The technology company development journey – from concept to commercialisation

Iain Inglis, Scottish Enterprise
Kenny Richmond, Scottish Enterprise

Introduction

It is widely recognised that Scotland has competitive advantage in key areas of science and technology within its research and company base. However, the nation performs relatively poorly in terms of numbers of active entrepreneurs, business start-ups and creation of high-growth technology businesses within knowledge intensive industries. Scotland needs to rapidly commercialise those technologies where there is both a strong market opportunity and an ambition to create or grow a company of scale. The Scottish Government's Economic Strategy (Scottish Government, 2011) highlights the role that commercialisation can play in contributing to economic growth and Scottish Enterprise (SE) has built a clear strategic commitment to commercialisation: developing and investing in a number of initiatives and programmes to support the conversion of science and technology based ideas into products or services which deliver value to a particular market.

With the ambition of converting the country's wealth of research assets into economic assets, a better understanding of the mechanics and transitions by which technology based ideas are transformed into marketable goods and services across the 'concept to commercialisation' paradigm is key to improving success rates and economic benefits for Scotland. This paper sets out the key findings from primary research that gives a unique insight into the experience of 32 companies that have been supported by SE. The research evidence highlights the challenges involved in the commercialisation process and path to market for Scottish-based technology companies, whose origins may be existing technology businesses, university spin-outs or start-up companies, and is the first in-depth analysis of its kind in Scotland.

Commercialisation and economic growth

Policy makers have long recognised the contribution of commercialisation (defined as the conversion of ideas into successful commercial ventures) to economic growth and productivity improvement. Where technological innovation (most commonly comprising incremental change within existing industries) is critical to long-term economic growth, transformational economic growth can occur only with the introduction of truly new goods and services, i.e. radical technological innovations that disrupt markets and create new industries.

Few relationships are more broadly supported by both theory and empirical evidence than successfully exploited technological innovation and sustained economic growth; and yet until around 20 years ago economists focussed little on the process by which ideas are transformed into new products and services, or how new industries and sectors of economic activity are formed and develop.

While the process through which a scientific or technological idea with potential commercial value is successfully converted into marketable products and/or services is highly complex (a complexity catalysed more recently by rapid advances across scientific frontiers), understanding the concept-to-commercialisation transition is essential in the formulation of both business strategy and public policy.

> *"You can have the best technology in the world, but for successful commercial implementation the essential focus has to be delivering innovative, on-time and cost effective solutions the market requires"*
>
> *- Des Gibson, Chairman & CEO, Gas Sensing Solutions*
> *(The Royal Society of Scotland: Science Scotland. Issue 12 Spring 2012)*

Looking at the nation's assets, from a technology perspective Scotland's research base has a good track record of producing outputs with global recognition. The Royal Society of Edinburgh (2012), however, highlight that Scotland has a less convincing record of 'commercialising these at the speed and scale necessary to translate them into internationally compelling propositions'.

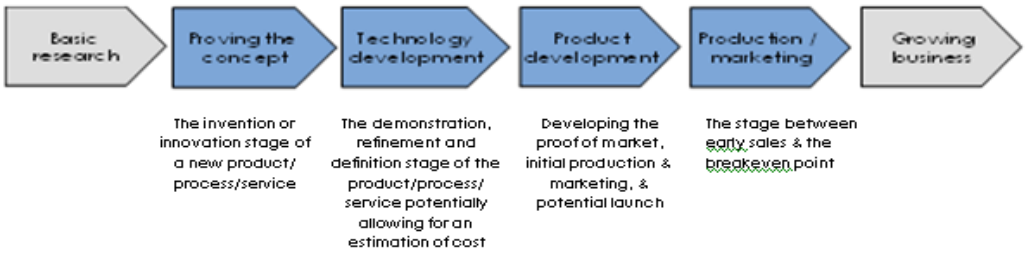
The commercialisation process

As part of the aim to improve Scotland's commercialisation performance, SE undertook a strategic review of its commercialisation activity spanning the period 2004-2008 (SE, 2009). A follow-up review (via face-to-face interviews with 32 SE supported beneficiary companies over the period 2008 to 2011) was published in 2012 (SE, 2012) and identified a number of key findings in establishing critical success factors in the journey to successful commercialisation, including:

- the need to build strong commercially focussed management and leadership teams who can establish route to market early in the process and who show ambition to sell in to international markets;
- the importance of an outward looking perspective and the need to build strong competitive positions by establishing new connections and building relationships with universities, customers, competitors, as well as via widening supplier relationships; and
- the importance of access to finance when time to product launch is increasingly critical but where companies are taking longer to get to market and at greater cost; though successful companies are getting better at attracting new sources of finance and support from outside Scotland.

The research exercise adopted the 'Branscomb Model' (see Figure 1) as the framework for conceptualising the company 'journey', allowing a mapping of company development from 'basic research' through to a 'growing business' across four key stages (Branscomb and Auerswald, 2002). While it is recognised that this framework represents an idealised view of technology progression (i.e. in reality the journey is often neither a linear process nor easily phased), the model includes multiple parallel streams and iterative loops making the approach a readily understood concept with which to engage businesses.

Figure 1: The Branscomb Model



The characteristics of the survey sample, according to technology development stage and trading position at the time of interview, are summarised in Table 1 below:

Table 1: Company characteristics

Company Characteristics			Branscomb Stage	
Sample size	32		Proving the Concept	3%
Origin	44% spin outs		Technology Development	22%
Status	91% limited company		Product Development	22%
Sector	44% enabling technology* 41% life sciences		Production/Marketing	31%
Trading status	34% pre-revenue		Growing Business	22%

* *defined as technologies that can be applied across more than one sector, such as electronics, high-value manufacturing, advanced materials, digital technologies, photonics and sensors, etc.*

In an attempt to better understand this complex and important area of government policy, the remainder of this paper draws on the research study findings and outlines the key enablers and blockers to successful commercialisation, considers policy implications and identifies future research activity.

As the recession and anaemic recovery has taken its toll businesses are taking longer to get to market, are finding time to product launch becoming more critical and that it is costing more, though they are getting better at attracting new sources of finance and support from outside Scotland

Development time to get to market is lengthening

A common difficulty cited by companies across each of the development stages was 'time to completion', with the evidence suggesting it is now taking an average of 5 years (60 months) to get to market from the initial 'proving of concept', 4-5 months longer than the sample of companies were reporting pre-recession. These findings mirror the company experience across other economies, with the time taken for a company to go from initial investment to IPO lengthening around the world since 2000, correlating strongly with conditions in the wider macro economy: the average time to flotation during the highs of the dotcom boom was around 3 years before increasing to 5-6 years in the aftermath of the dot com crash and lengthening further to historic average highs of 7+ years (NESTA, 2010).

From a sectoral perspective, as would be expected, companies in the 'enabling technology' field were slightly quicker through all commercialisation stages than those in 'life sciences', due to the less human-focussed element and the need for regulatory approval. This is similar to findings of other research studies (Nesta, 2010). When disaggregating the results by business origin, spin-outs indicated a shorter 'product development' stage (9 months vs 13 months across the sample), possibly due to the amount of early-stage development that occurs within a spin-out prior to company launch.

Current challenges facing companies affecting stage length are, in order of importance:

- difficulty in raising finance (which is having a negative effect on cash flow, and, therefore, product/service development timescales, and while equity finance is accessible it is taking time to negotiate);
- commercial skills gaps (specifically during 'product development' and 'production/marketing' stages which acts to slow down products getting to market and in some cases resulting in staggered product launch);
- technical uncertainty (increasing duration of the 'product development' stage);
- technology skills gaps (increasing duration of early stage 'technology development' and 'product development' stages);
- sales cycles taking longer than anticipated (mainly via establishing the sales process and setting up distribution channels);
- regulatory approval taking longer than anticipated; and
- difficulty in finding partners/collaborators to support product development.

And as a result it is costing more

An increase in stage length is negatively affecting a number of companies who are either running out of money or having to spend more time than the pre-recession sample sourcing investment to the detriment of other business priorities. It is encouraging, however, to note that the companies appear to be raising the finance required (even if they are working harder for it and it is taking longer to source) suggesting well developed investor-ready propositions.

From an absolute perspective, companies are needing more money to get to market and are funding this in various ways: median costs are indicated to have risen by around 20% to £920,000 since the financial crisis, though it is acknowledged this finding is influenced by the mix of sectors supported (the sample contains a number of life science companies and spin-outs that have the potential to achieve a scale of impact but which require higher development costs).

Disaggregating the proportion of expenditure by the respective development stages highlights clear peaks at the 'product development' and 'growing business' stages: at 6%, 16%, 34%, 7%, 37%. Sitting behind

these averages is clear industry variation, e.g. technology development costs for software businesses is close to nil versus around 13% for the bio-pharmaceutical industry.

In terms of use of funding, typically around 60% of expenditure goes to labour input vs 40% for development and running costs. Comparing to studies undertaken in other geographies (Booz Allen Hamilton, 2003; Auerswald et al, 2005), the proportion of expenditure at 'product development' by these Scottish companies is a significantly lower proportion, indicating a better balance across the stages and a likely ability to use resources more efficiently, a valuable skill in today's business environment. The downside to this, however, is the 'drip-feed' nature of early-stage funding for potential high-growth businesses means they often find themselves in the resource consuming process of actively seeking the next capital injection which is to the detriment of the development of the business itself.

With companies funding finance requirements in a variety of ways with public sector support remaining crucial and with sources beyond Scotland being accessed

A wealth of research highlights the complexity and scale of the financial architecture required to support the journey to commercialisation, particularly those engaging in novel applications that are inherently risky ventures for potential investors (see for example Technology Strategy Board, 2011). As a result of the changing financial climate, and the associated increased costs involved in securing funding, companies are using a different mix of investment and sources of finance to develop and grow.

In terms of scale, early-stage technology companies often require large up-front capital injections with regular follow-on tranches of investment. On account of holding intangible assets rather than tangible collateral, and with a likely lengthy lead time to revenue generation, finance is typically hard to obtain from conventional debt financing sources.

The champions of early-stage technology projects identified as part of this research are making use of a wide variety of funding options such as angel networks and venture capital finance. Further, as funding tightens across the domestic public sector, successful companies are seeking support beyond Scotland to UK and European sources, via for example the Technology Strategy Board (TSB), the Department for Business, Innovation and Skills (BIS), the Department for Energy and Climate Change (DECC), the National Institute for Health (NIH) and the NHS in order to help fill funding gaps.

The importance of public sector investment (which acts to provide direct support and help create the necessary conditions to attract private investment) can be seen in the mix of funding available such as co-investment with private funds (both venture capital and angel financing) and the uptake of 'bridging' funding vehicles to facilitate external private investments in early-stage businesses. Other research has highlighted that whereas public funds hardly featured during the dotcom era, they now they participate in around 40% of all venture capital deals and 55% of all early-stage deals (NESTA, 2010).

Figure 2 sets out the mix of investment and finance sources used to grow and develop the SE supported businesses, disaggregating total financial contribution by source and distribution of spend according to Branscomb stage and with the majority of spend denoted within the shaded areas. From this it is clear that:

- *private (equity) sector* investment – contributed around 45% across the stages. At any point 45%-70% of businesses are using this type of funding, peaking at the 'product development' stage
  - more life sciences than enabling technologies companies accessed private investment, possibly explained by the higher development costs associated with life science activity
  - spin-out companies accessed less private finance at early-stages of development than non-spin outs, but on reaching 'production/marketing' this situation reversed, possibly because of the earlier support within a university environment and comparatively low running costs when located within a university;

- *public sector* support contributed around 30% of total funding requirements with the majority of monies accessed at an early stage. While often unmatched by private sector funding during the 'proving the concept' stage, by early stage 'technology development' public sector funding becomes 100% match funded (60% by the private sector and 40% with

company/own money). Around 90% of businesses access public sector funding by the 'technology development' stage*;*

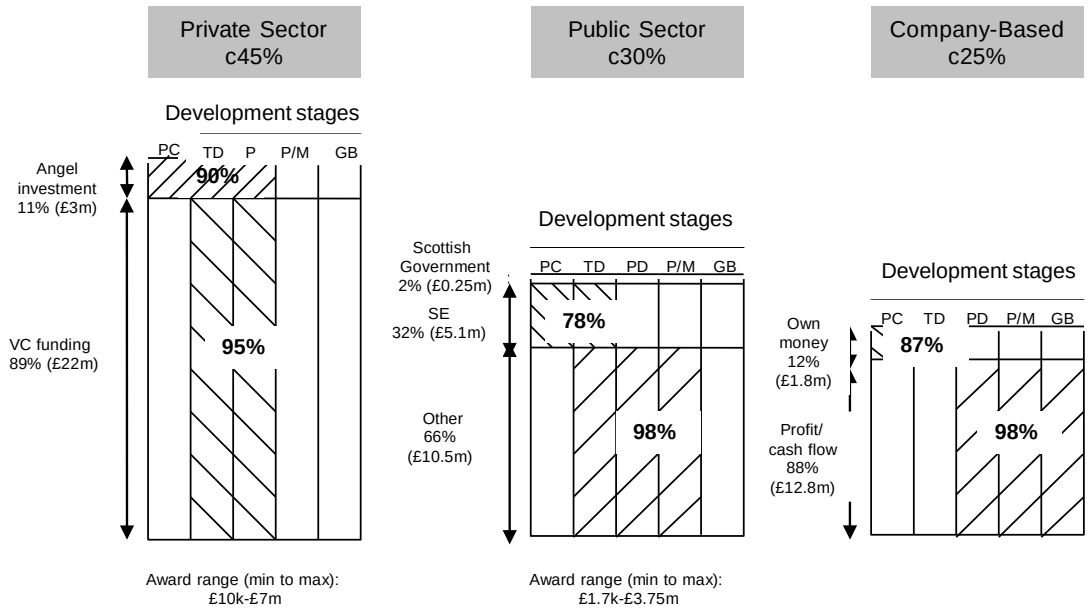
- the proportion of *company own finance* reinvested in the business, at close to 25%, increases as companies move towards the 'growing business' stage as they begin generating sales, undertaking contract work and generating income from licenses;

- companies are funding future plans from their *own cash* at the early stages of the development journey, used by around 60% of businesses during the 'proving the concept stage', which falls to around 1 in 8 of businesses by the 'growing business' stage;

- no companies in the sample accessed *bank* funding with many having been turned down for general bank finance.

Despite the increased cost requirements highlighted earlier, the effects of the financial climate and the resulting changing focus of risk capital markets, the key message from this research is that in spite of the difficulty experienced in raising funding and the resource-intensive nature of doing so, SE supported businesses are developing sufficiently attractive investor-ready propositions and that funding requirements are being met.

Figure 2: disaggregation of overall financial contribution to project funding



Companies are building strong management and leadership teams, focussing on their human capital in order to address key skills gaps and identifying route(s)-to-market early in the process

The research highlighted a series of inter-connected critical success factors that include:

- *management team experience*: requiring individuals with a track record of product development, planning for success and successful execution of commercialisation plans in order to plot a course through the development process and anticipate potential hurdles on the journey to market;
- *human capital & capability*: ensuring that the right stock of knowledge exists across the business to enable it to participate effectively in the marketplace;
- *market focus* as opposed to technology focus: focusing on route(s)-to-market from early-stage 'technology development' and the ability to execute early sales which gives both credibility to the company and confidence to the sales team.

The role of effective leadership

Developing investor-ready propositions at the earliest stage is a key component in the development of a successful technology business, where chances of success are closely correlated to the commercial experience of the management team. An increased commercial focus ensures the ability to build a stronger competitive position by identifying company priorities, assessing capabilities, defining potential performance gaps and determining investment requirements at the earliest stage. The ability to recognise the importance of identifying route-to-market and the value of export markets from the outset ensures positioning of the business to overcome the hurdles to be faced and sets it on the course towards successful product/service exploitation.

Expansion of leadership teams and/or teams with improved capability is a key theme, with the sample of companies clearly focussing on management team capability at an early stage (80% of management teams have a track record of starting businesses and 40% of businesses are committed to formal training to strengthen skills and fill gaps, such as understanding of intellectual property, marketing, market research and sales).

University spin-outs were more likely to undertake management training (around 95%) compared to start-ups (around 75%). A higher proportion of spin-outs also sought support to build their management team (circa 40% compared to circa 25%). This greater need for training and support in spin-outs businesses allies with the perception that the majority of senior management teams originate from a non-commercial background. The high level of training is evidence of progressive, learning organisations that understand this need and are acting to create sustainable businesses.

Stock of human capital

Human capital reflects a large part of the stock of knowledge and capability within a business (defined as the knowledge, skills, behaviours and commitment of employees), and is a key input to innovation, where skill levels are often used as a measure of the quality of labour input. Acting as one dimension of a firm's intangible assets, these elements are key differentiators in building the organisational capability that supports execution of the commercialisation plan (Robinson and Sexton, 1994). The Technology Strategy Board (2010) asserts that a diverse range of skills 'from market analysis to technology development, and from intellectual property management to business modelling' are required, but that it is inherently difficult for businesses developing disruptive technologies to appoint an experienced workforce with these associated skills.

Across the development stages, the research identified a number of key themes:

- skills barriers peaked during 'production/marketing' with 60% of companies citing barriers/shortages, with barriers also at the 'product development' and 'growing business' stages acting as a brake and contributing to increased stage length;
- technology skills gaps are evident during early stage 'technology development' and the 'product development' stage, while sales and marketing skills gaps are also recognised throughout the development process, peaking at the 'product development' and 'production/marketing' stages and again acting to slow the time it takes for products to get to market;
- the use of private sector consultants to fill skills gaps across all stages is used widely, peaking at 45% of businesses at the 'production marketing' stage and 40% during the 'growing business' stage.

Examples of specific skills gaps cited include:

- sufficiently experienced and skilled design engineers or lead scientists (affecting all development stages);
- engineering graduates with industry/practical experience;
- graduates with good technical skills; and
- sales, marketing and business development skills (cited from early in the development cycle, often as early as 'technology development').

In the short term, as businesses progress to develop a portfolio of products/services, gaps may remain through companies having insufficient finance to recruit the right calibre of individual full-time or being

unable to source personnel within the product development timescales. The expansion of business and technical networks, and specifically the increased links with universities, has the potential to minimise such gaps. Further, in the medium-to-longer term, businesses stated that they expected commercial skills gaps to narrow.

Early market focus

There is clear evidence from the research that companies are focusing on understanding preferred route(s)-to-market at an early stage in company development. Developing a clear route to market is essential for the commercialisation of any new product/service and is identified as a key element in the ecosystem for successful businesses, whether the most complex and expensive 'develop, manufacture, sell' option or lower-cost, lower-risk licensing agreements or distribution partnerships. It is a complicated, resource intensive process to set up and get right requiring an understanding of the hurdles to be overcome, such as barriers to entry and growth opportunities in target markets, patenting costs, regulatory compliance and national/regional procurement regulations. Selling a product directly to the market requires appropriate skills in branding, design and marketing, while selling in overseas markets requires additional patent protection as well as an understanding of export and distribution costs.

A high proportion of companies surveyed cited engagement with Scottish Development International (SDI) from an early stage. This aligns with the idea of an earlier market focus, and in particular export market development, where companies were using SDI for trade missions, exploring the market and helping develop future distribution channels.

An increased focus on accessing overseas markets highlights improved strategic thinking. The benefits of exporting to a wide range of markets (commonly) include a greater probability of survival and financial performance, as well as enabling companies to specialise in areas of relative strength, become more efficient, increase productivity, increase innovation intensity and reduce market risk by diversifying their customer base. During the 'growing business' phase 80% of businesses reported export sales as a key objective, to be achieved via joint venture or distribution arrangements and with over 80% of revenues projected to be generated by export sales by 2016.

Companies are building strong competitive positions and are outward looking in their perspective

As the mechanics of innovation and commercialisation become better understood, it is clear they rarely occur in isolation but rather reflect a highly interactive and multidisciplinary practice undertaken by a growing a diverse network of actors (OECD, 2010).

Access to complementary sources of knowledge acquisition act to offset elements of uncertainty and/or lack of in-house capability while catalysing the potential to create radically new products/services (Marvel, 2012). The research reveals that the SE supported companies are outward looking and building a strong competitive position at an early stage in the development process.

Successful commercialisation often requires the ability to co-operate effectively with other key actors, whether informal in nature (via networks) or through formal contracting. Actors include both the private sector (with companies as suppliers, customers, competitors and consultants) and the public sector (incorporating universities, government research institutions, funding agencies, etc).

Wider evidence highlights that as the complexity and costs of technology driven innovation increase, more businesses are using partnerships to help to reduce lead times and increase market responsiveness. More businesses are also now collaborating in areas of non-technical innovation in order to expand the pool of innovative ideas they have access to and widen the scope of expertise on their innovation projects.

The research highlights a group of companies who recognise the importance of collaboration and open innovation with other businesses, universities and support providers. Key highlights from the research include:

- a high proportion of companies working with universities across development stages, for example circa 75% during the 'proving the concept' and early stage 'Technology Development' stages; and
- recognition that where companies faced difficulty in making connection with customers until late in the development process this often resulted in costly and time consuming product re-engineering.

Lessons for policy support

As discussed, a number of significant barriers to successful execution of business plans have emerged from the research exercise, a number of which have a distinct policy focus. Public sector assistance (particularly from SE) is viewed by all the supported companies as contributing to successful development suggesting future, targeted policy intervention is not only valid but welcome. Building on SE's approach to commercialisation, further policy development activity has focussed in the following areas: *lack of finance* (specifically ways to try and address the gap of getting significant - £1m plus -investment into companies) and *acceleration of project timing*, where targeted responses include:

- trialling the potential use of new powers for Young Innovative Enterprises (offering aid of up to €1m to small enterprises less than six years old) to develop products/services/ processes which are technologically new and carry a risk of technological or industrial failure;
- active engagement with SDI in promoting opportunities with non-Scottish investors; and
- activity by the Scottish Investment Bank to engage with investors based outside Scotland;

Other areas SE are exploring to improve future commercialisation outcomes include:

- promoting entrepreneurialism; and
- providing a more joined-up approach to SE's product support offering to help make the transition from pre-company formation support to company specific support more fluid and seamless and to enable this transition to happen at the optimal time point.

Conclusions

This research suggests that line-of-sight to market, time to product launch, access to finance and cost control, strength and depth of management and leadership teams, connectivity across the innovation system and both access to, and utilisation of, human capital are key factors faced by Scottish technology companies in the development of intellectual property, the transition to successful commercialisation of resulting new or improved products/services and in the execution of ambitious growth plans. These elements are all barriers an economic development agency can assist businesses to overcome. To this end, and in order to continue to develop a more complete understanding of this complex area, a programme of future research is planned centred around the longitudinal tracking of the company journey with the aim of complementing the growing evidence base from which to develop policy based practice.

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