course to investors and their influence is indirect, I mean an investor would never come and say make it this colour or make it that colour, the investor will say ‘make revenues come faster, right?’ […] You know, we set priorities according to what we think would be most revenue generating, sometimes we’ve had to take short term decisions. (Dev2)

More specifically, capital investors exert control over technology developers through formal agreements that are renegotiated at each and every round of investment and that determine financial instalments. By controlling when money is made available and for what types of design priorities, capital investors influence the level of refinement of the technology being developed:

If we don’t have the money to automate the device, we’ll have to make it work manually. So, the final technology, the one that will be delivered will be compromised; it won’t be automated. And this is because the decision was made that no money would be available for that. (Dev1)

Thus, the pressures from capital investors have concrete and lasting impacts over the technology, including some that bear direct but largely invisible consequences for patients and third-party payers. For instance, the price at which a new technology will be sold depends, among other things, upon how well the details of the manufacturing process have been optimized:

If the company says that safety isn’t at stake, that it’s a manufacturing issue, the decision may be to not solve the problem. Because it would cost a [new] clinical trial. So, we’ll leave the product as it is, at its high price, it’ll take 2 women per product [to assemble]. Thus, we leave it costly and it’s the patient who pays. Because it’s the system that pays because we can’t solve the manufacturing problem. (Dev1)

Capital investors address safety problems differently because any financial, technical or commercial challenge that threatens the economic value of the ventures prompts immediate and more aggressive protective actions by capital investors. In order to protect the value of their investment, capital investors may, for instance, restructure the venture, reorder its R&D priorities, and fire or replace the CEO:

When the business is going well, generally, we’re not very, very much involved. […] When the management team has gaps that will cause delays, for sure at this point, we’ll start to be more involved. […] With [name of company], we had meetings every week with the CEO, we tried to help him progress. After a while, we came to the conclusion that it didn’t work, so we had to let go of the CEO, and it was I who took the position of CEO […] And that’s not something we’re looking to do, but when there’s a need to do it, we do it. It happened a few times. […] It’s quite dramatic for a company; then you must secure the employees when it happens, you must secure the bankers, the manager of the building, and so on. […] To ensure that everyone… do not panic. […] But the most important thing is to secure employees, obviously, because it’s they, really, who bring value to the company. (Inv4)

This last observation about human capital is important since employees and high-level executives are those who possess the core expertise without which the venture cannot grow. Overall, time and money are allocated to technology developers according to investors’ value capture expectations. To protect this value, investors actively intervene when progress is lacking and this appraisal is inevitably grounded in financial terms:

… my job is very capitalist, it’s about making cash with ventures. (Inv5)

Working for their investors’ good, capital investors have a concrete and lasting impact on the way an initial idea is transformed into a technology that can be commercialised.

### 3.3 Monetising value

While capital investors clearly enjoy nurturing technology-based ventures, their ultimate goal is to ensure an ‘exit’ through which they recoup their investment and monetise returns. When investors hold equity in a spin-off, the ‘main mechanism is to sell their shares’ when the time is ripe (Inv4). One of the milestones that increase the value of a venture most is market approval in the USA or the EU. When the likely value is at its highest, capital investors will seek to persuade other shareholders that the venture should be sold. Because of its legal underpinnings, the Board ‘is the place where everything happens’ and, in principle, ‘it is the interest of the company that must be prioritised by Board members’ (Inv6). For technology-based ventures, this typically implies a successful liquidity event. This event has been anticipated for a while: it is orchestrated by investors and negotiated with the members of the Board:

I’ve been asked, as a member of the Board if I would leave [investment firm] to take care of this venture full-time as interim President—which quickly turned into President—with the task of trying to find a honourable exit for shareholders, investors. So we raised a little more cash, we got funding related to fewer technologies —so we limited our activities around two technologies that were more promising, and it’s on that basis that we sold the assets to an American company. (Inv3)

Those who have created the venture and its core technology are closely engaged in the discussions and may also be jockeying for financial gain through the process, thinking that their own contribution to the venture’s growth is undervalued. Negotiating the shareholders’ agreement was described by some entrepreneurs as being as painful as ‘having a tooth extracted without sedation’ (Inv5). At an early stage and when ambitions are especially high, differential assessments of the prospective value of the technology may render negotiations intricate. In view of the putative exit, the shareholders’ agreement may be comprised of ‘very punitive mechanisms’ to reduce risks (e.g. non-compete agreement), but when a favourable exit takes place it may also enable entrepreneurs to become ‘very rich’ (Inv4).

On the whole, by establishing such contracts at the outset, capital investors have set in motion a significant corporate
... reason why one invests in a spin-off differs from the reason why one sells it later. (In4)

More specifically, at an early stage, an emerging venture that shows an important potential to grow swiftly is what investors covet (i.e. a venture whose core technology is likely to address large markets and/or multiple clinical indications). But, at a later stage, the investors’ goal is to make a profitable exit happen and the downsizing of the venture and of its R&D activities is what makes it sellable. Unsurprisingly, technology developers may feel deceived by transformative actions that alter the scope of the planned R&D activities:

Because the market is too small, the company finally decided not to adapt the product for small children. That’s an example where companies know they could help, but won’t do it because of the market. This part is really saddening for an engineer ... but from a business standpoint, it’s a niche and people and investors don’t want to go down that route. Thus, the government must find a system, to help develop those small markets. (Dev1)

This last observation regarding the support the government should bring to technological innovation brings our analysis back to where it began. Both capital investors and technology developers interact in a context where governments are increasingly expected to support technology-based entrepreneurship. Innovation policies rely on the presumption that publicly funded research should translate into private entrepreneurial activities, as underscored by a senior innovation policy-maker:

Research has to have an ultimate objective. Discovery is great but, we’re pouring an awful lot of money into research and development, so we need to make sure that we’re getting outputs from that. And in fact that’s really the driving force behind the Science & Technology Strategy, was the recognition that Canada really needs to do more to turn ideas into innovations that actually provide concrete solutions to whether it’s improving our economic competitiveness or addressing important environmental... health or other social challenges. (Pol4)

Such a framing of what innovation policy should accomplish posits innovations as highly desirable policy ‘outputs’ whose existence depends upon an entrepreneurial private sector. This economic orientation in public policy establishes a favourable context for venture capitalists to support technology-based ventures, play an influential role in technology development and shape key decisions about health needs.

4. Discussion

We introduced this paper by highlighting an important research gap: very few public policy scholars have qualitatively examined how venture capitalists assess the likely benefits new technologies may bring to clinical practice and healthcare systems and influence technology construction processes (Leonardi and Barley 2010). Paying attention to the socially institutionalised role of capital investors, our findings brought forward how they: first, assess the value of a deal; second, build and protect that value; and finally, monetise value.

4.1 Strengths and limitations

Our findings should be interpreted bearing their strengths and limitations in mind. The Montreal-based spin-offs around which our data collection was organised are strongly dependent on exports to North American and European markets and must therefore be responsive to worldwide regulatory and marketing expectations. The rapid-growth expectations and the market-oriented valuations we described are likely to be observed in other jurisdictions. Yet, our study cannot account for the structural differences (e.g. size, authority, accountability and legal frameworks) between different venture capital firms as well as variations in the support governments bring to the venture capital industry (Oakley 2003; Hirsch-Kreinsen 2011; Foray et al. 2012). Beyond the cyclical nature of capital investment and the fluctuations in financial markets (Fleming 2015; Pierrakis 2010), there are also region-specific dynamics that affect capital investors’ decisions and actions (Song et al. 2008). Our findings point the fact that Canadian investors are influenced by the practices of their American counterparts, but the policy context in which they work differ in many respects: both the level of private wealth and the portion of healthcare that is publicly funded are starkly different (see Robinson (2015) for a discussion of the relationships between capital investment in biomedical innovation and the American healthcare system).

In terms of the standards of rigor in qualitative research, we highlighted both the variations and similitudes across our respondents’ claims and focused our analyses on the institutional rules that shape their worldview and practices (Creswell 2013). Knowing how capital investors perceive the world in which they operate matters because their perceptions shape the materiality of health technologies in important ways. The key strength of this study is that it draws on a five-year fieldwork in which we gathered and analysed multiple sources of data to provide scope and depth to our analyses.

4.2 Summary, contributions and policy implications

Table 2 offers a summary of the cognitive, normative and regulative rules (Scott 2008) that condition the logic underlying capital investors’ decisions and actions, what they consider valuable when they invest in health technology-based ventures and what provides power to their interactions with technology developers and policymakers. These empirical observations contribute to current knowledge in three ways, each of which bears implications for innovation policy as well as health policy, which can affect:

... the uncertainty of or perceived risk surrounding regulatory approval, market adoption, and payment and reimbursement decisions. (Fleming 2015: 272)

First, our study makes a novel contribution to current knowledge by showing the extent to which the ‘coaching’ (Luukkanen et al. 2013) venture capitalists provide to technology entrepreneurs has tangible consequences for patients, healthcare providers and third-party payers. For Zider (1998), venture capitalists occupy a powerful position because they represent the only source of capital. Yet, our study offers richer insights into when and how capital investors exert power, a process that affects the technology development trajectory as a whole. Capital investors’ influence is all but ‘indirect’ since they mobilise institutional mechanisms through which they ‘de-risk’ the deal. These include shaping the venture’s governance, targeting the right applications, making sure entrepreneurs adhere to the investors’ vision, negotiating ahead the future worth of the venture and estimating a comfortable ROI model. By carefully setting the initial terms sheet, which includes the milestones at which money will be made available and by having a seat at the Board of Directors, capital investors actively establish and maintain a
dominant position (Hirsch-Kreinsen 2011). Hence, the societal benefits one may expect from foregrounding venture capital in science policy are largely conditioned by this institutionally powerful position.

From a policy perspective, there is a need to acknowledge that capital investors do not simply fill financing gaps within systems of innovation. Their decisions and actions condition: first, the kinds of venture that will be subsequently supported through various economic policy instruments (e.g. R&D tax credits, entrepreneurship-oriented programs, fiscal incentives etc.); and second, the kinds of technologies that will affect health policies and will ultimately be offered to patients. Our findings make more explicit why the rationale for initially investing in a spin-off differs greatly from the reasons why investors later orchestrate its acquisition by another domestic or foreign firm. An emerging venture that shows potential to grow swiftly is what investors are looking for in order to generate a profitable exit within a reasonable timeframe. The long-term economic consequences for the government that supported its creation and development are not considered in capital investors’ decisions. Innovation policy-makers could thus ponder whether the support they bring to capital-backed firms is truly aligned with their public policy objectives in terms of employment or economic sustainability (Foray et al. 2012; Lazonick and Mazzucato 2013). Our findings also show that certain technological solutions are abandoned in favour of applications that can be commercialised more easily within already established clinical markets. Such risk-averse institutional behaviour also explains why investors contend that regulatory requirements decrease the:

... chance that an investment will be made in a ‘new area’ and increase the chance an investment will be ‘made in a ‘me-too’ space. (Ackerly et al. 2008: 72)

Considering that investment firms may control a large segment of the domestic technology development capacity, an important question lies at the interface of innovation and health policy: should public support be directed only at those ventures that are truly innovative and address unmet needs?

The second contribution of our study is to provide theoretically-informed qualitative flesh around the bones of survey findings indicating that venture capitalists move:

... away from risky areas that might have the greatest potential to improve public health. (Ackerly et al. 2008: 73)

We applied a theoretical framework that helped elicit why and how capital investors use market-oriented valuations when they pick and coach technology entrepreneurs, act to transform and protect their investments and exert their authority throughout the ventures’ lifecycle. This framework forced us to ponder the rules that structure capital investors’ worldview and mandate. Our findings suggest that capital investors’ emotion-filled understanding of what makes a new technology valuable may prove compatible with supporting ventures that address population health needs. But, capital investors do not automatically see value in ventures that address pressing needs unless these ventures can compete as winners in the healthcare ‘marketplace’.

From a policy perspective, our study underscores the need to rethink the basis upon which the value of health technology-based ventures is assessed. Innovation policy scholarship posits that venture capital-backed ventures are likely to outperform non-venture capital-backed ventures. The main arguments are that ‘investors can identify firms with hidden value’, that their investments operate as a ‘signal of the quality of the ventures for uninformed third parties’ and that they bring ‘external resources and competencies that would be out of reach’ without their endorsement (Bertoni et al. 2011).

Such arguments leave aside questions regarding the intrinsic value of the technology being developed and do not acknowledge the market dynamics that are specific to healthcare innovations and which differ profoundly from consumer products. At an early stage, when there is uncertainty around the key value proposition underlying the new technology, investors and entrepreneurs may find it difficult to agree on, and articulate, a coherent business model (Sabatier et al. 2012). For example, what should be the revenue model of a venture that provides home monitoring for the chronically ill? How does one monetise the value of what this technology prevents from occurring such as unnecessary emergency room visits and hospitalizations? As our findings show, technology developers are pressured during the development stage by investors who need the venture to generate revenues. This logic essentially entails designing a technology that is sellable, but whose added value may remain marginal from a health policy standpoint. While many innovations have the potential to tackle healthcare system-level challenges (e.g. supporting primary care and chronically ill patients, reducing health disparities), policy-makers should recognize that the worldview and rules we have described are unable to detect and attribute value to such innovations and are thus likely to limit their emergence (Lehoux et al. 2014b).

The third contribution of our study is to signpost issues of contention in science policy scholarship. Scholars who argue that support to venture capital ‘should figure prominently’ in the policy agenda underscore that it ‘provides an important peculiar

### Table 2. Summary of our empirical observations

<table>
<thead>
<tr>
<th>Assessing value of a deal</th>
<th>Constructing and protecting value</th>
<th>Monetising value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The logic:</strong></td>
<td><strong>The logic:</strong></td>
<td><strong>The logic:</strong></td>
</tr>
<tr>
<td>- A technology will find its market if it relies upon the right entrepreneurial insights</td>
<td>- One deploys his/her resources to help grow the spin-offs and intervenes when progress is lacking</td>
<td>- The maximum of ROI for shareholders should be generated</td>
</tr>
<tr>
<td><strong>What is valuable:</strong></td>
<td><strong>What is valuable:</strong></td>
<td><strong>What is valuable:</strong></td>
</tr>
<tr>
<td>- To find one’s entrepreneur and rationalise one’s gut feelings</td>
<td>- To align the entrepreneurs to one’s vision and to reach milestones swiftly</td>
<td>- To hold and maintain a dominant position throughout the process</td>
</tr>
<tr>
<td><strong>What provides power:</strong></td>
<td><strong>What provides power:</strong></td>
<td><strong>What provides power:</strong></td>
</tr>
<tr>
<td>- To ‘de-risk’ the deal right at the outset</td>
<td>- A seat at the Board of Directors of the venture and an agreed upon timeframe for instalments</td>
<td>- To enforce contracts and provide fair compensation for those who facilitate the exit</td>
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(After an article or book, the reference code 'C15' is assumed to be the source of information or data used in the table.)
contribution to the creation of wealth in a knowledge-based economy’ that cannot be generated otherwise (Bertoni et al. 2011). This position usually evokes ‘market failures’ to justify such use of public resources, as explained in a Horizon 2020 policy brief:

Research and innovation are high-risk activities and there is no guarantee of success. If the risk of failure is too large, the private sector may be unwilling to invest, even if the economic and societal returns could potentially be very large. In addition, the economic benefits of research investments may be captured by others, meaning that individual firms will be unwilling to invest, or there may be compelling policy reasons which limit the size of the market and therefore the potential return. (European Commission 2013: 3)

While such arguments may seem logical, our findings suggest that very important decisions about technology development are being relegated to agents whose understanding of the societal healthcare ‘grand challenges’ remains incomplete (Foray et al. 2012). While a market-driven logic may deliver technologies that have some clinical value, it cannot generate the most valuable technologies from a public policy standpoint. Our observations on the way venture capitalists interact with technology developers suggest that important institutional changes would be required if the goal was to support the design of technologies that can address significant healthcare system priorities (Garber et al. 2014; Léhoux et al. 2008). For instance, capital investors may refer to efficiency and cost-effectiveness as valuable features of a new technology, but handling the subtleties associated with the fulfillment of valuable healthcare goals is neither part of their mandate, nor of their worldview. From an institutional standpoint, the rules underlying venture capital are not responsive to such societal considerations. We thus concur with Lazonick and Mazzucato (2013) who underscored the fact that innovation policies reward value extraction over value creation activities.

From a policy perspective, a macro, hands-off approach to innovation policy-making establishes a favourable context for venture capitalists to play an influential role in technology development and shape key decisions about health needs. The expertise of health policy-makers is rarely if ever called upon by innovation policy-makers (Léhoux et al. 2008) and none of the investors we interviewed considered health authorities to be relevant to their endeavour beyond ‘many, many things are happening’ and electrophysiology was a reassuring ‘well known domain of application’ for which there was no ‘need to create a new market’ (Inv3). Such risk-averse conceptualization is in conflict with the notion that capital investors should look for ‘disruptive’, ‘transformational’ or other ‘path-breaking’ technologies where ‘there’s no competition’ (Inv4). One could deliberately explore such inconsistencies and contradictions in order to enrich current health innovation frameworks (Lazonick and Tulum 2011).

Another avenue for further research lies in the structured approach, norms and culture our interviewees described, which were seen as less audacious:

In American firms, it really is private equity: you have 2 or 4 partners who have made a fortune in a previous life and end up with dozens or hundreds of millions to invest, and it’s these partners who decide to move forward. (Inv3)

Because European countries export to the USA close to half of the medical devices they produce (41%) and they import from the USA more than half of the devices they use (65%) (MedTech Europe updated) it would be enlightening to examine whether the structures, norms and cultures of venture capital firms within the EU and in the USA prove more or less responsive to health policy priorities.

Finally, our study focused on venture capital, which often steps in after entrepreneurs have fished out their core innovative idea with the financial support of relatives or ‘angels’ (e.g. wealthy individuals who finance entrepreneurial activities). As suggested by a reviewer, further research could examine the extent to which angels may help ‘bypass’ venture capitalists. Research on social finance, which is rapidly growing would also be enlightening. Social finance refers to the ‘active investment of capital in businesses and funds that generate positive social and/or environmental impacts, as well as financial returns’ to the investor (Canadian Task Force on Social Finance 2010). It consists in ‘the application of tools, instruments and strategies where capital’ is deliberately and intentionally put to the service of blended value returns (i.e. social and economic) (Emerson 2003). According to the Canadian Task Force on Social Finance (2010), impact investors could reach 1% of all managed US assets and a comparable shift in Canada ‘would yield $30B for investment in social enterprises’. Could social finance offer the ‘patient’ and long-term financial support that small firms need to engage in R&D activities and bring to market more valuable health technologies?

5. Conclusions
Our study critically explored how venture capitalists think, what they consider to be of value and what provides power to their actions in technology design processes. It showed that capital investors do more than just provide resources to technology-based ventures. By choosing which are valuable from a speculative standpoint and by actively intervening on the technology design process, they ultimately contribute to the shaping of new medical technology and, by extension, of healthcare systems. When capital investors’ decisions and practices are analysed in light of their interactions with technology developers and the policy environment, the logic at play raises fundamental questions because it largely determines which health technologies make their way into healthcare systems and which may never come into existence. If innovation policy-makers around the world increasingly endorse this logic, important societal considerations will be left unaddressed.
Funding

This research was funded by an operating grant from the Canadian Institutes of Health Research (CIHR, No. MOP-89776). The first author holds a Canada Research Chair in Health Innovations (2010–15). Our research group infrastructure is supported by the Fonds de la recherche du Québec-Santé.

Acknowledgements

We would like to thank the participants of this study who graciously agreed to be interviewed. Myraam Hivon, Jean-Louis Denis and Chris Longo, colleagues who are involved in the broader study from which this paper draws its data, shared insightful comments throughout the research process.

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