

China, Globalisation and Health Biotechnology Innovation: Venture Capital and the Adaptive State

Brian Salter

Received: 15 January 2009 / Accepted: 12 August 2009 / Published online: 24 September 2009
© National Science Council, Taiwan 2009

Abstract This paper explores the changing approach of the Chinese state to health biotechnology innovation and, in particular, the position of venture capital within that process. How has the Chinese state dealt with the opportunities and threats posed by globalisation in this field, what status has it attached to the role of venture capital in innovation and what are the implications of these actions for the role of the state? In addressing these questions, the paper begins by examining the global context of the venture capital and innovation relationship, the varied nature of VC organisation, the business models that inform the VC approach to health biotechnology innovation and the implications of these factors for the role of the state. Secondly, it explores the nature and impact of state intervention in China on the VC contribution to innovation, the particular character of the Chinese VC industry and its economic environment and the capacity of the VC sector to contribute to China's position as a global player in health technology innovation. The paper concludes by reviewing the insights this case study provides into the problematic character of state adaptation in China to the challenges of globalisation.

Keywords State · China · Innovation · Health biotechnology · Globalisation · Venture capital · Governance

B. Salter (✉)
Global Biopolitics Research Group, Centre for Biomedicine and Society, King's College London,
Strand, London WC2R 2LS, UK
e-mail: brian.g.salter@kcl.ac.uk

1 Introduction

At the opening of China's Fourth National Conference on Science and Technology in January 2006, President Hu Jintao made a landmark speech in which he strongly emphasised China's need to 'adhere to a new path of innovation with Chinese characteristics and strive to build an innovation-oriented country' (China.org.cn 2006a). His message was clear. In a rapidly changing global market, China could no longer rely on the economic advantages afforded by a cheap labour force which exploited the inventions of others. Instead, if it was to retain its international competitive advantage in the context of the economies of the developed world, China must rapidly develop an indigenous science and technology platform with the capacity to establish its own innovative directions, exploit its own intellectual capital and establish its own new industries. President Hu's message was subsequently incorporated into the 11th Five-Year Plan 2006–2010 and the range of policies flowing from it (China.org.cn 2006b). Biomedicine and the development of new health technologies is a key feature of that Plan.

Such ambitious statements about the relationship between innovation policy, national advantage and the high-tech industries of the global future are frequently made by state leaders and form part of the common coin of global politics. Thus in the UK, for example, the 2007 Sainsbury Review of the government's science and innovation policies, unequivocally entitled *The race to the top*, concluded that in the context of competition from the low cost emerging economies such as China 'the best way for the UK to compete, in an era of globalisation, is to move into high-value goods, services and industries'. It continued: 'An effective science and innovation system is vital to achieve this objective.' (Lord Sainsbury of Turville 2007: 3). With many of the developmental states of Asia now having 'caught up' in terms of their ability to compete in existing global markets where the demand is known (Weiss 2000), the preoccupation of developmental and competition states alike is how to position themselves for the high-technology markets of the future where the demand can be only guessed at.

States are thus aware that in their approach to innovation they must speculate if they are to accumulate. In the life sciences, as in many other fields, such speculative calculation has to include not only the intentions of other states but also the likely interaction between state policy and the numerous global currents flowing through the knowledge economy of biomedicine. Scientific activity and networks are international and collaborative; research materials such as oocytes and embryos form part of a global tissue economy (Andrews and Nelkin 2001; Waldby and Mitchell 2006); clinical trials are increasingly outsourced as part of the pharmaceutical industry's global strategy (Petryna 2006); financial institutions make their investment decisions in this field on a global basis (Kenney et al. 2002); industrial interests are continually bio-prospecting for new forms of information on human and non-human biological material that can be commodified and traded (Parry 2005) and definitions of international intellectual property rights in biomedicine are regularly challenged at political sites such as the World Intellectual Property Organisation (WIPO) and the European Patent Office (EPO; May and Sell 2005). Individual state action therefore forms one element in a shifting mosaic of global innovation forces.

It is nonetheless a significant element that takes the form of interventions in any or many of the policy arenas that contribute to the process of biotechnology innovation. In pursuit of an effective national innovation system, states may choose to introduce public, or facilitate private, governance interventions in terms of support for the science (investment, scientific workforce), mediation between the science and its cultural context (public consultations, bioethics committees), the maintenance of consumer confidence through the regulation of some or all of the stages of knowledge production (laboratory work, animal testing, clinical experimentation, clinical trials, commercial production) and the stimulation of market interest through intellectual property regulation, venture capital support and public–private partnerships. The anticipated engagement between, on the one hand, a state’s policy initiative designed to promote its innovative capacity and, on the other, the global bioeconomy context of that initiative, is therefore likely to form part of the political equation. As Wong points out: ‘National innovation strategies in the life sciences have to be understood as part of a larger, global enterprise’ (Wong 2006: 652). At the same time, given limited resources, states must choose where to focus their efforts in order to maximise their benefit from what the Sainsbury Review terms ‘the innovation value chain’.

The intrinsic uncertainty of the lengthy gestation of any innovative health technology from the basic science to the eventual therapy (usually calculated as between 10 and 15 years) places a premium on the arrangements for the flow of supporting finance into such a high-risk field (Perrin 2005). Although states often view investment in the basic science as a legitimate contribution to the innovation process, they generally regard the financing of the early stage biotech companies seeking to commercialise the science as the preserve of venture capitalists. For the USA and other Western countries with established venture capital (VC) industries such a view makes some sense (though the high risk of the field may still deter VCs). But for developing countries such as China where the VC industry is still weak and emergent, it may not. An alternative approach to this part of the innovation value chain may have to be sought and a different model of innovation constructed.

As President Hu’s speech makes clear, China’s politicians are aware that if this transition is to be achieved China must move beyond the established *modus operandi* of the developmental state. Traditionally, the developmental states of Asia promoted rapid economic development through the targeting of particular industries with large global markets. The markets were already there. The political task was to penetrate them. To achieve this goal, the state protected their chosen industries using a range of policies such as import and credit controls, promoted them through state investment, guided private capital and measured their progress in terms of export achievements (Applebaum and Henderson 1992; Onis 1991). Backed by a strong bureaucracy, the state sought to define the specific path of industrialisation through the robust ‘government of the market’ (Amsden 1989). However, such a model of state intervention resonates uneasily with the need to anticipate the future markets of a field such as biomedicine where the innovation path from bench to bedside is uncertain or unknown.

Given this context, this paper explores the changing approach of the Chinese state to health biotechnology innovation and, in particular, the position of venture capital within that process. How has it dealt with the opportunities and threats posed by globalisation in this field, what status has it attached to the role of venture capital in innovation and what are the implications of these actions for the role of the state? In

addressing these questions, the paper begins by examining the global context of the venture capital and innovation relationship, the varied nature of VC organisation, the business models that inform the VC approach to health biotechnology innovation and the implications of these factors for the role of the state. Secondly, it explores the nature and impact of state intervention in China on the VC contribution to innovation, the particular character of the Chinese VC industry and its economic environment and the capacity of the VC sector to contribute to China's position as a global player in health technology innovation.

2 Global Venture Capital, Innovation and the Role of the State

The global nature of the knowledge economy of biomedicine means that states interested in enhancing their innovation capacity in this field must consider their relationship with the global features of innovation such as scientific workforce, regulation and patenting arrangements. Venture capital is no exception to this rule. In its 2007 Global Venture Capital Insights Report, Ernst and Young describe the rapid acceleration in VC activity that produced a global investment total in the USA, Europe, Israel, China and India combined of US \$32 billion in 2006. VC funds are becoming larger, cross-border investments are increasing swiftly (almost 30% of deals were cross-border in 2006) and emerging markets are becoming an integral part of VC investment strategies (Ernst and Young 2007: 1–2). China in particular saw a sharper increase than the mature markets with deals growing by 37% and capital invested by 58%. With US \$1.9 billion venture capital investment in 2006, up from US \$325 million in 2002 (Balfour 2006), China became the second largest country recipient of venture capital after the USA. Other, more recent, data confirms that this rising trend has continued so that in 2007 VC investment in China rose to US \$3.2 billion (Fig. 1).

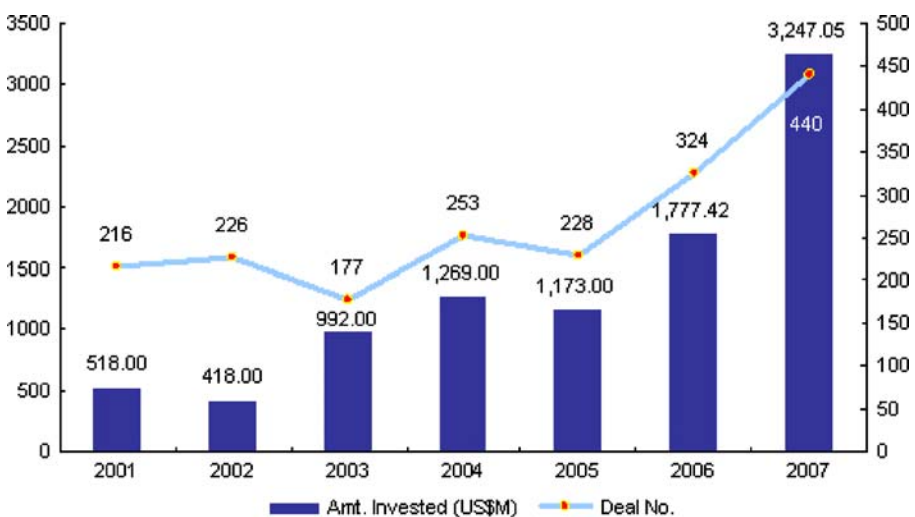


Fig. 1 Total VC investment in China 2001–2007. Source: Zero2IPO Research Centre, 2008a

However, although these data might imply that the globalisation of the venture capital industry is proceeding apace in ways that will allow China ready access to the flow of international finance in support of its innovation plans, the reality is both more complex and, from the Chinese perspective, more problematic. The international character of the VC industry may have its origins in the USA from whence it originated, but the form it assumes in different countries will vary depending on the effects of a number of factors. In their work on the institutional influences on the worldwide expansion of venture capital, Bruton et al. show how normative structures (cultural values and expectations), regulatory institutions and social networks play an important part in shaping the emergence of national VC industries (Bruton et al. 2005). Supply side institutional variables likely to impact on the path of VC development include the level of economic development, the existence of ownership regulations, the legitimacy afforded to private firms, educational attainment, the legal system and business cultures. On the demand side, the character of the VC industry will be influenced by issues such as the ability of new firms to commercialise new business opportunities capable of justifying high-risk equity investments (Ahlstrom et al. 2007: 247). In developing countries, and particularly in Asia, cutting across both supply and demand side is the role of social networks, or *gaunxi*, that not only provide benefits but also impose obligations on their members so that parties often focus more on maintaining interfirm relations rather than on profits (Perkins 2000). As a consequence, the sensitivity to market risk that is central to successful VC operation may be diminished. In their study of VC in India and Israel, Nye and Wasserman show how differing levels of political support, physical infrastructure and cultural learning have produced VC industries with very different ways of calculating and responding to market opportunities (Nye and Wasserman 1999).

The need for VCs to be able to calculate and manage the risk involved in their investment decisions is particularly acute in the new health biotechnology sector. The high level of uncertainty that characterises the innovation path from the biomedical science to its therapeutic applications means that there is no accepted commercial model on which VCs can draw when making their judgements. Indeed, the technological novelty of the field challenges the skills and inventiveness of the business community as much as those of science. Both are aware of the value of the speculative future of biomedicine yet neither can be sure of how, or whether, it will be achieved or of what kind of science–market relationship is appropriate at what point in the commercialisation process. Much of the most promising biomedical work in areas such as that of regenerative medicine involves cellular- and tissue-based products that span the two dominant business models of the health products field, pharmaceuticals and medical devices and, in a theoretical sense, can be seen to result in a third hybrid business model that incorporates features of both (Prescott 2005—Fig. 2). Whereas the pharmaceutical model recoups the high costs of its up-front investment and long development times (typically 15–20 years) through high gross margins and large markets, the medical devices model can tolerate lower gross margins and smaller, more focused markets because it has lower development costs. Unfortunately for its market appeal, the theoretical hybrid business model of health biotech products includes the negative characteristics of the other two models: high up-front investment,

Pharmaceuticals	New health biotech	Medical devices
<ul style="list-style-type: none"> • High up-front investment • Long development times • High gross margins • Large markets 	<ul style="list-style-type: none"> • High up-front investments • Medium/long development times • Low gross margins • Focused markets 	<ul style="list-style-type: none"> • Lower up-front investment • Short development times • Low gross margins • Focused markets

Fig. 2 New health biotech: a hybrid business model

medium/long development times (10–15 years), low gross margins and markets focused on a range of separate diseases.

There are ways of dealing with this extended uncertainty but their appeal to VCs wishing to support innovation in this field is dependent on a VC's ability to handle the novel business arrangements involved. For example, in the case of stem cell science, in the short- to medium-term cell lines from human embryonic stem cells could be used as disease models to explore the pathology of a disease, as drug screening assays to demonstrate efficacy and as the means for the toxicity testing of candidate drugs. Such intervening usages in the overall business model would generate an early cash flow to nurture the development of the field (Perrin 2005). Again, genomics companies have recognised the importance of refocusing their research efforts: in their case, downstream within the drug innovation cycle, in order to generate a more flexible business model (Rothman and Kraft 2006). Employing proprietary technology or knowledge-based assets protected by patent, research-based genomics companies have formed alliances with pharma and biotech partners to generate the all important cash flow through licencing arrangements and/or subscription fees. Admittedly this strategy has been facilitated by pharma's need to bolster drug pipelines through a focus on the *upstream* stages of the drug innovation cycle but genomics companies have still had to make their business models work.

One of the characteristics of Western VCs is their ability to deal with such uncertainties of commercialisation through the added value of the skills and knowledge they bring to their portfolio companies. In the USA, for example, VC firms typically have a number of roles beyond the simple provision of finance. In their comparison of four countries, Sapienza et al. classified the VC role contribution as interpersonal (the CEO as mentor/coach, friend/confidant), strategic (sounding board, business advisor, financier) and networking (source of industry contacts, professional contacts, management recruiter; Sapienza et al. 1996). Such a range of business resources increase the chances that a VC will enable the kind of adaptive strategies necessary for a portfolio firm to mitigate the risk inherent in the health biotech field, particularly in the early stage when proof of principle has been established but not yet applied to humans. As Kenney observes, 'it is the venture capitalists' experience and connections that differentiate them from other sources of capital' (Kenney et al. 2002: 10).

However, while this experience is embedded in the USA, and to a lesser extent the European, VC industrial cultures, it is not easily replicated in the Asian context where, as we have seen, domestic institutional and cultural factors are often resistant to this mode of VC activity and, instead, promote a different logic of VC

organisation rooted in connectedness and relationships (*gaunxi*). Such social networks are founded on bonds of reciprocal obligation so that parties often focus more on maintaining interfirm and interpersonal relations than on immediate profits. To that extent their responsiveness to market opportunities and risks, the essential quality of VC success, is diminished (Pye 2000). Furthermore, the transfer in unaltered form of the US model of VC organisation to Asian is inhibited by the very character of Asia's economies. Venture capitalists require that their investments be liquidated within 5 years through one of two exit strategies: corporate merger or an offering of shares to investors usually in an Initial Public Offering (IPO) on a stock exchange. For this to happen the target stock exchange must be both highly liquid and responsive to the more risky ventures—qualities that are present in the New York Stock Exchange and the Nasdaq but much less so in the Shanghai and Shenzhen Stock Exchanges for example.

The effect of this combination of factors is that the VC industry in Asia is less well developed than in North America and Europe and, as a consequence, innovative industries in that region such as health biotechnology are dependent on external sources of VC finance. Hence in Asia 37% of new funds raised comes from outside the region whilst in Europe the figure is 29% and in the USA less than 10% (Wright et al. 2005: 138–9). In this situation, the governments of developmental states with the ambition of hosting the health biotech industry of the future have some interesting choices to make. How can they intervene to enhance or replicate the VC contribution to innovation and what should be the role of the state in what will inevitably be the governance of uncertainty?

Like competition states, developmental states are obliged to adapt their strategies in the light of both threats and opportunities in the international economy (Mann 1997; Wade 1996). They are also aware that their traditional modes of direct state intervention do not suit the innovation requirements of what is an elusive science with a speculative future, an uncertain market and a difficult path to commercialisation. As a consequence, observers have noted the evolution of developmental state governance into new forms described variously as the 'adaptive state', the 'flexible state', the 'post-industrial developmental state', the 'transformative state' and the 'catalytic state' in their studies of Japan, South Korea and Taiwan (Weiss 1998; Kim 1999; Wu 2004). As Wong observes of biotechnology in Taiwan, it is a case of the state identifying 'the right mix of public policies aimed at facilitating technology innovation and knowledge-based interventionist strategies' and recognising that 'cutting-edge technologies can no longer be borrowed; rather they must be created'—which means a change in state direction and an investment in, or access to, basic science (Wong 2005: 169–70).

In moving from borrowers to innovators, developmental states are obliged to review the extent of their autonomy and the style of the bureaucracy that implements their policies. In the case of Taiwan this has produced a revision in policy maker thinking as they begin 'to understand that the unpredictable nature of the biotechnology sector and of life sciences innovation, undermines past practises in state leadership' and that 'gone are the days when economic technocrats—by definition, policy generalists—were able to lead industrial transformation from top down'. Instead, Wong argues, the state has taken on the role of 'innovation enabler' (Wong 2005: 186–7). In Taiwan this role included allocating nearly US \$1 billion of

public funds to private fund managers in the hope that their experience in investing in the bio-industries sector would generate new rounds of venture financing (Wong 2006: 658). Similarly in Singapore the state responded to the challenge with the establishment of the US \$1 billion Technopreneurship Fund in 1999 to induce leading VCs to use Singapore as their regional operation hub and train a core of VC professionals. However, although the amount of funds managed in Singapore has expanded dramatically to US \$16 billion in 2004, it has yet to have the desired impact on Singapore's wealth generating capacity through high tech start-up formation. Investments have been made in more mature rather than early stage ventures, most of which were based not in Singapore itself but in the wider region, particularly China (Edquist and Hommen 2008: 101). So state action may succeed in encouraging the growth of a VC industry but then face the further problem that the industry will inevitably focus its efforts on generating profits, wherever these are to be made. The geographical location of a VC is not a good guide to the location of its investments. The role of the state as 'innovation enabler' is not straightforward.

3 Venture Capital and Health Technology Innovation in China

Huaizheng Peng, portfolio manager of London based VC firm Reabourne Technology Investment Management, and an expert on China biotech investment, has commented

If there is no mature investment framework, no such industry called biotech can exist. [The Chinese] government needs to create an investment-friendly regulatory and financial environment for knowledgeable global investors. Without money from knowledgeable investors, it is impossible to support an expensive industry like biotech. (Jia et al. 2006: 8)

There can be little doubt that the Chinese state is as aware as Mr. Peng of the critical contribution that VC investment makes to the risky business of health technology innovation. But what is less clear is how far it is able to adapt the structures, habits and values of central state management to become an 'innovation enabler' in this field. Established healthcare markets such as those of the pharmaceutical industry present relatively little difficulty to government because the targeting of known markets by the developmental state is a familiar activity. Thus, between 2000 and 2005 China's health biotech and biopharmaceutical industry grew 30% annually to US \$3 billion compared with a 19% annual growth rate for the pharmaceutical industry as a whole. However, within this, the innovative biotech segment (including genetically engineered drugs, vaccines, antibodies and blood products) constituted a mere 7% (Frew et al. 2008: 37). In addition, just 3% of the drugs that domestic companies get approved in China each year are 'discovered in China', a clear indicator of the country's low innovative capacity in the field (Zhang 2008a, b:1170). If China is to position itself as a global player in the future health biotech industry, much still needs to be done. But just how does a state accustomed to traditional forms of intervention in predictable markets enable speculative investment in high-risk ventures with unpredictable markets? Furthermore, how does such a policy incorporate the flexibility to engage fruitfully with international capital and commodity markets?



4 Sinovac Biotech in China Starts Producing A/H1N1 Vaccine

The history of the Chinese state's approach to these questions is driven by the continuing tension between, on the one hand, the economic imperative to adapt to the demands of global innovation and, on the other, the political imperative to retain government control of the process of innovation. Beginning in 1986 with the formation of the China New Technology Venture Investment Corporation (a state owned enterprise intended to replicate the technology innovation capacity of the United States Silicon Valley and Route 128) policy makers have experimented with measures that have haltingly moved towards a venture capital system which, whilst only partially market driven, does nonetheless have a limited ability to respond to innovation opportunities. In the early 1990s, other state and local government sponsored venture capital firms emerged and, almost without exception, failed because government officials and entrepreneurs lacked the appropriate experience. One of the most famous was the China New Technology Startup Investment Company (Zhongchuan) which went bankrupt in 1997 and lost at least \$3 million, though some reports put the true losses as high as \$30 million (Oster 2001). By the mid-1990s, the need for a reappraisal was clear and policy makers began to change their perception of venture financing from a type of government funding to a commercial activity necessary to support market innovation in new technologies Building on a study of the USA and Hong Kong venture capital systems and lengthy policy deliberations involving seven ministries, in 1998 the MOST submitted its 'Report on establishing China's S & T venture capital system' to the State Council from which legislation then followed (White et al. 2005: 899). Two important regulations—"The resolution of developing venture capital in China" and 'Several opinions on establishing a venture investment mechanism'—were promulgated in 1999 and 2 years later the MOST, the National Industry and Commerce Administration enacted the 'Temporary regulations for establishing foreign venture capital' (Fung et al.

2005). In parallel with this central state activity, local governments implemented their own regulatory frameworks for VCs. For example in Beijing, the ‘Proposals for the regulation of Zhongguancun Science Park’ promulgated by Beijing People’s Congress make specific rules and recommendations regarding the form of venture capital organisation, the scale of investment and exit strategies for the venture capital of the Park.

By the end of the 1990s, the combined effect of these policy initiatives was to produce a variegated venture capital sector at both national and local levels with institutional characteristics suited to the domestic political conditions. Four types of venture capital funds (VCFs) can be discerned, situated along a continuum characterised by greater state control at one end and more market freedom to operate at the other: government VCFs (GCVFs—financed and controlled by central or local government), university VCFs (UVCFs—geared to the intellectual products of particular major universities with strong R&D platforms), corporate VCFs (CVCs—supported by listed and unlisted companies and some foreign firms) and foreign VCFs (FVCs—foreign VC firms that have entered China and domestic VC firms that are able to raise funds outside China; White et al. 2005: 904–6). As one would expect, it is the FVC which most closely replicates the US VC model. Perhaps unsurprisingly, as a new industrial sector engaged on a steep learning curve, venture capital in China in the 1990s experienced a volatile and chequered history. During the first half of the decade there was a steady increase in venture capital new funds raised, reaching US \$1.028 billion in 1995, more than 64 times the level in 1991. In 1996 the total volume fell by 71% to US \$294 million with further low levels recorded in 1997 and 1998 as a result of the Asian financial crisis. Funds increased rapidly in 1999 and 2000 to US \$2 billion before again dropping precipitously in 2001 (Fung et al. 2005: 31–32). Thereafter, as we have seen in Fig. 1, the sector stabilised and has since experienced steady growth.



5 SVG Moves to Shahu Venture Capital Centre and Welcomes New Members

It is significant that to a large extent that growth has been fuelled by the increasing interest of foreign VCFs in the possibilities offered by investment in the Chinese economy.

Following the regulatory reforms of the late 1990s, the engagement between the Chinese and global VC industries grew rapidly with the result that, as a proportion of the total VC sector in China, funds managed by foreign firms increased from 59 per cent in 2002 to 70 per cent in 2005 where a plateau was reached (Table 1). This dominance has been maintained with the FVCF share in 2007 standing at 68% (Zero2IPO 2008a: 21).

Regulations to promote the role of venture capital in the process of innovation have continued to emerge throughout the 2000s. In November 2005 the National Development and Reform Commission promulgated the 'Provisional measures for the administration of venture capital enterprises' which, entering into effect in March 2006, constituted the first national statute governing VC investment in China (HG.org 2006).

However, the ability of venture capital to contribute to innovation in the high-risk field of health biotechnology is dependent not only on the state's regulation of venture capital itself but also on state policies towards the environment in which venture capital operates and on which it is dependent for its success: for example, intellectual property rights (IPR) to recognise and protect ownership of the value of a potential innovation, tax relief to increase the likelihood that the potential value (profits) of the innovation will outweigh its investment risk, a stock market to enable realisation of that value and, where state finance of a VC firm is involved, the managerial freedom and ability fully to exploit that value.

Intellectual property rights are an essential component of a knowledge economy because they commodify the intangible capital of knowledge, generate value and facilitate trading (European Patent Office and OECD 2005). Without IPR, and in particular patent protection, emerging markets would find it difficult (or more difficult) to develop since the tangible product has yet to appear and economic value is embedded in the potential application of the knowledge. This problem is particularly acute in high-tech and research-based Small to Medium Enterprises for whom their IPR is their main asset. The economic significance of patents is further enhanced by the need for new forms of knowledge to compete for attention in an increasingly global venture capital market with its own clear demands: investors, often institutional investors, make their decisions in the light of the patents held by companies. For capitalisation of a new knowledge market to occur, then, investors need to be reassured that the value of the knowledge, as opposed to the value of the eventual product, is in the hands of the company concerned. Investors are likely to be particularly sensitive to the patenting issue in high-risk areas such as the early stage development of health biotechnologies where the science is very new and the potential therapies very distant.

With its accession to the World Trade Organisation (WTO) in 2001, China agreed to conform to the requirements of the Trade Related Aspects of Intellectual Property

Table 1 Domestic and foreign VC funds 2002–2006

	Domestic funds	Total managed (US \$ million)	Joint ventures	Total managed (US \$ million)	Foreign funds	Total managed (US \$ million)
2002	149	4,109			36	5,967
2003	162	4,853			37	5,739
2004	130	4,107			40	8,081
2005	130	4,791	17	635	45	11,463

Source: Zero2IPO 2006

Rights agreement and passed its ‘Patent law of the People’s Republic of China’ supported by the ‘Implementing regulations of the patent law of the People’s Republic of China’ in July of that year (MOST 2001). Since then China has cooperated frequently with WIPO and the EPO on personnel training and promoted IPR teaching and research in over 70 universities (Huang et al. 2004: 377). However, it remains unclear precisely how far the necessary respect for intellectual property is now thoroughly embedded in Chinese culture and economic behaviour given its history of international piracy in IPR (second highest after Vietnam; Doring 2004). Certainly there has been a dramatic rise in the amount of patenting in China with an increase between 1996 and 2006 from 103,000 to 573,000 patent applications and from 44,000 to 268,000 patents granted (MOST 2008: 21–22).



IPR protection is also important to the involvement of the international pharmaceutical industry in innovation, without whose commitment any new health

biotechnology sector in China is unlikely to take off. Pharma interest sends a reassuring signal to VC firms that the environment for risky health technology investment includes key economic actors in the innovation value chain. So it is interesting to note that almost 24,000 IP cases were adjudicated between 1998 and 2002 signalling to the biopharmaceutical firms ‘China’s seriousness in protecting IP’ (Zhenzhen et al. 2004). Leading pharmas have already established a presence in China—Glaxo SmithKline China (Beijing), Pfizer Pharmaceuticals (Beijing), Novartis Pharmaceutical (Beijing) and Merck China (Shanghai).

Potential investors are also interested in tax incentives and, aware of this, states compete in the global bioeconomy to attract inward VC investment, particularly in fields such as early stage health biotechnology that are characterised by both high potential and high risk. China is no exception. In February 2008 the PRC Ministry of Finance and the State Administration of Taxation jointly issued the ‘Notice on relevant tax policies for promoting the development of venture capital investment enterprises’—an orthodox incentive designed to reduce the burden on VC firms, support their development and be attractive to global finance (Zero2IPO 2008b: 183). However, its efficiency as a state instrument of preferential policy immediately came into question with disputes about whether it applies to investors of limited joint enterprises, how individual investors of CVCFs can be released from double taxation and whether the policy covers a broader field beyond small and medium new technology enterprises (Zero2IPO 2008b: 183).

Having made their investment, VCFs consider their exit strategy. The preferred one is the IPO because this normally generates the larger profit when compared to the other options of trade sales and mergers. As was observed earlier, such a strategy requires a stock exchange that is liquid and transparent with rules that promote the ready raising of capital (Black and Gilson 1998). Here again we find that China’s policy is in transition with some movement towards more viable stock exchanges but as yet not a sufficient amount alone to energise the domestic VC industry. The regulations of both the Shanghai Stock Exchange and the Shenzhen Stock Exchange Small and Medium Enterprise Board, designed to safeguard investors, actually present a barrier to VC exits through IPO when compared to other stock exchanges—hence the tendency for VCFs to look for exits on the New York Stock Exchange or the NASDAQ (Frew et al. 2008). Within China, the customary VC equation between high risk and high returns via IPOs is thus not easily achieved. The problem is compounded by state restrictions on the exportation of capital which act as a disincentive to foreign VCFs though; as we shall see, there are ways round the restrictions.

It is inevitably domestic VC firms that are most constrained by these and other government rules and, in the case of GCVFs, by government intervention in their management decisions. As White et al. observe

The government has a strong paternalistic view of the economy, and assumes that it both should and is able to provide direct guidance to emerging actors, such as venture capital firms. This takes the form, for example, of its identifying particular industries as priority sectors and providing incentives for investment in those sectors. Rather than a clear separation of government from business, China is more likely to develop a business system similar to Singapore’s ‘state capitalism’ with its government-linked companies. (White et al. 2005: 910)

Government controls combined with the need of CVCFs to realise returns sooner rather than later means that domestic firms are more risk averse than foreign VCFs, prefer to invest in expansion and late stage investment projects and are less likely to invest in the early stage ventures on which any emergent biotech sector is dependent. Only university VCFs, a minor player in the Chinese domestic VC market, see the latter as their primary function.

Thus the net effect of state policy on the environment for the VC contribution to innovation is to create a differentiated VC sector characterised by a reliance on foreign venture capital firms as a critical engine of change in the Chinese bioeconomy. Research shows that the different innovative capacities of domestic and foreign VCs are reflected in their management relationship with their investees and the degree to which they seek to bring added value to their operations. Chinese VCs are less active than foreign VCs in their attendance at their investee board meetings and in their monitoring and influence over their investees' management decisions (White et al. 2005: 901).

What are the implications of this analysis for innovative health biotechnology in China given that, as we have seen, at present it constitutes only 7% of the pharmaceutical and health biotech sector in that country as a whole? Taking the USA as a comparison, biomedical venture capital there captured 31% of the total available whereas in China the figure was a mere 2.4% in the second quarter of 2008, falling to US \$29 million from US \$43 million (6.2% of the total) in the same quarter of 2007 (ChinaBio Today 2008; Table 2). Of this US \$29 million, 79% (US \$14.44 million) came from foreign VCFs or Sino-foreign joint ventures (JVs; Table 3). Although this might be taken to indicate an absence of domestic interest in the risky biotech sector, it also reflects the balance in the venture capital industry as a whole for this particular quarter: 76% foreign/foreign and domestic/Sino-foreign JV versus 24% domestic. Unsurprisingly, low investment in health biotech is paralleled by its low proportion of IPO exits—5.6% (Table 4).

Considerably more important from the perspective of Chinese policy makers is the lack of interest in the health biotech sector from foreign investors given that they constitute over two-thirds of the industry's volume. Foreign VCF's may bring a range of management skills that are in short supply among domestic VCFs but this

Table 2 VC investment by industry: 2008 Q2

Industry (grade 1)	Deal no.	Percent	Deals with disclosed amount	Amount invested (US \$ million)	Percent	Average amount (US \$ million)
Broad IT	67	42.1	62	552.16	45.9	8.91
Traditional	35	22.0	35	239.58	19.9	6.85
Services	22	13.8	19	179.88	14.9	9.47
Other hi-tech	6	3.8	6	46.11	3.8	7.68
Bio/healthcare	9	5.7	9	28.74	2.4	3.19
Undisclosed	20	12.6	12	157.51	13.1	13.13
Total	159	100.0	143	1,203.97	100.0	8.42

Source: Zero2IPO 2008b: 30

Table 3 Amount invested by industry and investor type: 2008 Q2

Industry (grade 1)	Foreign	Domestic	Foreign and domestic	Sino-foreign joint venture	Total
Broad IT	417.95	120.22	14.00	0.00	552.16
Traditional	70.10	142.44	27.04	0.00	239.58
Services	163.23	16.65	0.00	0.00	179.88
Other hi-tech	14.00	5.94	0.00	8.80	28.74
Bio/healthcare	32.92	7.36	5.83	0.00	46.11
Undisclosed	157.51	0.00	0.00	0.00	157.51
Total	855.70	292.60	46.87	8.80	1,203.97

Source: Zero2IPO 2008b: 50

clearly does not overcome the obstacles to investment in the biotech sector; obstacles that the data indicates are not present in the US context. Nor has their presence changed the aversion of the Chinese VC industry to the risky early stage deals without which innovation cannot proceed. Only 8% of the investments of the 2008 second quarter focused on such deals and, within this, FCVFs occupied the two-thirds proportionate presence one would expect (Table 5).

Although the Chinese state is anxious to benefit from the global supply of venture capital, like all states it is also keen to protect the national interest through the regulation of its financial borders. If the consequences of foreign investment lead to the export of capital then the cost–benefit calculation of global engagement may, from the Chinese government perspective, soon move into a negative zone. One indicator of this boundary tension is the use of inventive partnerships between foreign VCs and domestic firms anxious to access global capital. One widely practised model is the ‘parallel fund’ established offshore with domestic and foreign partners. No matter where the exit occurs, both of the two funds can share the profit in the form of a trade sale (Zero2IPO Research Centre 2008b: 162). Slightly more inventive is the arrangement in Fig. 3. Here we can clearly see the boundary tactics adopted as a means for evading the Chinese financial border controls.

A second effect of a state VC infrastructure that does not adequately address the particular needs of early stage health biotech innovation, is that business models

Table 4 IPO exits by industry: 2008 Q2

Industry	Event no.	Percent
Broad IT	17	47.2
Traditional	12	33.3
Other hi-tech	3	8.3
Bio/healthcare	2	5.6
Undisclosed	2	5.6
Total	36	100.0

Source: Zero2IPO 2008b: 60

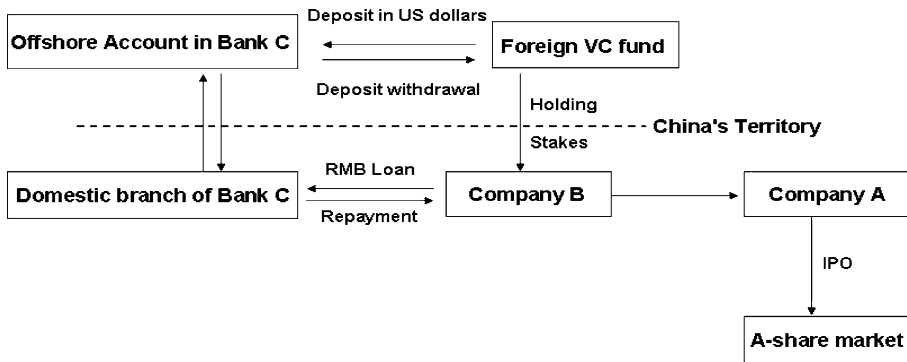


Fig. 3 Strategy of foreign venture capital funds to achieve domestic investment through foreign capital banks. Source: Zhang 2008a

must necessarily adapt because the pure R&D company model with a single institutional development path from science to product is unsustainable. Local collaborations that seek to commercialise the scientific projects of research institutes and universities, where possible supported by government grants, are one option. For example, Sinova Biotech is working with local partners including the Institute of Laboratory Animal Science (Beijing), the National Institute for the Control of Pharmaceutical Products (Beijing) and the National Institute for Viral Disease Control and Protection (Beijing) in developing novel vaccines against SARS and pandemic influenza (Frew 2008: 44). Another option is for Chinese firms to seek international partnerships that provide access to development resources through product co-development and market sharing arrangements. For example, Shanghai Genomics has entered into partnerships with the US firms of Organon and Centocor to expand their research capabilities and identify drug targets (Frew 2008: 45). Finally, some Chinese companies have chosen to generate short-term revenues to enable them to maintain their R&D path by selling non-innovative products such as bio-generics and simple diagnostics, providing contract services such as preclinical toxicity, animal studies and bioassays and outsourcing their early products.

6 Conclusions

China's use of the concept of *zi-zhu-chuang-xin* or 'independent innovation' as the guiding principle in its search for global prominence in the future industries of the bioeconomy requires that it combines the protection of the national interest with an openness to the opportunities of globalisation. In so doing, it has simultaneously to manage the tension between the uncertainties of health biotechnology innovation and the need for continuities in state power. Internal politics require that the role of the state adapts, but not at the cost of the loss of control over the process. A simple transition of the Chinese state to the role of a hands-off 'innovation enabler' with its implied acceptance of unknown economic, and perhaps political, consequences is therefore unlikely. State speculation in the future of the life sciences may be inevitable, but its form is subject to the constraints of the domestic political culture.

Table 5 Amount invested by stage development: 2008 Q2

Stage	Foreign	Domestic	Foreign and domestic	Sino-foreign joint venture	Total
Early stage	57.41	24.20	10.50	4.40	96.50
Expansion stage	522.13	132.63	22.37	4.40	681.53
Late stage	223.50	135.78	14.00	0.00	373.28
Undisclosed	52.66	0.00	0.00	0.00	52.66
Total	855.70	292.60	46.87	8.80	1,203.97

Source: Zero2IPO 2008b: 54

The case of venture capital and health biotechnology innovation illustrates the problematic character of state adaptation in China to the challenges of globalisation. Venture capital forms one of the several components of innovation that are global in their character; others, for example, being the transnational scientific workforce, the harmonisation of patenting arrangements and the continuing bioethical debate regarding what future health technologies are culturally acceptable and what not. These components are invariably inter-dependent so that a state cannot afford to have a policy on one and not on the other because internal domestic policies interact to enhance or inhibit the progress of health biotechnology innovation within a state's boundaries. At the same time such policies will also engage externally with the global context of venture capital, patenting, workforce and so on, perhaps influencing that context and provoking a response from other states.

Thus an obvious characteristic of an 'adaptive' state is its ability to learn national and international lessons about the path to innovation from its experience in a particular policy domain. China's early learning curve in the policy domain of venture capital was very flat indeed. From the initiation of VC policy in the late 1980s, over a decade passed before the rudiments of a regulatory structure were in place—with consequent large fluctuations in the volume of the VC industry, even allowing for events such as the Asian financial crisis in 1997–1998. Since 2000, regulatory reform has stabilised the industry to the extent that not only has there been a steady increase in total VC investment but also, within this, a growing proportion of foreign VC finance. On this simple measure, China's state could be viewed as having successfully adapted to the needs of the global VC market as part of its overall approach to innovation governance. Furthermore, initial figures indicate that it is an adaptation that is enabling China to weather the global economic downturn better than most other countries and that, of itself, the downturn does not pose a challenge to China's innovation strategy. In 2008, US \$7.3 billion was raised for VC funds, 33% higher than the year before, ensuring that China maintains its global position as second only to the USA as a site for VC investment (Zimbio 2009; Kenney 2009).

However, when measured in terms of VC support for the future and uncertain industry of health biotechnology the conclusion is different. The majority of domestic and foreign venture capital investment goes not to the early stage and high-risk firms of health biotech but to the established industries with predictable markets such as IT. The reasons for this are twofold. Firstly, China may have imported the concept of the VC contribution to innovation from the USA but its implementation

of that concept is very much influenced by domestic social and economic conditions. The reciprocal obligations of *gaunxi* combined with the lack of managerial skills of domestic VC firms inhibit them from risking involvement with early stage investments. They are different organisational animals to their US counterparts. Secondly, although foreign VCFs may have the required managerial qualities to handle high-risk enterprises in principle, the Chinese policy environment of patenting, stock market and tax incentives is only slowly becoming conducive to the use of these qualities in practise. The Chinese state is aware that this policy environment should be adapted to the needs of venture capital but also intent that the state should retain control of the global forces it seeks to harness through the continuing maintenance of its financial borders.

In the meantime, inventive arrangements for access to foreign capital combined with hybrid business models for the development of early stage health biotech are for the present ensuring China's position as a potential player in the global future of this industry. Given the global competition between states for advantage in the construction of innovation, the speed of China's adaptation will be dependent not only on how this internal dynamic plays out but also on the impact on Chinese policy thinking of the progress of other states in health biotechnology, notably that of the USA.

References

- Ahlstrom, D., Bruton, G. D., & Kuang, S. Y. (2007). Venture capital in China: Past, present and future. *Asia Pacific Journal of Management*, 24, 247–68.
- Amsden, A. (1989). *Asia's next giant. South Korea and late industrialisation*. New York: Oxford University Press.
- Andrews, L., & Nelkin, D. (2001). *Body Bazaar: The market for human tissue in the biotechnology age*. London: Crown.
- Applebaum, R. P., & Henderson, J. (eds). (1992). *States and development in the Asian Pacific Rim*. Newbury Park: Sage.
- Balfour, F. (2006). Venture capital's new promised land. *Business Week*, 3967, 44.
- Black, B., & Gilson, S. (1998). Venture capital and the structure of capital markets: Banks versus stock markets. *Journal of Financial Economics*, 47, 243–277.
- Bruton, G. D., Fried, V. H., & Manigart, S. (2005). Institutional influences on the worldwide expansion of venture capital. *Entrepreneurship Theory and Practice*, 29(6), 737–60.
- ChinaBio Today. (2008). *Spotlight on China biomedical investment*. Available at: <http://seekingalpha.com/article/85836-spotlight-on-china-biomedical-investment> Accessed 1st December 2008.
- China.org.cn. (2006a). *Hu outlines strategic tasks for S and T innovation*. Available at: http://english.gov.cn/2006-01/10/content_153815.htm Accessed 6 October 2008.
- China.org.cn. (2006b). *11th Five Year Development Guidelines*. Available at: <http://www.china.org.cn/english/MATERIAL/157595.htm> Accessed 7 October 2008.
- Doring, O. (2004). Chinese researchers promote biomedical regulations: What the motives of the biopolitical dawn in China and where are they heading? *Kennedy Institute of Ethics Journal*, 14(1), 39–46.
- Edquist, C., & Hommen, L. (eds). (2008). *Small country innovation systems*. London: Edward Elgar Publishing.
- Ernst and Young. (2007). *Acceleration. Global venture capital insights report 2007*. London: Ernst and Young.
- Frew, S., Sammut, S., Shore, A., Ramjist, J., Al-Bader, S., Rezaic, R., et al. (2008). Chinese health biotech and the billion-patient market. *Nature Biotechnology*, 26(1), 37–53.
- Fung, H., Liu, Q., & Shen, M. (2005). Venture capital cycle, opportunities and challenges in China. *The Chinese Economy*, 37(4), 28–49.

- HG.org. (2006). *China: venture capital regulations*. Available at: http://www.hg.org/articles/article_1193.html Accessed 28th November 2008.
- Huang, C., Amorim, C., Spinoglio, M., Gouveia, B., & Medina, A. (2004). Organisation, programme and structure: An analysis of the Chinese innovation policy framework. *R and D Management*, 34(4), 375–85.
- Jia, H., Jayarama, K. S., & Astvatsatuyan, M. (2006). Lack of private financing hobbles emerging biotech regions. *Nature Biotechnology*, 24(1), 7–9.
- Kenney, M. (2009). *Venture capital in China and India – a comparison*. Corporate Affiliate News. Stanford University. Available at: http://aparcfellows.stanford.edu/news/march_2009_dispatch_venture_capital_in_china_and_india_a_comparison_20090309/ Accessed 23 June 2009.
- Kenney, M., Han, K., & Tanaka, S. (2002). *Scattering geese: venture capital industries in East Asia*. Report to the World Bank. Available at: <http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1009&context=brie> Accessed 13 November 2008.
- Kim, Y. T. (1999). Neoliberalism and the decline of the developmental state. *Journal of Contemporary Asia*, 29(4), 441–62.
- Lord Sainsbury of Turville. (2007). *The race to the top. A review of Government's science and innovation policies*. London: HM Treasury.
- Mann, M. (1997). Has globalisation ended the rise and rise of the nation state? *Review of International Political Economy*, 4(3), 472–96.
- May, C., & Sell, S. (2005). *Intellectual property rights: A critical history*. Boulder: Lynnee Rienner.
- Ministry of Science and Technology of the People's Republic of China. (2001). *Implementing regulations of the patent law of the People's Republic of China*. Available at: http://www.most.gov.cn/eng/policies/regulations/200501/t20050107_18490.htm Accessed 28th November 2008.
- Nye, D., & Wasserman, N. (1999). Patterns of VC evolution: Comparing the Israeli and Indian venture capital industries. *Journal of Private Equity*, 3(1), 26–48.
- Onis, Z. (1991). The logic of the developmental state. *Comparative Politics*, 24(1), 109–26.
- Oster, S. (2001). *Nothing ventured*. *AsiaWeek.com* (July 27–August 3). Quoted in Kenney 2002: 107.
- Parry, B. C. (2005). *Trading the genome: Investigating the commodification of bio-information*. New York: Columbia University Press.
- Perkins, D. H. (2000). Law, family ties and the East Asian way of business. In L. Harrison & S. Huntington (Eds.), *Culture matters: How values shape human progress* (pp. 232–243). New York: Basic Books.
- Perrin, N. (2005). *The global commercialisation of stem cell research*. London, UK Trade and Investment. Available at: http://www.chrisrmason.com/industry_library/assets/UKTI%20Stem%20Cell%20Res.pdf Accessed 15th October 2008.
- Petryna, A. (2006). (2006). Globalizing Human Subjects Research. In A. Petryna, A. Lakoff & A. Kleinman (Eds.), *Global pharmaceuticals: Ethics, markets, practices* (pp. 33–60). Durham: Duke University Press.
- Prescott, C. (2005). *Investing in stem cells: a venture capital perspective*. Avlar Bioventures. Presentation to the East of England Stem Cell Network, 8th March 2005. Cambridge.
- Pye, L. C. (2000). Asian values: From dynamos to dominoes. In L. Harrison & S. Huntington (Eds.), *Culture matters: How values shape human progress* (pp. 244–255). New York: Basic Books.
- Rothman, H., & Kraft, A. (2006). Downstream and into deep biology: Evolving business models in 'top tier' genomics companies. *Journal of Commercial Biotechnology*, 12(2), 86–98.
- Sapienza, H. J., Manigart, S., & Vermeir, W. (1996). Venture capital governance and value added in four countries. *Journal of Business Venturing*, 11, 439–469.
- Wade, R. (1996). *National diversity and global capitalism*. Cornell: Cornell University Press.
- Waldby, C., & Mitchell, R. (2006). *Tissue Economies: Gifts, Commodities, and Biovalue in Late Capitalism*. Durham: Duke University Press.
- Weiss, L. (1998). *The myth of the powerless state*. Cornell: Cornell University Press.
- Weiss, L. (2000). Developmental states in transition: Adapting, dismantling, innovating, not 'normalising'. *The Pacific Review*, 13(1), 21–55. 29.
- White, S., Gao, J., & Zhang, W. (2005). Financing new venture in China: System antecedents and institutionalisation. *Research Policy*, 34(6), 894–913.
- Wong, J. (2005). Remaking the developmental state in Taiwan: The challenges of biotechnology. *International Political Science Review*, 26, 169–190.
- Wong, J. (2006). Technovation in Taiwan: Implications for industrial governance. *Governance*, 19(4), 651–72.

- Wright, M., Sarika, P., & Lockett, A. (2005). International venture capital research: From cross-country comparisons to crossing borders. *International Journal of Management Reviews*, 7(3), 135–65.
- Wu, Y. (2004). Rethinking the Taiwanese developmental state. *The China Quarterly*, 177, 91–114.
- Zero2IPO Research Centre. (2008a). *China venture capital annual report 2007*. Beijing: Zero2IPO Research Centre.
- Zero2IPO Research Centre. (2008b). *China Venture Capital Report Q2 2008*. Beijing: Zero2IPO Research Centre.
- Zhang, M. (2008a). How do oversea PEs evade control by Chinese government: case analysis. Quoted by Zero2IPO Research Centre (2008b). *China Venture Capital Report Q2 2008*. Beijing: Zero2IPO Research Centre: 193.
- Zhang, T. (2008b). Made in China? *Nature*, 455(7217), 1168–70.
- Zhenzhen, L., Jiuchun, Z., & Ke, W. (2004). Health biotechnology in China: Reawakening of a giant. *Nature Biotechnology*, 22(Supplement), DC15.
- Zimbio. (2009). *China tops South Asia VC investments in 2008*. Zimbio. Available at: <http://www.zimbio.com/Venture+Capital/articles/83/China+Tops+South+Asia+VC+Investments+2008> Accessed 23 June 2009.