

Nesta...

HARNESSING CHINA'S COMMERCIALISATION ENGINE

**Collaborating with China to help UK
innovation scale-up and succeed in
the global market**

Dr Benjamin Reid, Professor Peter Williamson, Kirsten Bound

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About Nesta

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Executive Summary

Along with the rest of the world, UK policymakers, universities and companies have been watching the extraordinary trajectory of both public and private spending on research and development (R&D) in China. While it may be some time before we see the full impact from the surge in patenting, a cadre of Chinese home-grown tech companies are already capturing the attention of global markets. As the UK negotiates its position – as both a favoured research partner with a future science super power, and as a financial hub for an economic giant – this report seeks to understand if UK players risk missing out on a near-term opportunity: harnessing China's 'engine' for commercialisation and scaling of technology.

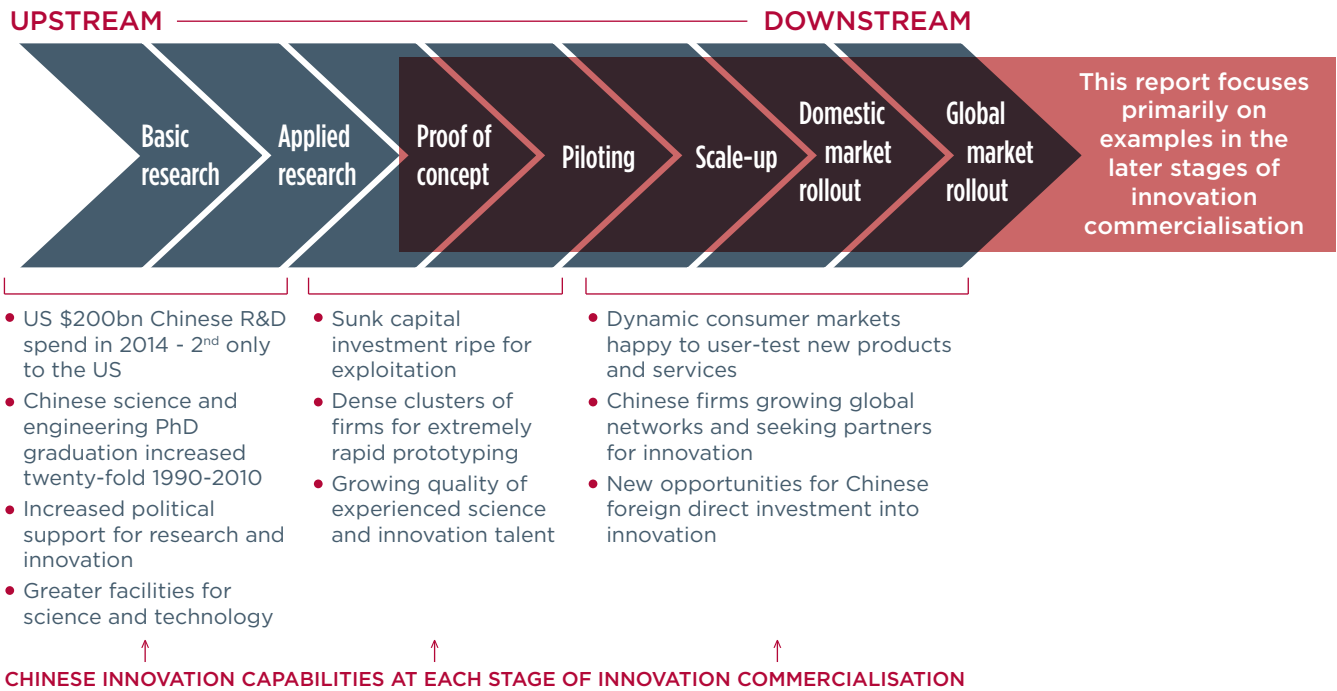
Harnessing the engine

This 'engine' is not only driven by the rapidly transforming conditions for innovation, but also by a unique set of capabilities that are pervasive in Chinese innovation hubs. In *China's Absorptive State*, Nesta outlined China's impressive ability – demonstrated in industries from supercomputing to high speed rail – to rapidly absorb global technologies and 're-innovate', while adding novelty and value to ideas and technologies in the process. In *Accelerated Innovation in China*, Professor Peter Williamson explored the ways private Chinese companies from Lenovo to Tencent were slashing the time and cost requirements of innovation: bringing technology rapidly to full commercial scale, developing process innovations necessary to produce it efficiently, and creating complementary innovations for leveraging new ideas, technologies and inventions.

Through partnership, could UK companies harness these Chinese capabilities to help their innovations succeed in the global market? Could (and should) companies enlist the help of Chinese counterparts to turn the inventions, new technologies and ideas that the UK has in abundance into competitive products and services that conquer the world's markets? If so, this doesn't mean just getting Chinese companies to manufacture what's dreamed up in the UK. Instead, it requires collaboration on innovation and commercialisation: the processes of rapidly piloting, improving, and scaling up new technologies, as well as developing complementary manufacturing methods to enable these new products to be made efficiently.

The full spectrum of innovation collaboration

Collaborating on innovation can describe a range of activities, from more transactional partnerships such as technology licensing and marketing agreements, to joint ventures where partners pool both risk and reward, sharing the costs of research, development, iteration and diffusion of innovations. While policy discussions about innovation and commercialisation are often focused on the early stages of commercialising R&D, the value of collaborating on innovation is found at all stages along the innovation process including piloting, scaling up and market rollout. The innovation process is not linear, and instead involves a range of cycles and feedback loops within companies, between collaborators, and with markets. However, to understand the diversity of opportunities to partner with China on innovation, it's helpful to consider the full spectrum of innovation processes, from upstream R&D, to downstream diffusion and scaling across markets.



Those companies, universities and other organisations seeking to partner with China on innovation could benefit from rapidly growing capabilities right along this innovation spectrum. In this report we focus on the ‘downstream’ part of the innovation process. This is for two reasons. First, because previous research has flagged these downstream elements as areas where Chinese capabilities are strongest. Second, because the globalisation of value chains means that it is possible to reap the benefits of the early stages of research and innovation ever further from their points of origin. Both national governments and multinational firms recognise the growing importance of ‘downstream’ strategies for securing competitive advantage.

Assessments of the value of the opportunity of harnessing China’s commercialisation engine are often coloured by perceptions of how difficult it is to do business in China, or the – both very real and exaggerated – stories of intellectual property infringement. Few examples seem to circulate about the companies that do make it work, and more importantly *how* they do it.

In order to better understand the scale and nature of the opportunity to harness China’s commercialisation engine, in this report we draw in depth on the experiences of five high tech British companies who have managed to successfully collaborate with Chinese counterparts on innovation. We look at the strategies they pursued, the challenges encountered, the ways in which they managed to capitalise on China’s commercialisation engine, and what their experiences have to offer other innovative companies aspiring to partner in China. Our examples include:



Crystec Pharma, a Bradford-based pharmaceuticals company which has developed operations in Tianjin in order to extend their capability to provide innovative services to larger clients and leverage existing Chinese investment in science. Working with the National Academy of Nanotechnology and Engineering in Tianjin, they have expanded their capability and technology to take on larger projects from major western-based customers.

“ Innovation is a terrific platform for building relationships with China in a much more equal way – and a primary route to developing the Chinese market.”

Crystec Pharma CEO Paul Thorning



Dynex Semiconductor, a Lincolnshire-based designer and manufacturer of high-power-throughput semiconductors which became an R&D and innovation subsidiary of large Hunan-centred, Chinese State-Owned Enterprise CSR Times Electric in 2008. The tie-up has seen Dynex's R&D departments expand in both Lincolnshire and China. Global sales for the Chinese division are now also based in the UK, as the company seeks to integrate operations, and sell more competitively into global markets after trialling new products in the Chinese domestic market.

“ Dynex wouldn't be here in the size and shape we are without the Chinese behind us.”

Bob Lockwood, Dynex CFO



Green Biologics, an Oxford-based biotechnology firm specialising in the conversion of feedstocks into green chemicals for use in consumer products. They partnered with a range of processing sites in China, ultimately testing their innovative technology most extensively with a plant in Jilin province. Originally seeking a direct commercial returns from the Chinese large-scale test sites, they later pivoted to a model of leveraging Chinese investment to provide a world-first proof of concept for their technology, allowing them to scale operations in other global jurisdictions: for example, they recently closed a US\$76 million round of funding to expand in the US.

“ Were cast our benefit to be the learning from leveraging Chinese investment dollars... this was a shared technology development between us and our Chinese partners, not a one way street.”

Sean Sutcliffe, CEO, Green Biologics



Sondrel, a Reading-based hardware chip design company that has developed a bespoke university programme for engineers in partnership with the University of Nottingham campus in Ningbo, to provide access to the specialised capability they need to continue to provide innovative designs and rapidly scale their operations. At the same time they established design offices close to new clients in Xi'an, Shanghai and Shenzhen: more than two-thirds of Sondrel employees are based in China, with rapid expansion planned.

“ We would likely not be here today if we had not made the move to expand operations and engineering in China: we wouldn't have been able to compete with the Indian firms on cost and ability to scale-up, and wouldn't have grown so quickly because we couldn't have hired enough people or reached the same range of customers.”

Sondrel CEO Graham Curren



TestPlant, a London-based fast-growing software firm that provides tools for automating the process of software performance testing and troubleshooting. TestPlant developed a partnership in China with Beijing-centred HiRain Technologies to scale their ability to service large Western clients like Cisco, GE and SAS – who themselves were increasingly basing their development capability in China. Through the partnership, TestPlant has been able to access larger Chinese markets, and take advantage of the ability to rapidly test new software products in new sectors such as automotive, where their Chinese partner has existing strengths. TestPlant's Chinese expansion has contributed to its revenue growth of more than 1,000 per cent in the five years to 2014.

Findings:

While each company's experience was different, we can draw several key findings from their experiences:

- **Evidence of success:** If risks are effectively identified and managed, there are opportunities for smaller firms to collaborate for innovation in China. The companies we studied had succeeded in harnessing elements of China's commercialisation engine to scale their innovation in different ways.
- **Lack of a 'model' format for partnerships:** Firms used a wide range of partnership models. They were structured to access different Chinese innovation capabilities at the appropriate point in the chain of commercialisation, and designed with careful assessment of strategic and operational risk.
- **The importance of flexibility:** Firms benefited when they maintained flexibility and adaptability in their partnership structure and strategy, as they sometimes had to shift how they realised value from the partnership as it evolved.
- **Strategic focus on China:** Since major investments of senior executive time and other resources are required to develop a successful partnership, smaller firms are likely to need to focus on partnering in China as the primary strategy for innovation-led growth, rather than as one of a number of simultaneous international partnerships for innovation.
- **Drawing on public support:** Firms benefitted from a range of government support in developing their partnerships, including grants, R&D tax credits and institutional investments in the UK, as well as trade missions and political support. Some also benefitted from Chinese government support.
- **Intellectual property strategies:** The firms have generally taken pragmatic approaches to the management of intellectual property risks, avoiding a reliance on enforcement of intellectual property rights.
- **Management challenges:** Even firms with considerable prior experience of Chinese business face culture clashes – and incorrect assumptions about business norms – when it comes to innovating together. This is most evident when moving from a transactional business relationship to an innovation partnership involving new shared management responsibilities and decision-making.

It is challenging to make recommendations from the evidence of only a small number of examples, but from our analysis we believe the following points should be considered:

Recommendations for SMEs looking to scale their innovation with China:

- Pinpoint the specific capabilities that the Chinese commercialisation engine can offer and where these can possibly assist with each stage of the innovation cycle: basic and applied research, proof-of-concept, piloting, scale-up, and Chinese or global market rollout.
- Identify a suitable Chinese partner as efficiently as possible: by beginning with existing contacts and connections, exploring the full range of support programmes available from the private sector, UK and Chinese governments, and by focusing on clusters of industry expertise in China – which may lie outside the main city hubs.
- Focus on designing a collaboration structure that provides direct access to Chinese capabilities and creates shared incentives, but also enables the business model and ways of capturing value to evolve over time in the face of changing market realities, partner priorities and experience.
- Plan for significant investment in developing and monitoring the partnership, including a substantial and on-going allocation of senior management time (hence the need for substantial benefits in terms of improved chances of success, acceleration and/or reduced costs of bringing the innovation to scale in the market)
- Anticipate and pragmatically address the likely risks of collaborating with China on innovation and commercialisation: risks of intellectual property leakage, cultural clashes, and uncertain and non-transparent Chinese regulations and bureaucracy.

Recommendations for policymakers seeking to support SMEs innovating with China:

- BIS should explicitly broaden the current focus of policy support to include all the stages of the commercialisation of innovation process: basic and applied research, proof-of-concept, piloting, scale-up, and Chinese or global market rollout, with greater emphasis on the latter stages where many of the largest economic benefits are to be gained.
- UKTI, BIS and the China Britain Business Council should all target policy toward addressing the most significant barriers that stand in the way of SMEs harnessing China's commercialisation engine: high search costs of finding suitable partners, difficulties in accessing existing pools of knowledge about how best to set up collaboration with China, and managing potential risks of intellectual property leakage.
- BIS, UKTI, with the support of the Foreign Office through the Prosperity Funds should develop a more conscious strategy linking public support for innovation collaboration within the UK (e.g. investment tax incentives, EU funds, soft-landing incubators), between countries (e.g. trade missions, workshops, exchange programmes and visa conditions) and in China (policy influence, diplomatic and political support).
- BIS and other funding agencies, including regional government should continue to experiment with – but also improve the evaluation of – support for intermediaries (including science parks, incubators, venture and angel networks, online match-making platforms, and integrated sectoral initiatives – such as the Lancaster University China Catalyst Programme) as a route to cost-effective support for innovation collaboration.
- The Chinese and UK governments should work together to improve the access to, and quality of, knowledge on how to effectively collaborate with China on innovation, to help reduce the upfront costs for small firms. This could include stronger case studies, clearer signposting of the multiple routes for support, the establishing of relevant 'advisory panels' on key issues, and the promotion of strong examples of collaboration including the lessons learned from less-successful experiences.

1 COLLABORATING FOR INNOVATION WITH CHINA - AN OPPORTUNITY FOR UK SMES?

Some UK commentators have suggested that China's economic woes in 2015 alter the position of China as a strong partner for innovation – either because Chinese mal-investment and policy direction¹ means those opportunities have dried up, or in the more extreme cases, because they fear the imminent meltdown of the world's second largest economy.² And many rightly flag up ongoing concerns on issues around intellectual property³ and corruption.⁴ Others again question even whether Chinese business possesses sufficient innate innovativeness due to the allegedly over-dogmatic rote-learning approach of its education system.⁵ However, while some of these concerns are undoubtedly real and require suitable caution when seeking to access opportunities, the vast Chinese economy and its growing innovation capability continues to offer serious, distinct and interesting opportunities for UK firms – and in fact, may even be part of a solution to a long-standing concern about UK innovation: its ability to scale innovations to a commercial level which would allow UK firms to better compete globally.

Why collaborate?

Collaborations between organisations are playing an increasing role in successful innovations. This, in part, reflects the need to bring together a range of different capabilities which are dispersed among different firms and geographies in order to create innovative customer solutions, disruptive business models, or even completely new industries. Working to innovate with another firm, while sharing the risk and rewards of innovating together,⁶ encourages greater investment in innovation by those firms, and extends the scope of their innovation capabilities.⁷ It is therefore unsurprising that choosing with whom and how to collaborate is one of the most important decisions a firm will make.⁸ In many industries, international collaboration is increasingly critical. Firms may seek out international partners for a range of reasons: to access product and financial markets; to share the costs of research and development; to access complementary resources and skills of partners, such as finance or complementary technologies; to benefit from research synergies or access facilities; to accelerate return on investments through more rapid diffusion of innovation, or to attain legal or political advantages in host countries.⁹

The UK hub for science and innovation collaboration, and growing links with China

The UK has a highly internationalised innovation system. Around 46 per cent of the UK's scientific publications have an international co-author, and this share is growing rapidly. An exceptionally high proportion of UK business R&D is funded from abroad: in 2011, the UK attracted almost US\$7 billion of overseas-financed R&D – the same as Canada, Finland, Japan, China, and Russia combined.¹⁰

Within these networks, collaboration between the UK and China on science and innovation is growing fast, but there remains untapped potential. Nesta's recent work on China tracked this partnership, finding that the UK overtook Japan in 2011 to become China's second most prolific source of research co-authors after the US.¹¹ The work also highlighted the growing capabilities in science and innovation in China, where spending the equivalent of half a billion dollars a day on R&D is starting to demonstrate results.

In the realm of science and research collaboration, there are now a range of mechanisms that the UK has in place to support UK-China projects: The UK Research Councils established a China Office in 2007, and more recently the UK government's central £375 million Newton Fund has China as a crucial country to target with match-funded research collaboration projects.¹² There is, in addition, considerable political support for trade, finance and major deals which sometimes have an innovation component – as demonstrated during the recent Chinese Presidential State Visit to the UK in October 2015. The broader policy context is also highly favourable: from the Chinese side, the State Council – the primary decision-making group of ministers in the Chinese executive branch of government – has set out a blueprint for policy measures to 'Boost Mass Entrepreneurship and Innovation' which also emphasises the role of international partnership for innovation.¹³ The Chinese Ambassador to the UK has recently described the business collaboration opportunities with Britain as a 'Golden Time'.¹⁴ And on the British side, there has been a concerted effort to encourage Chinese inward investment in the UK by the current Conservative government.¹⁵

The missing middle?

While government support for both early stage research collaborations and the larger individual trade deals between the UK and China has been growing fast, there appears to have been less focus on supporting small and medium-sized innovative companies (SMEs) to collaborate. But is this where some of the biggest 'wins' could be in the short term?

Nesta's earlier work on Chinese innovation characterised China as an 'absorptive state', increasingly adept at attracting and profiting from global knowledge and networks. China's growing innovation system has succeeded in combining rapidly improving home-grown capabilities and infrastructure with foreign technologies and knowledge to build the world's fastest supercomputer, sending astronauts into space and pioneering the Beidou Satellite Navigation System. Some of that is the result of classic Research and Development. But much involves what Nesta has called 'hidden innovation': the innovation in design, processes and organisational models in manufacturing and services which isn't captured by the traditional measures of R&D.¹⁶ The research found that Chinese firms' impressive ability to rapidly absorb and re-innovate, while adding novelty and value to ideas and technologies in the process, is also crucial to understanding their future competitiveness.

These growing capabilities have been closely tracked elsewhere, uncovering how Chinese firms are excelling at 'accelerated innovation' – re-engineering research and development and innovation processes to make new product development dramatically faster and less costly:¹⁷

“ There is more to the rise of Chinese companies than simply an ability to do things on the cheap. Many Chinese companies are using mass-production techniques to speed up not just the manufacture, but also the development of products. They are developing management techniques that help them create things faster, and they are proving adept at reacting quickly in rapidly changing markets.”¹⁸

The benefits are considerable but, as in any collaboration, so are the risks. Is there greater scope for government to help UK companies harness China's commercialisation engine? How can firms maximise chances of a successful outcome? And how could government provide the most cost-effective and impactful support for these activities?

We set out to answer these challenges in the following way:

- First, in **Section 2**, by exploring the spectrum of ways in which innovative UK companies might collaborate with China on innovation – tracing how Chinese innovation capability now stretches across the chain of innovation development, from R&D through to global rollout of products or services.
- Second, in **Section 3**, by focusing on the stages of collaboration most relevant to understanding how innovation can be scaled-up through an in-depth exploration of how five leading UK companies have successfully collaborated with Chinese counterparts to develop their innovation.
- Finally, in **Section 4**, by drawing out the practical insights for companies and the implications for government policy in ensuring UK firms can successfully harness the increasing power of China's commercialisation engine.

2 HARNESSING CHINESE INNOVATION CAPABILITY ALONG THE CHAIN OF COMMERCIALISATION

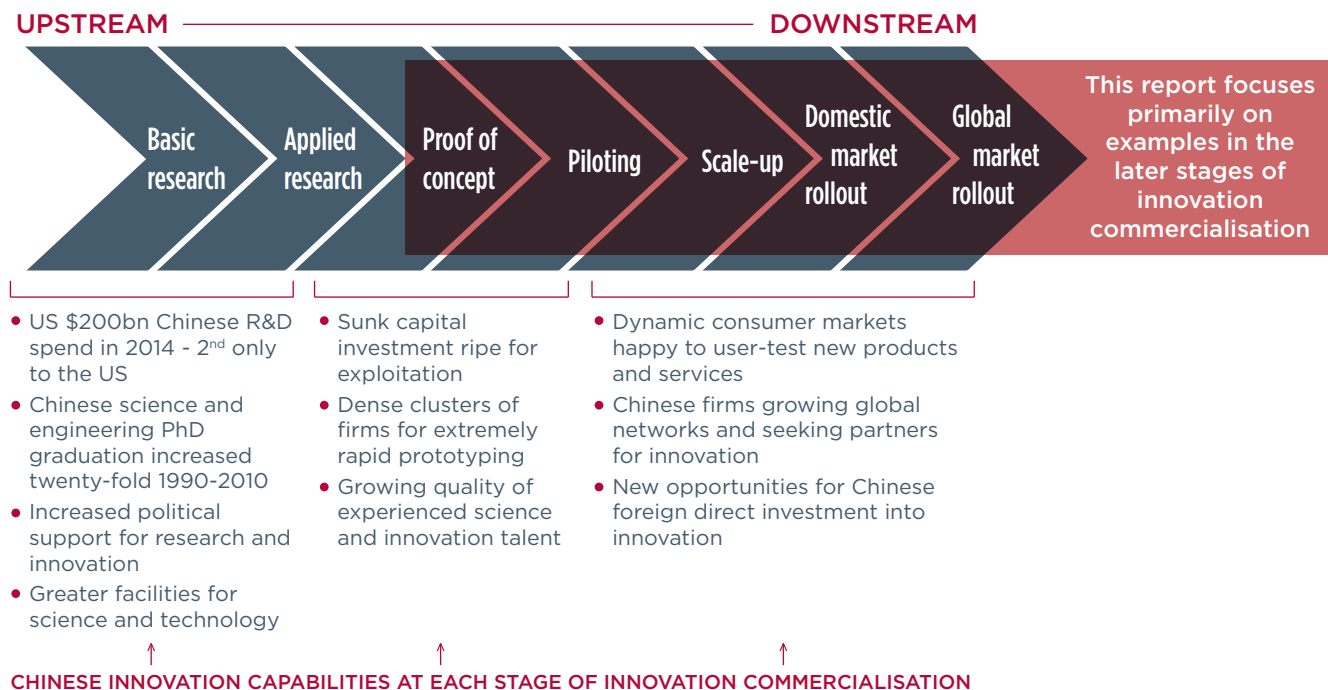
Much of the previous research and policy initiatives in the area of cross-border cooperation in innovation have focused on the 'upstream' element of innovation collaboration: research and development in basic and applied research.¹⁹ However, the bulk of the economic benefits of technological advances, both private and public (in terms of job creation, other economic multipliers, and taxation revenue), are generated when new technologies are commercialised and scaled up. These benefits are obviously magnified when new technologies, and the new products and processes they support win a significant share of global markets. As a review on the benefits of scaling and commercialisation of UK technology for the UK government concluded in 2014: 'In a globally competitive environment, commercialising swiftly and effectively can make the difference between being a market leader or a market follower'.²⁰

How can we understand the full spectrum of possible collaborations for innovation between the UK and China? In this part of the report we explore the opportunities for collaboration on innovation as part of a 'chain of commercialisation'. Commercialisation here is the whole chain of development – not just reaching a market with a product or service, but also the process of scaling that innovation to address a global market.²¹

The process of developing an innovation is complex and messy. It tends to mobilise networks of resources, and rarely proceeds in a stable and predictable step-by-step way.²² However, to aid our understanding of how innovation collaborations can develop between UK and Chinese organisations, a model which explores the activities and implications of several stages can be very useful. This section of the report describes a stylised model of developing and scaling an innovation through a 'chain of commercialisation'. It then examines how Chinese innovation capability might be harnessed at each stage of that chain.

Figure 1 below simplifies the process to trace the potential stages a firm may go through as it develops an innovative product, service or technology, looks to scale that innovation – in this case in partnership with China – and then to sell it into both a Chinese and UK domestic, and then a global marketplace. It is important to emphasise that not all of the stages of the model are relevant for any particular firm: some may collaborate for innovation only for scientific research, or for the creation of a prototype, or to develop a new approach to user testing to roll out their innovation.

Figure 1: A stylised model of stages in developing an innovation - indicating which complementary Chinese innovation capabilities might be harnessed at each stage



Each of these stages in the commercialisation process requires specific resources, capital, know-how and access to a network of partners, suppliers, and service providers with complementary capabilities. Many SMEs face barriers in accessing these resources and capabilities. Difficulties in overcoming these barriers often means the full potential economic benefits to the UK of innovations aren't realised. Delays in the piloting and scale-up of promising innovations results in the innovation being stranded in a small niche segment rather than breaking through into the mass market, or the company's sale to foreign acquirers who shift the commercialisation activities offshore.

Given the persistence of these wider barriers, it is opportune to examine whether collaboration between UK and Chinese companies and institutions, especially at the stages of piloting, scale-up, and market rollout, could play a complementary role in overcoming these remaining barriers to a UK innovation reaching a global scale. In exploring this possibility our next step is to analyse the resources and capabilities that Chinese companies and institutions might bring to these commercialisation processes.

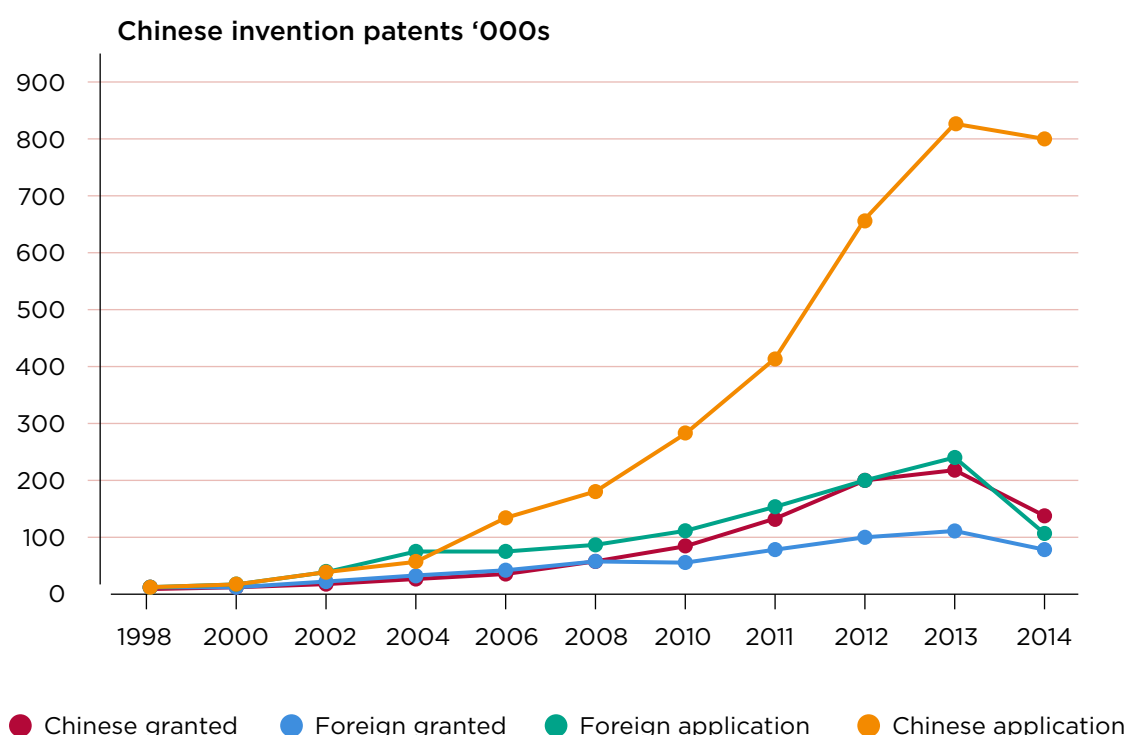
Below, each step in the commercialisation chain model is described, with a focus where Chinese firms have developed strong and distinctive capabilities and how these might be harnessed. The emphasis is on the later stages - from proof-of-concept through to global rollout, where the capabilities of Chinese firms appear to be the strongest.

2.1 Basic and Applied Research

Over the past fifteen years China's basic research activities have been growing at a rapid pace, with dramatic increases in the quantity of output, both across broad fields such as engineering, and in newer fields such as biomaterials: publications output has grown 15-fold in the last decade.²³ However, recent analysis, including that reported in Nesta's *China's Absorptive State*, has found that basic research still accounts for less than five per cent of total R&D expenditure, and that impact of Chinese basic research remains below the world average in most areas.²⁴ While strong in engineering and mathematics research, and with pockets of excellence dotted elsewhere, the overall figures mask distinct variability in quality. However, this is changing, with Chinese universities now graduating more than 10,000 science PhDs a year – and increasing numbers of the vast diaspora of Chinese foreign-trained scientists also returning to work at home.²⁵ The training of scientific and innovative talent is also a major area of UK-Chinese collaboration. By 2024, it is estimated that 44 per cent of the UK's international graduate students will be from China, and leading UK universities are building science and technology ties through successful joint ventures in Chinese cities ranging from Beijing to Suzhou, Guangdong to Ningbo. At the end of 2013 the UK was the largest global provider of Sino-Foreign joint degree programmes.

Within the total Chinese research and development spend for 2014 of almost US\$200 billion, it is applied research that accounts for the lion's share of that investment.²⁷ The number of Chinese 'invention' patents has risen almost exponentially since the early 2000s. Prior to 2000 the number of invention patents issued to Chinese organisations in China was roughly equal to the number granted by the Chinese authorities to multinational companies and other foreign applicants (see Figure 2 below).²⁸ Today the number of Chinese patents, both applied for and granted (around 10 per cent of which are also filed with Patent Offices in the US and Europe), far exceeds those submitted by and granted to foreign applicants in China. This suggests there may be significant potential for fruitful UK-China co-operation at the 'applied research' stage of the commercialisation chain.

Figure 2: Growth in Patentable Innovation in China. Source: National Bureau of Statistics of China



2.3 Proof of Concept

The classic image of the process for coming up with the idea for an innovative product or service and proving the new concept, at least in the West, is of an inventor or a small team brainstorming and experimenting with new technologies and ideas. Large scale and tightly defined processes are generally seen as inhospitable to creativity and innovation. Although innovation may be systematised and scaled up to involve thousands of scientists and engineers in some industries, such as pharmaceuticals and IT, the core R&D activities nonetheless revolve around a set (perhaps a large set) of relatively small teams.

A number of Chinese companies, however, have been successfully challenging this conventional view by pushing the boundaries of systemisation and scale to a whole new level in their efforts to accelerate innovation, leveraging the potential of a large pool of competent technicians, engineers. Their approach is to divide the innovation process into a large number of small steps, and then to assign teams to work on each stage. The goal is for the 'assembly line' to accelerate the process and deliver results quickly. Chinese firms have coupled these structural changes with innovations in management with a strong focus on 'responsiveness, improvisation, flexibility, and speed: Chinese companies have learned to manage differently over the past 30 years because they've had to cope with a turbulent environment.'²⁹

A good example of this expertise in accelerating the proof of concept stage is the work on a new drug for the treatment of chronic hepatitis C by WuXi AppTec, a pharmaceutical, biopharmaceutical, and medical device outsourcing company with operations in both China and the United States. Rather than relying on a small team working in the laboratory with a few machines, however, WuXi AppTec began by dividing the R&D process into a series of eight steps, with dozens of people assigned to each step. The initial creation of the reactive intermediates required specialised staff, with at least Masters degrees and considerable research training. The other steps required 'R&D workers' (graduates of trade colleges), thousands of whom WuXi AppTec hire each year. Rather than relying on automation (with the associated high capital costs and risk of bottlenecks), WuXi AppTec uses manual techniques that can be quickly scaled up or down as required to keep the project moving rapidly. Efficiency is increased by using SAP's enterprise resource-planning software adapted from a manufacturing assembly line to manage the innovation process. This highly industrialised approach has enabled WuXi AppTec to complete projects between two and five times faster than comparable projects using conventional approaches the company benchmarked in the US.³⁰

2.4 Prototyping and New Product Development

Traditionally, new product and service development in the West has been organised as a sequential 'waterfall' process, where prototyping does not begin until proof of concept and designs for all the underlying technologies and components are complete. More recently, however, companies have tried to speed things up by tackling certain steps in parallel, an approach pioneered by NASA and now commonly referred to as 'simultaneous' or 'concurrent' engineering. Although the concept is simple, many companies in mature economies have found it hard to implement in practice because of barriers such as unwillingness by engineers to release information early, limitations in existing software systems and difficulties in coordinating multi-disciplinary teams.³¹

Chinese companies, however, are not only embracing simultaneous engineering, they are pushing it to new levels. A prime example is Lenovo Group Ltd., which acquired IBM's personal computer business in 2005. At the time, its new product development cycle was 12 to 18 months. Since then, Lenovo has managed to reduce the cycle by half by applying simultaneous engineering across the entire innovation process, beginning in R&D through design, manufacturing engineering, quality control, procurement, marketing and service. For every project, team members work on different

elements in parallel, under the supervision of one leader. Lenovo overcomes the usual problems of implementation by breaking down its product designs into separable modules linked by standardised interfaces; redesigning its software to be compatible across all activities associated with the new product; establishing short lines of communication where each team member can represent their respective functional department; and introducing open design processes where information is shared with the entire team as early as possible.

Certain Chinese cities like Shenzhen have developed world-class product prototyping capabilities through their dense networks of manufacturing companies, which now offer a speed of hardware and product prototyping unlike anywhere else in the world:

“When you’re creative you want to try an idea and move on to the next idea and then the next idea. That’s the kind of dynamic flow that’s possible in hardware in Shenzhen that’s not possible in the United States Today’s hardware startups say it’s not low-cost and low-skill labour that draws them to Shenzhen – wages in Chinese factories are rising and by some estimations are now 20 per cent higher than those in Mexico. Instead, Shenzhen and the entire Pearl River Delta region offer a manufacturing ecosystem unmatched anywhere else in the world, with clusters of symbiotic factories turning the area into a one-stop shop for many projects.”³²

These capabilities in rapid prototyping could be extremely useful for UK SMEs wishing to bring new products and technologies rapidly to market if they could be accessed through collaboration with Chinese partners. For example, SeeedStudios, based in Shenzhen, are specifically set up to provide rapid, small batches of prototypes and early product runs for small businesses based outside China and looking to rapidly develop new products. However, those who have experience of such partnerships, such as Steve Cook, Strategy Advisor at BP, suggest that China’s capabilities in rapid experimentation are often undervalued by foreign companies, observing that:

“China is a great place to be empirical and learn by doing. The government is very keen to promote innovation and so small Chinese companies can get hold of factories rent free...There are also lots of service industries supporting this innovation drive. For example, it’s 10–20 times cheaper in China to build a prototype production line. It’s so cheap it’s almost disposable. This means you can experiment. There is a boiling cauldron of people just trying stuff.”³³

2.5 Scale-up

In response to the huge scale and growth of their domestic mass market, Chinese companies have developed strong capabilities in scaling up innovations from proven prototypes into volume products and services. This includes capabilities in: developing the process technologies necessary to produce the innovation efficiently at large scale (and similar information technologies in the case of services); the management of large-scale projects, including the rapid and cost-effective construction of manufacturing plants and other facilities; the assembly of large and diverse supply networks; and the capability to mobilise the financial resources to support the necessary capital investment.³⁴

These capabilities are often summed up as Chinese expertise in getting innovations through the scale-up phase ‘from one to 100,000’. A good example is Da-Jiang Innovations (DJI). Launched in 2006 DJI has become a leading player in the fast-emerging drone industry, with revenues currently estimated at US\$1 billion. The company has filed hundreds of patents, especially in designs for

ease of manufacture and process technologies, and successfully launched lawsuits against rivals for infringement of this IP. Its ability to rapidly scale up the production of new designs is helped by the huge and highly responsive local supply network it has developed in China. At the launch of its new Phantom 3 range of drones in New York, London and Munich in March 2015, DJI's founder, Andy Pan, summed up DJI's strengths in scaling up innovative products this way: 'our giant defence company competitors are technologically advanced, but they take five to six years to scale up supply of a new model whereas we take five to six months'.

The prototyping and scale up capabilities are primarily driven by collaboration between firms and within an industry, but as the products and services are rolled out within the domestic market, there is also the possibility of external collaboration with customers.

2.6 Domestic Market Rollout

Complementary to Chinese companies' capabilities in scaling up the production and supply of innovation is an ability to rapidly roll out new products and services across the Chinese market and incrementally improve them continuously as they learn from customers: moving from collaboration with the supply chain to innovating with customers in the market. Many large Chinese companies have access to huge distribution networks that extend even into the far reaches of rural China. This distribution infrastructure allows them to introduce new product variants quickly, and to rapidly learn to how to adapt any new product to fit the needs of different market segments and to keep up with fast-changing customer expectations.

A combination of the characteristics of the current Chinese market environment, and these capabilities in distribution and in capturing market feedback, has gifted some Chinese companies the ability to leverage rapid iteration cycles in the development of new products. The Chinese market is particularly fluid and fast moving, with many first-time buyers and open-minded consumers and generally fewer regulatory hurdles to clear before new products can be launched. Moreover, many Chinese companies have relatively little brand equity, and thus face only relatively limited reputational risk if a new product fails. As a result, they have the capability for rapid learning in the Chinese domestic market by quickly moving through successive cycles of innovation with customers as they iterate the process of 'launch-test-improve'.

Despite the recent noticeable slowdown in China's economic growth, the scale of the Chinese domestic market continues to be enormous: in 2013, China online shoppers outnumbered the total US population, and one McKinsey commentator considers a 'totally realistic' set of tweaks to the regulation of Chinese service markets and industries could 'easily add US\$2 trillion' to the Chinese economy by 2025.³⁵ Even China's niche markets are huge by international standards. A recent McKinsey report makes the point well, comparing the vast scale of peripheral Chinese markets with central ones in other economies: the Chinese online gaming industry being larger than the Turkish car industry, and spas in China yielding more than automobiles in Poland.³⁶

The speed of Chinese 'launch-test-improve' cycles, coupled with the scale and openness of even niche areas of the Chinese domestic market, has seen an extraordinary amount of innovation with consumers: effectively combining prototyping with scaling and rollout. For example, when Tencent launched the first version of 'QQ Reminder' application, it was geared toward appointments, birthdays and anniversaries. Users quickly pointed out a missing feature: reminders for when their favourite sporting events were about to begin. More surprising to Tencent's developers, however, was the flood of input they got from gaming enthusiasts who wanted reminders about the schedules for computer-game tournaments. Within weeks the Tencent team released a new version that incorporated both functions. This rapid cycle of 'launch-test-improve' has now become core to Tencent's innovation process. Rather than nailing down a full-fledged product before launch, the Tencent development team routinely launches ready-to-use new platforms with limited functionality and harnesses user feedback to improve the final product. To achieve this, the company has created channels to encourage user feedback, rapidly communicating this to the R&D team, and ensuring the product architecture and design process is sufficiently flexible to incorporate new functionality quickly.

Similar rapid 'launch-test-improve' cycles are deployed in many Chinese companies. SIM Technology Ltd., a designer and manufacturer of cell phones based in Shanghai, launches new products based on market feedback every month compared to between three and nine months for foreign competitors. Sometimes the improvements are relatively minor (such as giving users the ability to turn up the sound volume higher than competing products in noisy urban environments); others are more significant (such as doubling or tripling battery life). In most cases, rapid response to market feedback drives the innovation process.

2.7 Global Market Rollout

As Chinese firms become more international and outward-facing,³⁷ the potential for UK-China collaborations to accelerate the scaling up and commercialisation of UK innovations in the Chinese market may also pave the way for subsequent global rollout of UK innovation. Having proven the concept, produced prototypes and potentially reached scale in China through collaboration with Chinese partners, innovative UK companies may be well positioned to establish themselves in the global mass market. This potential, however, raises complex issues concerning who has the rights to the intellectual property (IP) embedded in the resulting products and services (as well as the complementary process technologies, improvements and adaptations that may have been developed with Chinese partners).

One potential risk is that the Chinese partner will eventually become a new competitor in the global market using intellectual property resulting from the initial cooperation. But creative solutions exist to mitigate those concerns. One approach is to agree upfront an arrangement to divide up international markets for the resulting products. For example, when San Diego-based HUYA Bioscience International entered into a co-development agreement with Shenzhen Chipscreen Biosciences for a prospective cancer treatment, Chidamide, it was agreed that Chipscreen would retain the marketing rights in China, with HUYA retaining the remaining global marketing rights.

Typically, the Chinese partner will be given the rights to sell the products in China and potentially other emerging markets where its capabilities and experience in marketing and distribution are most relevant. The foreign partner, meanwhile, might retain the rights to sell the products in its home market, and other developed markets where it has established distribution networks. For the foreign party, such agreements have the advantage that any violations can be pursued through courts outside China.

In other cases the parties could agree that sales into the global market will be made by a joint venture rather than independently. This was the case when Chicago-based Velsicol Chemical LLC, a leading specialty chemical company, announced a joint venture with ECOD Specialties Co Ltd of Wuhan, China in October 2013. The joint venture is located in Wuhan and not only manufactures, but also sells its environmentally-friendly plasticisers globally, with Velsicol contracted to act as its sole marketing agent worldwide.³⁸

2.8 Linking UK firms to Chinese innovation capabilities

In each of the stages of commercialising an innovation, China's capabilities are increasing; its innovation engine is strengthening and improving. Huge challenges still exist in forging a successful partnership, but the implication of these developments is that China should no longer be viewed primarily as a big market or for low-cost labour; an outsourcing site where developed country firms place parts of their value chain wholesale in low-labour cost countries.³⁹ Instead, across the spectrum of innovation, China has moved to develop the capabilities to be an important partner for UK firms on innovation.⁴⁰

There is now evidence of a wide range of Chinese firms, including smaller firms, deploying 'open innovation' capabilities such as technology licencing, long-term international alliances, and collaboration with local and international universities to develop their capabilities and strengthen

their innovation performance.⁴¹ They might not yet be as adept as the best UK firms in this kind of open innovation collaboration, but the emerging capability means that, with appropriate caution and assessment, there is a distinct opportunity for UK businesses:

“To develop alliances with Chinese players in order to tap into accelerated innovation know-how, especially at the stage of rapid piloting and scale-up of new technologies and ideas. This last approach should be particularly attractive to small- and medium-sized foreign companies that face financial, regulatory and knowledge barriers to commercialising their innovations at scale at home.”⁴²

While the benefits of collaborating with Chinese partners on downstream innovation are becoming clear, the practical ways to identify specific opportunities and develop successful partnerships are not obvious. The next section of the report looks at how existing examples of smaller UK firms have made it work.

3 COLLABORATION STORIES: HOW FIVE UK SMES SUCCESSFULLY SCALED THEIR INNOVATION BY HARNESSING CHINA'S COMMERCIALISATION ENGINE, AND WHAT THEY LEARNED

Commercialising an innovation is something which is undertaken by firms of all sizes, but the development of innovation by smaller organisations is particularly important for the UK economy: a disproportionate number of new jobs come from a small percentage of high-growth businesses, including small and medium-sized firms (SMEs), and smaller firms require greater support to drive that growth and innovation.⁴³ In addition, sufficient investment in innovation by small firms is central to their growth.⁴⁴ There is therefore a large vested interest in the UK government maintaining a focus on SME innovation when seeking to drive jobs and economic growth.

This section of the report therefore examines where the UK has been perceived to be weak on the 'chain of commercialisation' of innovation from the previous section – growing those innovative small firms into global players (Box below), before examining in some depth how selected individual firms have harnessed that downstream Chinese innovation capability to help them scale.

Does the UK have a particular problem with scaling innovative companies – and could China help?

The UK has a strong tradition of basic and applied research,⁴⁵ and, in certain sectors and geographies, thriving startup ecosystems.⁴⁶ It therefore has a strong base of innovative, high technology, small companies from which to grow and commercialise innovation – particularly internationally. There is a close relationship between a firm's innovativeness and propensity to export: firms with a track record of innovation are more likely to export, export successfully and generate growth from exporting than non-innovating firms. There is also an important inflection point in an innovative firm's growth, whereby the strength and success of its first international engagement often sets the intensity and geographic scope of its internationalisation path.⁴⁷ While some commentators caution that firms which are not innovative already should not be prematurely pushed into international collaborations⁴⁸ overall there is a clear national value in terms of jobs and growth to supporting the internationalisation of innovative high-technology small and medium enterprises, particularly those that have built an organisation around the UK's strengths in basic and applied research. But others have warned that the UK's strengths in the earlier stages of the commercialisation chain have not always been matched with an ability to build UK-owned companies on the world stage.⁴⁹ As an influential report on the UK's ability to commercialise technology noted in 2010: 'the UK has a science capability second only to the US: an undoubted source of competitive advantage. However, it falls short on translating scientific leads into leading positions in new industries.'⁵⁰

In a recent lecture to mark the 75th anniversary of the Cambridge University computer laboratory, Mike Lynch, the founder of highly-successful UK technology firm Autonomy, bemoaned the fact that all the brilliant work done by the university's scientists had failed to translate into many big

hitters in the FTSE100. He suggested that when many companies with excellent technology reached a certain stage, they or their backers lost confidence, selling up to American firms. The UK was, he suggested, a world-class R&D laboratory producing technologies for overseas firms to exploit, rather than going on to turn high quality research into products for global markets. Just one UK computer business had made it into the FTSE100: Sage, the Newcastle-based accountancy software firm. Lynch concluded: 'our universities are second to none... but they're failing to translate the gold coming out of them into economic growth.'⁵¹

Certainly the mergers and acquisitions data confirms that American companies' appetite for UK mid-sized companies is strong, and fund managers see this activity accelerating. As Neil Hermon, director of UK equities at the Henderson Smaller Companies Investment Trust observed in a recent presentation in London: 'American companies are not interested in narrowly-focused, strictly domestic UK assets. Instead, they prefer to use the London-listed companies as gateways to the rest of the world. They buy global companies with niche positions, most likely in the industrial and technology sector. They're buying unique UK assets that have a global outlook'.⁵² Examples of innovative UK businesses being gobbled up by overseas purchasers before they achieve a global scale include: Cambridge Silicon Radio, which was bought by Qualcomm for around US\$2.4 billion in 2014; and software-maker Anite acquired for US\$600million in August 2015 which the U.S. buyer, Keysight Technologies, said would support its 'strategy to grow globally in wireless and expand its software offerings'.⁵³

A detailed recent study of the future of 354 promising young firms in the Cambridge high-technology cluster found that 87 had been acquired, that in 98.9 per cent of cases the firms were acquired before they reached a size of 250 employees, and that almost 50 per cent were approaching mid-sized (50 employees) at the time they were sold.⁵⁴ Firms with a record of growth, good prospects and university spinoffs were the most likely to be acquired. In fact, 42 per cent of all of the highest growth firms in the cluster were acquired. Analysing the available data for the acquired firms three years pre- and post-acquisition showed that profitability and cash flow improved, but the pace of growth in the number of UK-based employees halved after the acquisitions. Just four companies in the sample became international leaders in their sector having remained independent. Many of today's new entrepreneurs appear to be resigned to this pattern being repeated. Paul Sheedy, founder and CEO of payment systems start-up Reward Technology, sums up the sentiment as follows:

“ ‘I'd love to stay [in the UK, but] my gut feeling would be that, looking at the international market, it would most likely be an American corporation that would want to gobble us up. I would prefer to go public on the London Stock Exchange and think it's sad that so many tech companies sell their souls to American venture capital firms.’⁵⁵

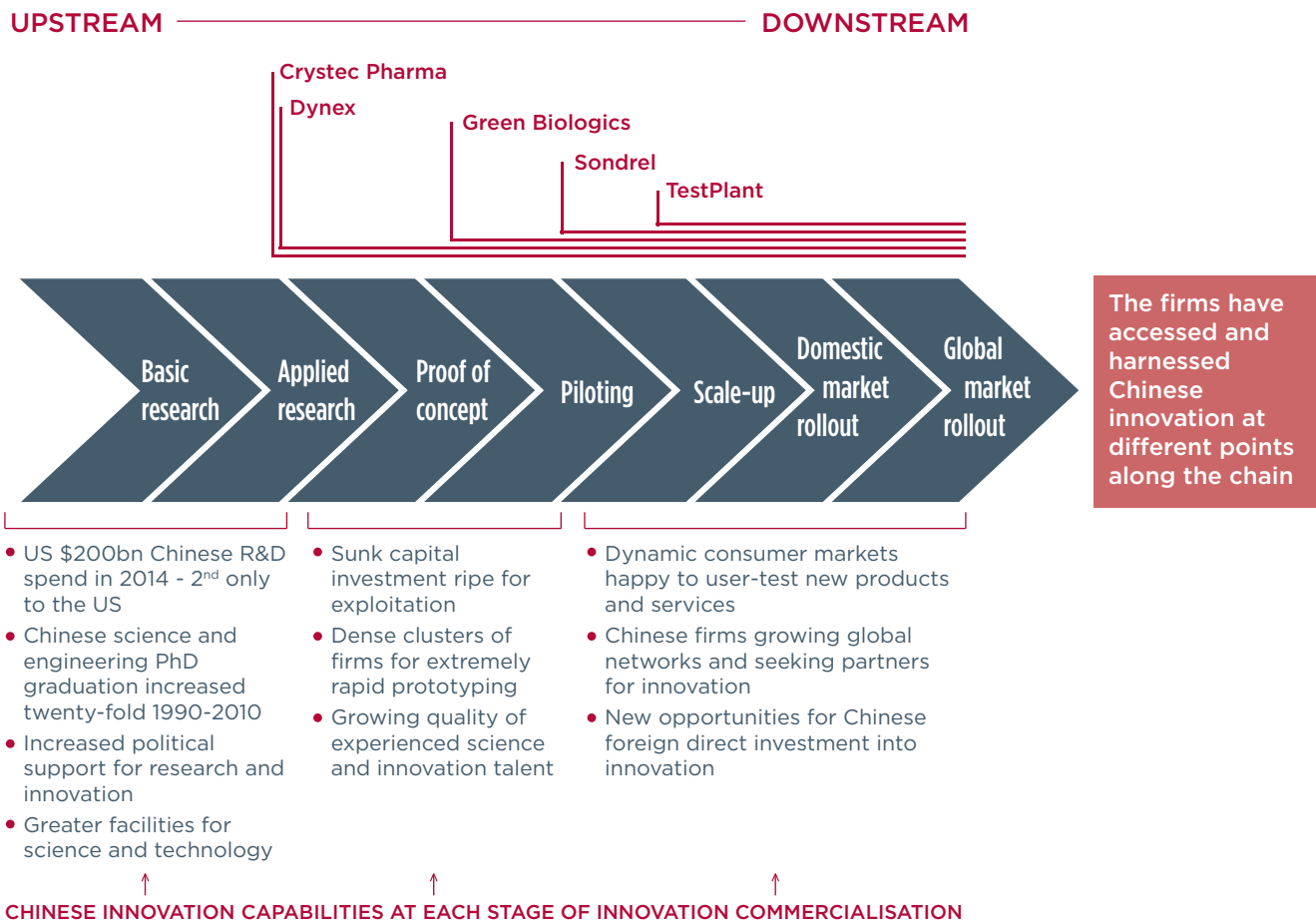
If the UK is to improve its ability to scale globally-competitive, innovative companies, one approach could be for them to harness China's commercialisation capabilities which were assessed in the previous section.

Below, we examine five examples of UK small or medium-sized enterprises which have collaborated for innovation with China. Each of these firms are manufacturing, manu-service or high-tech product-based, with some proprietary technology, at least five years' experience of partnering in China, and some evidence that they were looking to scale a relatively innovative product or service by partnering in China.

The firms are Crystec Pharma and Green Biologics, two biotechnology firms – one of which specialises in techniques for the pharmaceutical industry – both of whose innovations are primarily in biochemistry. Two firms working with chip design, Dynex Semiconductors and Sondrel, of which Sondrel focuses on the design phase and Dynex undertakes both design and manufacturing, whose innovations are around design capability, and TestPlant, a software firm whose innovation is around the development of software tools for software testing.

They were selected for their variety of engagements and experience in China, and the variety of approaches and aims of innovating with China. As Figure 3 below indicates, the firms entered into collaborations in China at different point when looking to develop their innovation, depending on their need and the point of development of their technology. This already reinforces the point that international collaboration to scale an innovation is not a mechanical step-by-step process, but a fluid and interlocking set of decisions around which complementary capabilities a firm needs to scale its innovation.

Figure 3: Mapping the firms' partnerships with China across the chain of commercialisation



3.1 Crystec Pharma

www.crystecpharma.com



Crystec Pharma is a small biotechnology firm founded in 2008, based in Bradford, UK and Tianjin, China. It currently has 20 employees, of which five are based in China. It applies supercritical fluid technologies to improve the performance of medicines. They provide crystal and particle engineering solutions to the pharmaceutical industry; that is, technical solutions as part of the pharmaceutical manufacturing process. An example of Crystec's work would be being commissioned in 2014 by a pharmaceutical company to develop its cystic fibrosis (CF) medicine as a dry powder for use in an inhaler in addition to its existing tablet form.

Because of the overlapping interests of its founding partners and academic staff, Crystec Pharma has a close relationship with the University of Bradford, and has drawn heavily on the connections – including to China – of that institution.

Choosing and entering China: Establishing capability

Crystec CEO Paul Thorning had been active in China prior to founding Crystec. He led the Institute of Pharmaceutical Innovation (based at the University of Bradford) which had a strong network of collaborations with China and became the foundation for a successful Science Bridges programme, developing partnerships with China for UK university academics and SMEs. When founding Crystec, he and his team (including Crystec's Chief Operating Officer) already had a range of important personal contacts in the industry in China. This personal network was crucial to the early stage development of the business.

China also offered a range of benefits for developing Crystec's innovation capability: cost-effective access to scientific talent such as post-doctoral researchers, and the potential for Chinese government support for the siting of research businesses in China. Crystec chose to locate its Chinese operations within the Tianjin Economic Development Area (TEDA) – one of China's priority areas for the pharmaceutical sector. This also provided access to high-level analytical capabilities from the Chinese National Academy of Nanotechnology and Engineering in Tianjin – one of the main centres for the technical and analytical skills Crystec needed.



Crystec did not receive funds directly in the early stages from Bradford University, but it did receive some Science Bridges funding for a project to develop an improved anti-malarial product, linking to the University and the Shanghai Institute of Materia Medica. Additional funding was received from the Chinese municipal government in Changzhou, developing an improved anti-fungal product with Changzhou Pharmaceutical Factory. Generally (and typically) Chinese funders have been more interested in products made using Crystec's technology, rather than their technology expertise per se. CEO Paul Thorning sees another specific link to China; that some of the technology they were deploying can also be applied to the improvement of traditional Chinese medicine (TCM). Crystec has already picked up two substantial contracts in this area and is working with China's national association for TCM.

Developing innovation with China

Crystec Pharma's original structure for operating in China was as a subsidiary of an existing UK company. However, they later realised that they could have been structured differently (by establishing a subsidiary of the subsidiary) in order to qualify as a local company for additional support from the Chinese government - this despite the executives' extensive China experience; an indication of how difficult it sometimes is to navigate the system of support in China.

As the firm has developed operations in both the UK and China, they have invested in a wider range of tangible assets - such as custom supercritical fluid equipment - to be able to undertake a wider range of projects. CEO Paul Thorning stresses that while both the UK and Chinese operations are bringing scientific expertise, it is not just a financial contribution from the Chinese end - they have gradually refined the business model to fit the relative advantages of the UK and Chinese capability: the front end of innovation development has been with the R&D capability in Bradford, and it is with Tianjin that they can scale up the processes, and develop a robust process for their technology, before providing that service to clients globally. Within this, they identify one of the primary values of a mature relationship for innovating with China is the relative speed at which this scaling up can occur.

They are bringing specific technologies to China, and then using the considerable investment the Chinese have made in capability in this area to commercialise the product, then they share the profits of the outcome. There are also differential benefits as well as shared ones: the Chinese partners to Crystec benefit from gaining access to a technology which improves product performance, such that they will ultimately charge a premium for such products in their own markets. As its products launch in the Chinese market in the coming years, Crystec expects to see shared benefits with its partners in China.

Key challenges in collaborating for innovation in China

- **Intellectual Property:** CEO Paul Thorning feels that the IP issue in China has been overemphasised recently; that the Chinese are taking it increasingly seriously, and that a high quality partner, particularly one with government links, is as likely to be as interested in protecting IP in its home market as a western firm. However, it remains important to be aware of where there might be potential risks and take appropriate precautions. For example, in Crystec's case, they separated which company they worked with to make different individual elements for new equipment, and which they worked with for the final assembly of that equipment - to ensure no partner had access to their full technology.
- **Clear communications:** Much of the emphasis in establishing partnerships has been about creating and building trust and creating a shared understanding. For example, with an extremely fast pace of change, many Chinese organisations see contract terms as a snapshot of a relationship which can develop, rather than something to be over-relied on as the situation and market changes.
- **Meeting global standards:** One challenge which Crystec had in mind from the beginning was ensuring that any Chinese partner could meet exacting global standards for their industry, as most of their clients would be based outside China. This meant ensuring that their organisation in China drew on high-end expertise linked to important academic institutions, and that contracted manufacturing firms further down the supply chain were also working to equivalent recognised standards.

Support for collaborating for innovation in China

As a startup, Crystec benefitted from an early travel grant from UKTI to develop potential partner relationships - UKTI also stepped in to provide support for a late-payment issue Crystec encountered. Crystec's primary support mechanism for developing in China has been through the senior executives' involvement in UK-China partnerships through Bradford University and other partners (e.g. Medilink). This has given them a strong overview of the strength of potential collaborators, as well as of the steps required for success in partnering for innovation in China.

In particular it has given them an insight into the way in which they can work with the broader ecosystem in China – with the government, academia, and trade associations, as well as commercial partners – to scale up their innovation capability.

Conclusions/Implications

“ Innovation is a terrific platform for building relationships with China in a much more equal way – and a primary route to developing the Chinese market.”

Crystec Pharma CEO Paul Thorning

Crystec have a set of innovative processes and capabilities which they are deploying globally, at greater scale, because they are partnering in China. Leveraging their knowledge of the primary sites of their highly-specific technical expertise, they carefully selected partners – particularly university-related partners – with the level of capability they required to ensure that they could service clients globally. Particularly important has been the speed of prototyping and developing technical processes available by working with China.

Central to their success in partnering for innovation in China has been leveraging the broader ecosystem: wrapping other relationships around their primary partnership. This has ensured they are seen as a valuable part of the ecosystem, bringing jobs, technology and capability to China, while allowing them to access capital for growth and operate more effectively for global clients.

3.2 Dynex

www.dynexsemi.com



Lincolnshire-based Dynex Semiconductor designs and manufactures high-technology, high-power-throughput semi-conductors, which are deployed in heavy industrial settings, such as trains and power stations. The firm, including under its previous names, has been in existence since the late 1950s. For a considerable period it was part of the GEC Marconi family of companies. The firm had been selling products in China since at least the mid-1980s.

In 2008 the Chinese State-owned Enterprise, China South Rail (CSR) Times Electric, took a majority stake in Dynex. Since the purchase, Dynex has now expanded from 100 to more than 350 employees across China and the UK, including more than 75 in the research and development (R&D) division with 52 in Lincoln, of which almost half are Chinese nationals.



Rationale for collaborating with China

Facing fierce competition in the mid-2000s from both western and Asian competitors, Dynex needed considerable investment to retain its edge in innovation and to access global markets effectively. Then primarily owned by a small number of individual investors, Dynex needed to access greater levels of capital at a cost-effective rate, and create new links to larger-scale market opportunities – both in terms of accessing new customers, and increasing their ability to have the marketing reach to compete in global markets.

Dynex has a long history of operating in China but has gradually developed its capability there – particularly around innovation. Its primary approach from the mid-1980s was technology transfer: licencing designs and approaches to Chinese clients, but gradually it added component sales through a third party. An important customer was CSR Times Electric – Dynex had worked with them for more than 10 years. Initially they were also a competitor – looking to develop their own design and manufacturing capability in China for semi-conductors, but ultimately they decided bringing Dynex into their larger company was the most effective way to develop their own innovation capability, specifically in high-throughput semi-conductors.

Choosing and entering China: establishing capability

Dynex had, themselves, explored a number of different options in terms of partnering in China, but considered CSR to have the best ‘feel and fit’ as they were already established in sectors Dynex was keen to develop new products within, and, as existing customers, it was clear how Dynex’ capability could be integrated into the CSR supply chain of new products. In addition, Paul Taylor, the Dynex CEO, felt that the management style of CSR was ‘a bit more entrepreneurial and open, especially for a state-owned enterprise’, than other Chinese partners they had considered. There was also an odd personal connection between the CEO and Chinese engineers – Paul Taylor had written a textbook in the 1980’s which somehow (royalty-less!) had become a standard textbook in China, and many of the CSR and other Chinese senior managers had studied the book earlier in their careers. This allowed him to be a ‘name’ when introduced to potential Chinese partners and new contacts.

For CSR there was the need to access technological know-how and develop their R&D capability to bring innovation to a wider range of sectors within their existing Chinese operations, but also, ultimately, to improve their competitiveness in other markets against global players such as Hitachi. They felt the UK was a ‘good location to place their overseas research centre’, especially for making an investment to increase the scale of the manufacturing alongside the core R&D – so they could ‘prove out their product in the UK’ before scaling it within Chinese operations.

Scaling UK innovation with China

While the original arrangement post-purchase was primarily UK-developed, Dynex-supplied products for use by CSR within its own operations, gradually functions were integrated and expanded. More or less from the start of the formal relationship, there were exchanges of Dynex and CSR R&D personnel, including an expansion of R&D in China overseen by Dynex. From 2011 there was also a concerted effort to integrate sales and marketing, to the point where they are now led by a Chinese national who is based in Lincolnshire as the base for sales of Dynex products globally – not just within China or to CSR divisions. The R&D function across both Chinese and UK operations has expanded considerably, and Dynex now has responsibility across both sites, but with Chinese nationals as the R&D director and deputy director. Their R&D capacity has been considerably increased through extensive CSR investment, with 52 R&D personnel now in Lincolnshire (up from ten in 2008) and now 40 in the R&D function based in China.

As it has developed its capability across the UK and China, Dynex has taken advantage of a range of Chinese innovation strengths – particularly around their speed of prototype development, and their willingness to experiment. Dynex are now more comfortable with a ‘suck it and see’ approach to early user testing when deploying newer technologies, because CSR as a user and customer are less bothered than western clients might be if a product fails. This is because: ‘if it fails ... they’ll have a specialist team there in 30 minutes’. Dynex senior management have been constantly impressed

by the capability of the people in their Chinese operations, finding their diligence 'awe-inspiring' in the way they 'manufacture prototypes so fast' with 'no concept of delay'. These capabilities have started to change the workflow approaches of R&D, both in Lincolnshire and China.

The increased investment, capability and combination of Chinese R&D approaches with Dynex UK technology leadership has meant Dynex can expand into newer technologies such as insulated-gate bipolar transistors (IGBTs) – built originally in Lincolnshire before being deployed in China. The continued partnership also allows them to get products into applications and locations they wouldn't otherwise reach. As Vincent Li, Lincolnshire-based Deputy Director for R&D, notes, Dynex's increased R&D range means that through CSR it can now build a wider application platform for entering markets such as public electric vehicles, and then to leverage the wider CSR reach to sell these products in international markets. They are now competing against US and European players with whom they had previously lacked the scale to compete.



Key challenges in collaborating for innovation with China

- **Accessing and sharing talent:** Central to Dynex' approach is to integrate the workforce between R&D and manufacturing in Lincolnshire, and R&D and the broader CSR in China. Visa issues – particularly around bringing Chinese nationals to the UK and recruiting UK-educated Chinese engineers from UK universities into Dynex – has been a clear challenge. There are concerns that the extreme unavailability of visas for Chinese nationals might deter Chinese companies making similar investments as they have in Dynex, instead choosing a firm in a jurisdiction where their staff could more easily be exchanged.
- **Integrating management cultures, including in R&D:** While great strides have been made in joint working, and the visibility of senior Chinese nationals within Dynex in Lincolnshire has helped to cement the relationship, a range of challenges remain. These include establishing effective dialogue between UK engineers' project planning and expectations with Chinese management expectations, and the integration of Chinese nationals with the broader Dynex manufacturing workforce. However, with several senior Chinese nationals based in the UK, the need for UK execs' regular, on the ground presence in China is reduced.
- **Intellectual Property:** since the merger, Dynex have not had major issues regarding intellectual property and their operations and activities in China. They attribute this CSR's role as a large state-owned enterprise offering a degree of protection, both ensuring alignment of Chinese and UK partner interests, and in discouraging others from potential infringement if they wish to address either the Chinese or broader global markets where CSR are looking to operate.

Support for collaborating for innovation in China

In the course of developing and deepening the relationship with CSR, Dynex have accessed a wide range of support from the UK and Chinese governments, including support for R&D. Their research activities have been supported by Technology Strategy Board (now Innovate UK) grants when they have sought to partner for R&D with universities, and a successful bid to the Regional Growth Fund (£1 million+) in the last round built on prior funding received from the Regional Development Agency to expand manufacturing and test facilities in Lincolnshire.

Local support from the constituency MP in Lincolnshire has proved important in navigating the political implications of what was originally perceived externally as a Chinese 'takeover' which might cost jobs in the UK – in fact the investment has increased the jobs on-site in Lincolnshire. A demonstration of local government support and the R&D grants was also an important confidence-booster for CSR executives when assessing Dynex's capabilities when they were considering their investment. In operating in China, being part of the UK Prime Minister's China 'mission' in 2011 to China gave Dynex executives 'a bit of backing in terms of a presence' when looking to impress the CSR hierarchy.

Conclusions/Implications

“ Dynex wouldn't be here in the size and shape we are without the Chinese behind us.”

Bob Lockwood, Dynex CFO

From requiring considerable investment to maintain its R&D pipeline and to gain sufficient capacity to remain competitive in Western markets in the late 2000s, the 2015 Dynex now has a secure pipeline to deploy its products in China, beefed-up R&D capacity in both China and the UK, and the scale and reach to access new markets with new products both in China, and, increasingly, globally. Dynex have been able to expand their innovation, and offer a model of UK technology leadership which is integrated into a Chinese large business, with distributed responsibilities rather than a one-way flow of authority.

From the CSR side, they are keen to extend the collaboration, noting both the importance of keeping their innovation capability close to the world-class university system of the UK, and the importance of using the UK as a base to sell CSR products globally.

3.3 Green Biologics

www.greenbiologics.com



Green Biologics is a privately-owned UK-based biotechnology firm. Founded in 2004, it originally provided biochemical expertise to clients and partners who manufacture consumer and industrial products, but now also owns its own biofuel production and processing plants. One of their primary technologies uses the Clostridium microbial fermentation process to convert a range of sustainable feedstocks – such as corn or corn-waste – into high performance green chemicals for use in a range of consumer products, and potentially in the longer term in biofuels. Now with operations in the UK, China and the US, Green Biologics has over 100 staff – the majority of whom are either operational staff in the US or scientists in areas such as microbiology, metabolic engineering and biochemistry – and recently raised US\$76 million to enable retrofit of an ethanol plant in the US to be its first full-scale production facility.

The basis of the Green Biologics core technology is not new: much of the underlying chemistry has been known since Chaim Weizmann developed it in 1916 (the so-called ABE – Acetone-Butanol-Ethanol – microbial fermentation process) and was relatively widely used prior to the 1940s, but was overtaken at that point by the then more cost-effective oil- and petroleum-based approaches. Prior to Green Biologics, the use of this technique in recent times to produce commercially-viable and sustainable scale of production had not been achieved.

Green Biologics was named in the Global Cleantech 100 list of the top Cleantech companies in the world for 2014. The company was also 6th on the 'Hottest Small Companies in the BioEconomy', and 28th on the 'Hottest 30 list for Bio-based Chemicals and Materials' for 2014.

Choosing and entering China: establishing capability

In the mid-2000s, China sought to reduce its reliance on imported petroleum, and looked to renewable alternatives, so built a number of ABE production facilities to a previous Chinese design. However, price controls on the agricultural inputs meant that the plants were uneconomic.

At a similar time, Green Biologics had looked to develop its novel ABE technology, and saw the opportunity to prove its technology at scale in china in the newly-built ABE plants. Green Biologics was therefore looking for clients and partners with processing plants at the same time as the Chinese required biochemical/technology support.

Through a range of contacts, including a venture capital expert who had fundraised for a range of such deals in China, and hiring an expert with extensive links to Chinese senior scientists in the area, Green Biologics explored a number of potential options for collaboration from 2008. Part of the original business plan was to scout a site where Green Biologics could operate with some joint investment and ownership, but the relationship with Chinese plants began with Green Biologics as technical consultants, with contracts with several plants in different provinces, looking to utilise different feedstocks such as molasses, cassava, corn and corn waste.



“ How do you learn [to find opportunities in China]? You hire a knowledgeable local manager, and get out there a number of times to build relationships.”

Sean Sutcliffe, CEO, Green Biologics

Developing innovation with China

Despite some early promise it was a relatively long gestation before Green Biologics saw the first effective results – and originally at a relatively small scale. In addition there were several false starts as different plants faced different kinds of setbacks, including local plants obtaining appropriate permits, and the bankruptcy of some plants in the same period. However, with a corn waste feedstock plant in Jilin province, Green Biologics were able to scale their process from a first run producing 50 tonnes of product in 2012, to a subsequent run of a more commercial scale of 400 tonnes in 2013.

The success in producing a commercially viable product was driven by two related changes in approach by Green Biologics:

- Firstly, an acknowledgement that although considerable funds had been sunk into the development of biofuel capability by Chinese investors and plants, the position of the industry in China was still very ‘emergent, rather than structured’, and that the approach with them would be highly experimental, where they ‘make mistakes and are prepared to try things’.
- The second was a shift in business model for operating in China by Green Biologics, from seeking potential new shared revenue streams from production, to utilising the Chinese sites as an opportunity to test and scale their innovation where key costs of production had already been invested on the Chinese side; that is, they used the Chinese opportunity and readiness to experiment to get their own innovation to scale to where it could have credibility in other markets.

“ We re-cast our benefit to be the learning from leveraging Chinese investment dollars... in some senses this was a shared technology development between us and our Chinese partners, not a one way street.”

Sean Sutcliffe, CEO, Green Biologics

As the parameters of the kinds of innovation benefits to be gained from the relationship settled, so did the partnership with the Chinese: ‘over a period of time we’ve found a relationship which works for us and works for them - four years on - they’re now part of the team’.

It was proof of the ability to scale their innovation in China which convinced US buyers to purchase the product produced in China, and then subsequently new investors to come on board, enabling Green Biologics to be funded to extend its own operations in the US. The 2015 major round of funding is to enable further expansion in the US. Green Biologics maintains its partnership in China although its focus is now on US-based production.

Key challenges in collaborating for innovation in China

- **Protection of IP:** Despite now more than seven years of experience, Green Biologics has had to be aware of the potential for Chinese operators perhaps unconnected with Green Biologics partners to try to deploy their technology without making contractual payments. In many ways they have acknowledged this as a risk of doing business – but it did partly drive their move to change business model around their Chinese partnership.
- **Being prepared to be flexible in terms of how to realise benefits from partnership:** Green Biologics had to pivot from expecting a direct commercial return from Chinese operations, to expecting a learning benefit because they could scale their innovation in a way the US/Europe could not fund upfront: instead of putting capital into a Chinese venture, a UK SME might seek opportunities to ‘build the relationship and trust’ in order to then ‘help [the Chinese] deal with a sunk capital problem’ which can, in return, offer an opportunity to scale a technology or innovation.
- **Working out what’s going on:** Despite local expertise and hires, from Green Biologics’ perspective the partnerships in China were often driven by political or other motives which were difficult to perceive, with complex corporate structures and local government requirements, and sometimes opaque decision-making processes.

Support for collaborating for innovation in China

Green Biologics have not made extensive use of public sector support mechanisms for their move into China. They relied primarily on prior personal contacts to enter the market, as well as connections through the China Britain Business Council. They have found broader UK innovation incentives – such as R&D Tax Credits and the Enterprise Investment Scheme (EIS) – to be important in general, but not particularly for their operations in China.

Conclusions/Implications

Green Biologics has a genuinely innovative process and product, driven by high-end applied scientific advances. Originally looking to China as a potential major source of revenue for their innovative product, through building and developing multiple partnerships, they gradually pivoted their value proposition to one where ‘significant, sustained Chinese investment in the sector’ could be leveraged to scale their technology, and provide a platform for international expansion and sales.

“ With care you can build a collaboration, but to innovate with China you may need to explore how you can get value other than cash: through technology development and through product and product improvement.”

Sean Sutcliffe, CEO, Green Biologics

3.4 Sondrel

www.sondrel.com/index.php

sondrel
Success through partnership

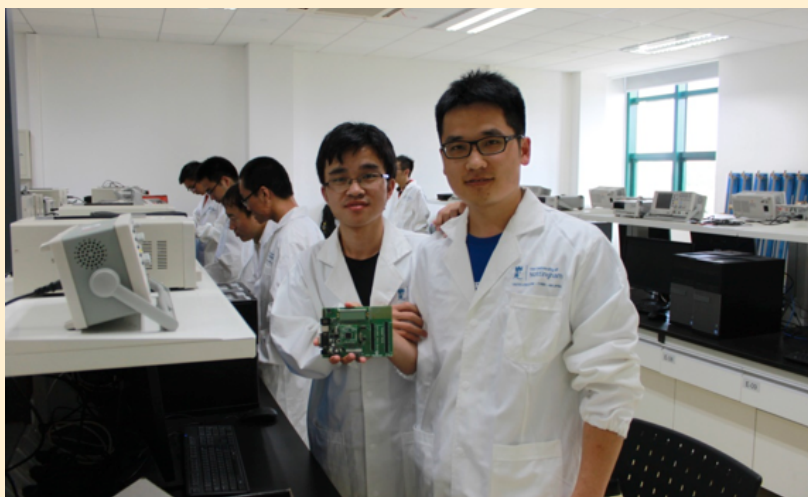
Sondrel are a privately-owned medium-sized enterprise, founded in the UK, which provides semiconductor chip design services; specifically, taking system designs and creating the manufacturing design of the actual silicon chip. Founded in 2002, they now employ 150 people globally but have plans to expand to over 250 staff in the next 24 months. More than two-thirds of their employees are based in China - including the majority of their engineering staff, and some central support functions. Their position in the value chain is as a value-add consultancy service, typically taking software designs (and sometimes specifications) of chips and providing expertise and design of the transistor-based hardware to be manufactured by a semiconductor fabricator. They are one of only a very small number of UK or European medium-sized companies which operate in this market space, the primary competitors being based in India, or the in-house capabilities of some very large integrated chip designers.

Many large multinational chip-using companies have targets for external procurement, and Sondrel benefits from being a smaller player to whom they can outsource some of their chip design work. Sondrel's primary customers are large multinationals, many of whom are US headquartered, but they also have a range of smaller customers, including China-based customers.

Rationale for operating in China

Sondrel was founded in 2002 by its current CEO, Graham Curren, and made their original investigations for operating in China in 2008. The original move was strategic, with a combination of factors driving moves to establish capability in China: 1) declining local market in Europe (which continues to decline) and growing market demand in Asia; 2) the difficulty of accessing appropriate engineering talent in Europe (and its increasing availability in China); 3) the rise of lower-cost base competition for chip design from Indian companies.

China was selected because of the perceived availability of engineering talent, because the full 'ecosystem' of semiconductor chip supply chain was available in-country, and because there was more chance of a first-mover advantage than in India, where competitors were already established. Because of reduced competition for engineering talent from other industries and areas, Xi'an was selected as the original base, rather than better known science and technology centres like Shanghai or Shenzhen.



Entering China and establishing capability

In 2008, Sondrel used a UK-based employee who was a Chinese national as their primary conduit to investigate potential opportunities for setting up an engineering base in China. On the first scouting visit, the Xi'an provincial government sent a car to pick up the Sondrel representative and took him around the local companies, as well as giving a formal presentation. The officials' openness

made the initial step relatively easy. The first office in Xi'an in 2008 was followed by a larger site in Shanghai in 2010 and an office in Shenzhen. The process of establishing capability in China was resource intensive, with the Sondrel CEO travelling to China for at least a week per month in the early years, in addition to other senior managers' trips, ultimately at least 30-40 visits over six years.

“As an SME we did pretty much everything ourselves. Step by step, with the CEO on the ground [in China] every month for probably three years.”

Sondrel CEO Graham Curren

Scaling up the availability of talent

The availability of engineering talent was a key reason for establishing capability in Xi'an - but Sondrel quickly found that they needed more specialised engineers if they were to be able to capture an increasing share of both the fast-growing Chinese domestic chip hardware design market, and be positioned to undertake work for major multinationals fabricating in China. While there were graduate engineers available, Sondrel encountered two problems: one around specialisation, and one cultural. Sondrel's work is highly specialised, utilising a range of near-bespoke design tools. It is relatively high-variety project-based work, with design specifications difficult to define in advance. The second concerned the perceived creativity of Chinese engineering graduates they encountered:

“Chinese culture and education is more tailored to bright and clever people - but is also repetitive, and very proscribed. A lot of our work isn't as straightforward as that.”

Kevin Steptoe, Sondrel VP of Engineering

They therefore decided in 2012 to collaborate with the UK's University of Nottingham campus at Ningbo, and EDA software vendor Mentor Graphics to develop a bespoke twelve-week course for graduates in the tools and techniques of chip hardware design from software specifications. Sondrel provided design input to the programme, teaching expertise from their engineer base, and a student subsidy for qualifying graduates. This programme looks to tackle both the cultural and the specialisation concerns - creating a pipeline of appropriately skilled engineers, who also have some early insight into the Sondrel way of working. 21 students graduated from the first run of the programme in 2013, and in fact, all of the 2013 and 2014 graduates were hired by Sondrel on programme completion. One hundred students have now completed the programme, with Sondrel now also recruiting Chinese nationals from UK universities to put through the Ningbo programme. As the market for talented graduate engineers tightens in Xi'an and Shanghai, securing the programme for the longer-term offers Sondrel some ability to funnel talent towards themselves, creating some stability in the pipeline they need to scale up using Chinese capability and accessing Chinese markets.

Key challenges in collaborating for innovation in China

- **Scale of upfront costs required:** a large amount of resources had to be ploughed into developing the China operations, both in terms of senior management time on the ground in China, and in travel and recruitment costs.
- **Intellectual Property:** some key US clients of Sondrel remain wary of trusting their design IP to a predominantly China-based company. This could put them at a disadvantage compared to India-based competitors. However, in general as a service provider they do not directly own the IP - they are licensing the design technology their engineers utilise, and the design outputs are owned by their clients.

- **Adjusting to Chinese business culture and innovation approach:** despite support of Chinese nationals who are Sondrel employees from the beginning, the 'unknowns of operating in China' remain a challenge: 'trying to find out anything in China is very, very hard'. This would include keeping abreast of regulations and rules, but also cultural differences in looking to 'learn to build teams of high-skilled, dedicated people' with both Chinese and British nationals – hence the attempt to use the Ningbo programme to 'smooth' that process. In addition, local Chinese clients have very different requirements compared to the western multinationals: for them 'speed of delivery is everything' and they tend to expect delivery over quality, something not natural to performance-oriented engineers, but yet still hold them responsible for any quality issues – in that way it can still feel 'a very harsh business environment'.

Support for collaborating for innovation in China

Sondrel clearly have used the support of Nottingham University in the UK and in Ningbo for the development of their graduate programme. But they have also had extensive connections with the China Britain Business Council – a business-led membership organisation in which Sondrel feel they have been able to learn from other high-growth firms who are a similar size and working in China. Sometimes they have found the overall range of public sector support options difficult to navigate – knowing which agency to approach for help and expertise on which topic. An area where they feel UK government support has been lacking in specifically is around work visas for their Chinese employees to work for a period in the UK (although they suggest this is now greatly improved).

Implications/conclusions

“We would likely not be here today if we had not made the move to expand operations and engineering in China: we wouldn't have been able to compete with the Indian firms on cost and ability to scale up, and wouldn't have grown so quickly because we couldn't have hired enough people or reached the same range of customers.”

Sondrel CEO Graham Curren

Sondrel operate in a highly-technical, fast-moving area, with huge difficulties in competing for scarce talent and against larger multinational rivals. They have entered China partly to be close to the growth market, and for cost-effective talent, but have used Chinese capability to help scale their business, innovate, and address new market opportunities. Their Chinese clients – only really accessible through their engineering capability in China – are providing new challenges for them and their mixed Chinese-UK staff.

Sondrel see this as a springboard for growth – expanding their footprint in China and looking to use it as a base for further internationalisation: 'it is ... about using the scale of the market and the availability of people to scale up. [But also...] we are learning to use those people to change how we innovate – through improved project management and processes'. Sondrel are not, for them, creating a trade-off between innovation and growth in the UK or in China – they believe the Chinese development was crucial to their ability to double their staff number in the UK as well.

3.5 TestPlant

www.testplant.com



TestPlant is a UK-based software company that provides tools for automating the process of testing software and systems for bugs, problems and performance. The company was founded in 2008 – only ten days before the collapse of Lehman Brothers triggered the global credit crunch. From this potentially inauspicious start, TestPlant still managed to gain several rounds of venture capital funding to maintain its growth trajectory, and has maintained an impressive pace of revenue growth: 1,010 per cent over five years to 2014. Its software is highly disruptive innovation in those industries and firms still using a manual approach to software testing. It employs more than 50 people in the UK. A relatively niche technology product company, TestPlant developed a growth strategy focused on international expansion early on – beginning with its largest potential market: the US. Still headquartered in the UK – with a development R&D centre in Congleton, Cheshire – they also have staff in the US and in China, and their products are currently used in over 30 countries by over 350 enterprise customers. Recent recognition of their growth includes being listed in the Deloitte UK Technology Fast 50 and Queen's Awards for Enterprise for International Trade in 2013 and 2015. The EggPlant tools – TestPlant's principal product range – incorporate several patents owned by TestPlant, with others pending.

Choosing and entering China: Establishing capability

“ Being included in the Prime Minister's official visit to China in December 2013 was the trigger to our move into this vast market.”

George Mackintosh, CEO, TestPlant

TestPlant had identified China as a potential market by 2011, with key 'reference users' for their software – global western multinationals such as Cisco, GE and SAS – all having large software development and R&D footprints in China. In 2011, TestPlant executives took part in a UKTI-organised trip to explore options and assess potential partners and collaborators. TestPlant recognised it would need a strong route to market – primarily by collaborating with a Chinese partner who was already serving those same multinational clients.

However, it was TestPlant's inclusion in the UK Prime Minister's trade mission to China in 2013 which they saw as the breakthrough, as this allowed them to raise their profile among potential Chinese partners – and allowed them to open a productive dialogue. Nonetheless they also did their own research, commissioning a firm to work on their behalf to create a shortlist of potential partners covering the right geography, size, sector reach, and with the right local connections. Even with this there was considering 'shuttle diplomacy' to be undertaken by senior TestPlant executives – with both face-to-face meetings and extensive online technology demonstrations. This process led in 2013 to the selection of HiRain as their primary partner in China – giving TestPlant access to both clients in China, and to an experienced collaborative partner for operating and innovating in China. Their new partner they found was hugely enthusiastic to help TestPlant develop new relationships with their clients in China, although on occasion TestPlant (as a much smaller business than HiRain) had to manage the different 'clock speeds' as it was used to faster sales cycles and decision-making internally.

“ Our investment in China is evident in the work carried out to create a Chinese version of EggPlant [TestPlant's main software product] and with the employment of people in China, in London with sales administrative staff and in Congleton, Cheshire in our UK software development centre.”

TestPlant

Scaling up with China

TestPlant is now looking to scale their operations in China, just as they have done in the US and Europe. But they are cautious about committing fully to an additional development centre in China. They indicate that their priority is to develop local relationships with clients through their Chinese-based partner – particularly hiring their own sales, marketing and support people, before committing to R&D staff. They feel that spreading their development capability to be based in China is only appropriate with sufficient scale and maturity: when you have access to good talent resources, with a clear cost advantage over development staff elsewhere within the more developed markets, and with a minimum of 250 employees.

TestPlant are not particularly looking for new graduates – rather they are hiring experienced staff through their local partner who have an understanding of local contexts in China. TestPlant note that high churn among talented and skilled employees is a particular concern for operating in China – one reason they have opted to operate partly through an experienced local partner. An important outcome of the development of TestPlant's relationship in China is that it has been able to enter new industries, such as automotive, and now has the potential to also expand in that sector outside of China from its track record and experience there.

Key challenges in collaborating for innovation in China

- **Understanding geographic diversity:**

TestPlant were keen to stress the importance of geographic diversity in working across China; that working with clients in Shenzhen is different in development, approach and culture to working with ones in Shanghai, Chengdu or Chongqing. Having a partner who is experienced at navigating the different contexts, provincial cultures and networks is central to being able to manage this challenge.

- **Intellectual property:** If TestPlant had strategic-level risk concerns about their IP in China – then they indicate they would not be operating there at all. But the size of the China opportunity outweighs the recognised specific potential concerns around IP. In their particular market and value chain position, TestPlant are often providing services for very high profile State-Owned Enterprises, such as the Shanghai Automotive Industry Corporation and ZTE Communications. These companies have international reputations to protect and therefore there are unlikely to be organisationally sanctioned breaches of a UK company's IP.



Support for collaborating for innovation in China

TestPlant consider the raising of their profile in China through their inclusion in the Prime Minister's showcase visit in 2013 as crucial to being able to secure an appropriate local partner. But they also noted a number of additional areas of support they received in varying degrees from public and private sector sources. These included the networking opportunities afforded by membership

and engagement with the China Britain Business Council, and the original insight into the market potential afforded by the UKTI trade mission of 2011, all of which had helped to create 'buzz, and kudos' for the firm among senior and important Chinese potential clients and partners.

George Mackintosh, CEO of TestPlant, noted particularly that the export focus of the Coalition government of 2010-2015 had been of assistance to them; that TestPlant has been fortunate to 'ride the crest of that policy' focus – but that he would like to see greater focus on Chinese partnerships for mid-sized businesses, those falling 'between the GSKs and the startups'. He feels some of these mid-sized firms would be crucial for assisting Chinese stakeholders in trusting emerging and fast-growing British businesses looking to innovate in China.

Implications/conclusions

TestPlant's approach to innovating with China has been an extension of their broader internationalisation strategy. The main element was collaborating through clients and partners – this helps to diversify the risk and give a solid platform for them to operate. They needed to source a partner with both the capability to sell the product, but also to reliably deliver the services, in a way that was sensitive to the local context. Many of the largest western firms who were TestPlant's clients in China were looking for stability and reliability. While the Chinese partners were looking for TestPlant to operate in new ways and provide innovations for their clients, in general they were more cautious than the more risky 'bleeding edge' that Silicon Valley clients might demand.

Central to innovating with China was creating the quality of reputation and profile (for what remains a relatively-small UK business) which could attract the trust of a Chinese partner with the market access. This allowed TestPlant to scale up into new industries, such as automotive in China.

3.6 Strategies for collaborating for innovation with China

Looking across the experiences of the firms, it is clear that each was entering into partnership in China for subtly different reasons – and often looking for different results from the collaboration. Table 1 below summarises the kind of partnership each created, their purpose for seeking to collaborate with China, and the primary result they have achieved to-date.

Table 1: Summarising the partnership approaches of the five firms

Company	Industry	Partnership type	Primary purpose for collaborating with China	Main results from partnering for innovation in China
 CrystecPharma	Pharmaceuticals	Contractual: Has operations in China drawing on scientific expertise of university sites	<ul style="list-style-type: none"> • Extending capability to service larger clients • Leveraging Chinese investment in science to scale 	<ul style="list-style-type: none"> • Ability to provide service to clients globally at scale and technological sophistication required. • Access to talent pool, and capital investment for specialised equipment
 DYNEX	High-power throughput semi-conductors	Ownership - Chinese parent	<ul style="list-style-type: none"> • Access to capital and important clients • To improve scale of deployment of technology 	<ul style="list-style-type: none"> • Enhanced R&D scale in UK and China • Access for products to huge and growing Chinese markets
 GreenBiologics	Biotechnology	Contractual, some joint venture with companies (including state-owned) with large processing plants	<ul style="list-style-type: none"> • Originally, to see commercial returns from activities. Pivoted to leveraging Chinese investment proof of the commercial potential of their technology 	<ul style="list-style-type: none"> • Proof of commercial scalability of technology for sale into global markets
 sondrel Success through partnership	Chip design	With Chinese universities to improve talent access	<ul style="list-style-type: none"> • Access to engineering talent, and new markets 	<ul style="list-style-type: none"> • Scale of expert resource to deliver for clients
 TestPlant	Software	Contractual, for market access into new industrial sectors	<ul style="list-style-type: none"> • Exposure to high-growth new markets and sectors • Scaling product 	<ul style="list-style-type: none"> • New expertise in servicing important sectors: can now provide globally

Analysing the experiences of the five companies in the round, a range of central issues emerge, covering the strategy, structure and value models of the partnerships, as well as illustrating some of the recurring challenges faced in making those partnerships successful, and the way in which they tapped into Chinese innovation capabilities and leveraged those capabilities.

3.6.1 Strategy

Firms are looking to partners for innovation in China for a variety of (sometimes overlapping) reasons: overcoming talent shortages, accessing new high-growth markets, accessing suppliers and partners with considerable prototyping and speed-to-market capabilities, and drawing on new sources of capital for expansion.

For example, Sondrel's approach combined three elements: the need to address the growing Chinese domestic market, to be closer to major western chip manufacturing firms who were often now manufacturing in China, and, primarily, accessing talent through their firm-specific university course partnership in China. They provide bespoke chip designs, and entered the market largely with their already-strong UK design capability, but have been able to harness Chinese capability to scale that capability through access to Chinese talent, local markets, and being close to the innovation happening among western chip manufacturers based in China.

Green Biologics' strategy was to look to China for proof-of-concept for their technology at commercial scale. They drew on existing investments in plant and capability that China had made – their original strategy being to create revenue directly from the Chinese domestic market, and to demonstrate the commercial level of their proprietary technology.

None of the companies analysed here had entered China purely to export standardised products or services, or to access low-cost manufacturing labour.

3.6.2 Partnerships

Although all companies examined for this report had looked to develop or scale an innovation with China, a variety of partnership models and structures were deployed to achieve those goals, including: ownership, subsidiary structures, contract-based partnerships, open innovation collaborations, and sponsorship.

For example, TestPlant looked to partner in China to deploy their innovative software testing technology in new markets. Their relationship with their partner, HiRain, was an explicit attempt to leverage their innovative technology into new sectors through their partner's experience in sectors in which TestPlant's core product had not yet been deployed. Green Biologics were looking for partners with which they could act either as joint venture partners or consultants in order to prove their technology was viable at a commercial scale in the Chinese market.

This strongly suggests that there is no one required structure of partnership for achieving success. It is more about considering what complementary innovation capabilities a firm is seeking to harness by collaborating with China, and ensuring that the partnership structure provides the maximum opportunity to leverage that capability. A partnership structure that retains some flexibility in how a firm can realise value – for example, being able to switch to a value model through globally-recognised proof that a technology works at scale rather than a direct revenue model – also appears important.

3.6.3 Challenges

The challenges the companies faced throughout the process of developing a partnership in China and realising value from it should not be understated. Each faced considerable risk in deciding to partner for innovation with China, in sourcing a partner who would have to be trusted with the joint development of major areas of their business, and in realising value from the partnership. For most of the firms, the decision to partner with China was an organisation-level strategic risk: the failure of the innovation collaboration with China could have brought down the company. Within the range of risks faced by the companies, the following challenges were recurring across the different firms:

- **Intellectual Property** – The majority of cases adopted a cautious but pragmatic approach to IP, predominantly trying to manage the risks strategically through careful planning, rather than by relying on formal legal protections which they would need to enforce in the event of a breach. A good example is Crystec Pharma's separating of the core elements of their proprietary process to be processed by two different laboratories in China, with them integrating the final product, to ensure that neither Chinese-based lab had access to the full process know-how of the technology.
- **Culture clashes** – Differences in management style of Chinese and UK staff each presented occasional difficulties for the leadership of the UK firms, as did understanding and anticipating how some decision-making processes worked within Chinese operations and within Chinese markets. For example, Dynex's integration of R&D and sales and marketing functions – now both headed by Chinese nationals based in the UK – has required considerable adjustment around management styles and approaches. Green Biologics' collaboration with a range of state-owned plants for biofuel fermentation required considerable patience, despite their local partner knowledge, as decisions taken about the future of the plants' operation often remained difficult to discern or to gain information about.
- **Legal issues** – Recurring challenges here included navigating Chinese employment law when recruiting, and processes for accessing public sector business support in China. Another repeated legal issue across the cases concerned visas and immigration, and the inflexible approach of the UK government to employee exchanges and extended partnership visits. For example, Sondrel needed considerable expertise in Chinese HR to be able to recruit a new workforce from their specially trained university programme in chip design – and particularly to hold on to those skilled engineers once they were in place. And Dynex, looking to place Chinese nationals in senior and other R&D positions in their UK operations, has struggled with gaining suitable visas, despite excellent connections.

3.6.4 Chinese innovation capabilities accessed

The firms utilised a variety of Chinese capabilities and capacities to develop and scale their innovations through their partnership, including leveraging existing Chinese investment to trial and scale technology, accessing talent which was hard to reach in the UK, and the ability of their partner to increase the pace of innovation prototyping and market testing. For example, Dynex has been able to test their newer products within the Chinese context, safe in the knowledge that their Chinese partner is comfortable it has the repair and recovery capacity to quickly assess and rectify any product issues in the market as an alternative to exhaustive pre-market testing.

TestPlant has leveraged the scale of the Chinese domestic market to access new sectors in the Chinese market through their partner, and Green Biologics utilised considerable existing Chinese investment in biofuels processing plants which were performing poorly, to provide technology know-how to ensure the plants are successful, and demonstrate at scale the viability of Green Biologics' technology.

3.6.5 Leveraging Chinese innovation capabilities

As the partnerships for innovation with China developed, several of the companies also shifted how they looked to extract value from the partnership, including moving to a different business model or partnership structure, balancing and rebalancing the partnership between UK and Chinese operations as the markets shifted around them, and using their experiences and development in China to access global markets.

For example, Green Biologics originally focused on extracting value from profitable Chinese biofuel processing plants deploying their technology, but later switched to using Chinese sites as a proving ground to allowing them to sell their technology globally – and particularly in the United States, as they were the only company that had successfully operated their technology at sufficient commercial scale, thanks to their Chinese operations.

4 LEARNING TO SCALE BY PARTNERING FOR INNOVATION IN CHINA

This report has sought to describe some of the interesting ways in which UK firms are collaborating for innovation with China. In particular, it looked at the experiences of UK firms in seeking to harness the later stages of the commercialisation chain by collaborating with China: entering Chinese collaborations at the stage of proof of concept or later, and then attempting to scale their technologies, IP or innovation through collaborating in China, and leveraging this to compete in markets across the globe.

The four main conclusions from analysis of the companies' experiences are:

- 1. Despite the clear risks, there are opportunities for smaller UK firms to collaborate for innovation in China: all the companies we studied had succeeded – in different ways – in harnessing elements of China's commercialisation engine.**

For several of the firms they have been able to scale their innovation through accessing complementary Chinese innovation capabilities so that they are now in a better position to sell into global markets – not just in China. They are doing so through using partnership to access high-level, hard to source technical abilities; through using China's markets as a test site for products in new sectors; through leveraging Chinese investment to provide proof of concept for their technology, and through using the scale of production and resource available in China to address global markets.

Even those such as TestPlant, whose original strategy for entering China was focused on accessing Chinese markets, are now better able to serve Western firms because they have been able to leverage their China partnership to enter new sectors outside China.

For some of the firms, growth through their innovation partnership with China has been the crucial competitive advantage which has allowed them to remain in business. Improved collaboration for innovation with China – and the take up of the opportunity by a wider range of UK organisations – therefore can be one part of the solution to the problem of the UK's middling record of scaling innovative companies.

- 2. There's no one model for success when developing a partnership in China for scaling an innovation: the important element was to structure a collaboration that gave the UK company access to the required complementary Chinese innovation capabilities. But most do seem to go through the same steps in the process of scaling an innovation – even though they may join and exit that process with China at different points.**

The companies in this report indicate that different kinds of structural models can be deployed successfully, with – from a small sample – no clear patterns of relationship between structures such as JVs, contracts, and subsidiary ownership and scaling success. The key appears to be ensuring your chosen model gives you suitable access to the complementary capabilities needed to scale – and being prepared to switch structures as the partnership develops.

Different Chinese capabilities are being utilised at different points in the commercialisation chain model – science and technology talent for joint R&D phases, existing Chinese capital investment for proof-of-concept stages, prototyping and speed to market for scaling innovations, and market access and scale for the rollout stages.

3. Major investments of senior executive time and other resources are required to develop a successful partnership, and it is complex and challenging to maintain it effectively in order to realise value. This means smaller firms are likely to need to focus on partnering in China as the primary strategy for innovation-led growth, rather than as one of a number of simultaneous international partnerships for innovation.

For four of the five companies, partnering for innovation in China was their main strategic approach: it involved deciding to partner at the expense of, for example, trying to develop the same capabilities only in the UK, or seeking to collaborate internationally in a serious partnership elsewhere such as India. TestPlant were able to pursue expansion in multiple international jurisdictions, but they were the example among the companies who were seeking to collaborate in China further down the chain with a more commercialised existing product: the other four, partnering further up the commercialisation chain, all took a China-centred approach.

The China focus seems necessary to ensure: that sufficient scarce resource can be targeted on creating the partnership and making it work; being able to navigate the serious remaining risks around issues such as IP, as well as the more-than-occasional difficulty of discerning what's going on in particular Chinese business contexts. While this report doesn't compare directly against companies with more 'standard' export or supply contracts in China, it appears that the lead times to develop working partnership relationships and undertake effective operations may be longer for innovation-focused partnerships.

The role of prior personal connections was a feature in several examples: Dynex's leverage through their CEO's name-recognition from an engineering textbook, Crystec's existing partnerships further up the commercialisation chain in the areas of applied research with Chinese universities, and Green Biologics' connection with a key technology expert in China looking to spread their type of technology in existing Chinese plants.

4. Smaller firms can benefit from a range of government support in developing their partnerships – and that support is welcome when provided. It seems particularly important that it is available in a relatively co-ordinated set of measures across support for innovative operation in the UK, support for operating internationally, and access to support in China – including from the Chinese government.

While the effectiveness of government support programmes was not a core focus of this report, nonetheless the companies in their innovation collaboration tended to have accessed a range of different types of public sector support.

Particularly noticeable was the mix of different types of support that were drawn on. This ranged across: support for innovation being done in the UK but with China; support for operating internationally, such as export support and visas; support within China, such as access to HR and legal expertise, but also to local Chinese investment and taxation support for R&D and innovation.

For example, Dynex sees UK government support through R&D grants through Innovate UK and the Regional Development Authority – and local political engagement – as highly important in signalling to their Chinese partners that they are appropriate for considerable investment. TestPlant and Dynex both considered high-profile politician-led trade missions to be important for their credibility with potential partners. Crystec Pharma was able to access Chinese local government support through its investments in R&D capability in China. Green Biologics, TestPlant and Crystec each noted they had drawn on the support of introduction services to assist match-making in China provided by UKTI, the China Britain Business Council or similar publicly funded programmes. Most of the firms benefitted from broader UK innovation policy such as R&D tax credits.

The focus on tracing the in-depth experience of a small number of illustrative companies in this report means it will not suggest recommendations as 'rules' for all UK SMEs. However, a number of implications and recommendations can be drawn from the analysis for both UK SME leaders considering scaling their innovation in partnership with China, and for policymakers seeking to support those SMEs' efforts.

4.1 Recommendations for SMEs looking to scale their innovation with China

China is a potentially powerful international partner to scale UK innovation – and its capabilities can be harnessed through a variety of different strategies. UK firms need to carefully consider the specific Chinese capabilities they want to access and how these can be efficiently harnessed. This is likely to involve multiple strategies as a collaboration is considered, developed, and value is realised from it. UK SMEs therefore should:

Pre-China planning:

- Understand what kind of innovative capability needs to be accessed in China, and at what points along the chain of commercialisation.
- Consider what support could be beneficial in seeking and gaining a suitable partner – from both the UK and Chinese governments.
- Have completed the prior market intelligence work needed to identify China as the primary innovation partner – resource constraints are likely to require a total focus on that partnership rather than pursuing multiple innovation partnerships simultaneously.
- Develop a full plan for the resourcing required to source, establish and maintain the partnership – such a partnership is not likely to be successive as a ‘nice-to-have’ addition to international activities.

Sourcing appropriate information and support in advance:

- Detailed research to understand firms, clusters and provinces in China with specific expertise and capabilities.
- Become aware of the range of support programmes and policies on offer and how to access them appropriately, including:
 - Introduction and match-making services, including integrated programmes for developing partnership with Chinese firms in particular provinces.
 - Tax relief for R&D investment in the UK and in China.
 - Direct support through travel grants on trade missions.
 - On-the-ground support in China around legal, IP and human resource expertise.
 - Innovation grants from the UK agencies for collaborative innovation activities.
 - Existing resources around case studies, guides and networks from those who have already sought to achieve such partnerships.

Developing the partnership, and considering how to extract value from the partnership on an ongoing basis:

- Understand the legal and practical requirements for establishing a presence in China and hiring local staff in order to manage the collaboration through the scale-up phases.
- Encourage Chinese partners to invest capital in the venture through an equity stake to maintain buy-in on both sides and give greater resources to scale an innovation.
- Put in place channels for on-going exchange and joint working between operations located in both the UK and China.
- Seek to involve Chinese customers as well as innovation and investment partners.
- Leverage the results of initial proof of concept at commercial scale in China in other global markets.
- Be very flexible in evolving their partnership strategy – including looking to shift business model and the type of value gained from the partnership if necessary.

Seek to mitigate potential challenges, particularly:

- Invest the time to understand in some detail the operations of your partners, their connections and their way of doing business.
- Acknowledge the potentially difficult process of developing shared approaches to management of staff in China.
- Accept the probable need to invest in the Chinese partners by sharing technology and training their staff with consequent, but controlled, exposure of IP and trade secrets.
- Taking a fairly pragmatic view of issues like IP, while looking for practical work-arounds to circumvent and manage the risk rather than relying solely on IPR protection and enforcement. Approaches to managing such risk strategically, rather than accepting the operational risk, might include:
 - Cross-licencing.
 - Up-front agreements on how to share markets for joint innovations internationally.
 - Compartmentalising proprietary versus shared technology.
 - Reciprocal obligations to share subsequent innovations or incremental improvements.⁵⁶
 - Ensuring the Chinese partner has sufficient market influence and brand equity to deter other Chinese market participants from infringing, or the partner appropriating the technology themselves.

4.2 Recommendations for policymakers seeking to improve UK-China SME partnerships for innovation

For every successful collaboration, like the ones studied in this report, it's hard to know how many unsuccessful collaborations with China there have been, or indeed the opportunity cost of others avoiding engagement entirely. An innovation policy expert group set up by the Department of Business, Innovation and Skills has been analysing these issues over the last year. Based on various discussions, including a workshop with business innovators, policy-makers, venture capital providers, science parks and incubators, they found that the three most important market failures that impede successful UK-China collaboration on innovation and commercialisation of new ideas and technologies are:

- High 'search costs' that stand in the way of potential UK and Chinese collaboration partners quickly and economically identifying and engaging with each other;
- High fixed costs of establishing the legal entities and infrastructure necessary for reliably financing and managing innovation collaborations between UK-Chinese partners (especially relative to the resources available to small and medium-sized firms);
- Difficulty in effectively and efficiently mitigating intellectual property risks.

One response to these challenges on behalf of government might be to try and scale up the amount of direct, tailored support for innovative companies looking to scale their innovations in China. However, an interesting insight from the case studies we looked at was the wide range of ways their collaborations had benefitted from public support. Sometimes these were direct, like trade missions and government promotion of sectors and individual firms, in other cases these were far more indirect, like longer term bridge-building between regions and universities. Designing an approach to public support, which is both cost-effective and has a measurable impact, is a significant challenge for policymakers. We recommend the following as a guide for future approaches:

- BIS should explicitly broaden the current focus of policy support to include all the stages of the commercialisation of innovation process: basic and applied research, proof-of-concept, piloting, scale-up, and Chinese or global market rollout, with greater emphasis on the latter stages where many of the largest economic benefits are to be gained.

- UKTI, BIS and the China Britain Business Council should all target policy toward addressing the most significant barriers that stand in the way of SMEs harnessing China's commercialisation engine: high search costs of finding suitable partners, difficulties in accessing existing pools of knowledge about how best to set up collaboration with China, and managing potential risks of intellectual property leakage.
- BIS, UKTI, with the support of the Foreign Office through the Prosperity Funds should develop a more conscious strategy linking public support for innovation collaboration within the UK (e.g. investment tax incentives, EU funds, soft-landing incubators), between countries (e.g. trade missions, workshops, exchange programmes and visa conditions) and in China (policy influence, diplomatic and political support).
- BIS and other funding agencies, including regional government should continue to experiment with – but also improve the evaluation of – support for intermediaries (including science parks, incubators, venture and angel networks, online match-making platforms, and integrated sectoral initiatives – such as the Lancaster University China Catalyst Programme) as a route to cost-effective support for innovation collaboration.
- The Chinese and UK governments should work together to improve the access to, and quality of, knowledge on how to effectively collaborate with China on innovation – to help reduce the upfront costs for small firms. This could include stronger case studies, clearer signposting of the multiple routes for support, the establishing of relevant 'advisory panels' on key issues, and the promotion of strong examples of collaboration including the lessons learned from less-successful experiences.

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London EC4A 1DE

research@nesta.org.uk

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