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Entrepreneurship†‡

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High-tech businesses are the driving force behind global knowledge-based economies. Academic institutions have positioned themselves to serve the high-tech industry through consulting, licensing, and university spinoffs. The awareness of commercialization strategies and building an entrepreneurial culture can help academics to efficiently transfer their inventions to the market to achieve the maximum value. Here, the concept of high-tech entrepreneurship is discussed from lab to market in technology-intensive sectors such as nanotechnology, photonics, and biotechnology, specifically in the context of lab-on-a-chip devices. This article provides strategies for choosing a commercialization approach, financing a startup, marketing a product, and planning an exit. Common reasons for startup company failures are discussed and guidelines to overcome these challenges are suggested. The discussion is supplemented with case studies of successful and failed companies. Identifying a market need, assembling a motivated management team, managing resources, and obtaining experienced mentors lead to a successful exit.

1. The university entrepreneur

The era of global entrepreneurship offers worldwide trade, international capital and investment, intercontinental supply chains, migration of talent, and expansion of knowledge-based economies. The integration of international economies has resulted in open policies, liberalization of trade and advances in transport and communication. The multinational businesses in the developed world are now challenged by the new global players emerging from the BRIC (Brazil, Russia, India and China) economies. The realization of foreign direct investment and increasing export of expertise are vital channels for global integration and technology transfer through multinational corporations. Knowledge spillovers from academic institutions to private industry are major driving force behind economic growth and increase in welfare.[1–3] Increasing investment in research is an incentive for universities to raise revenues by licensing intellectual property (IP) and spinning off companies.[4] The focus of technology transfer is directed to exploitation of comparative advantages within global competition. Hence, optimization of technology transfer from academic institutions to industry and creating high-value products through university spinoffs has become a necessity for fueling economic growth (Fig. 1). This trend also represents a shift away from physical assets to knowledge and intangible assets such as human capital.[5]

Fig. 1 The development of a startup company in knowledge-based economies.

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The high-tech industries include photonics, nanotechnology, biotechnology, artificial intelligence, semiconductors, robotics, and telecommunications.[6–18] These sectors require smaller, lighter, faster, more efficient and functional components at the nano/microscales. This demand gave rise to miniaturized self-contained and high-throughput microelectromechanical systems, lab-on-a-chip components and microfluidics to transform the way researchers investigate and gain insight into fundamental chemical, physical and biological processes.[19] These fields lie at the interface of engineering, physics, chemistry and biology and offer promise in the development of practical lab-on-a-chip systems for applications in single cell analysis,[20] drug discovery,[21] genetics and proteomics,[22] environmental monitoring,[23] plant sciences,[24] and point-of-care diagnostics.[25,26] High-tech entrepreneurship involves creating a new business by turning an idea into a high-potential commercial product, gathering resources such as co-founders and financial capital, developing commercialization and marketing strategies, and managing the growth of the enterprise (Fig. 2).

The efficient transfer of emerging technologies from academic institutions to industry requires entrepreneurial culture, optimized licensing strategies, strong academia-industry partnership, and organizational support to spin-off companies.[27,28] While the mission of academic institutions is to exchange knowledge by supporting basic scientific discoveries, they also focus on commercial initiatives. For example, the mission of the Wyss Institute and Innovation Lab at Harvard is to translate ideas into products by developing prototypes, validating them against market needs, forming startups, and building corporate alliances. The Vice Provost for Research at Harvard, Professor Richard McCullough,

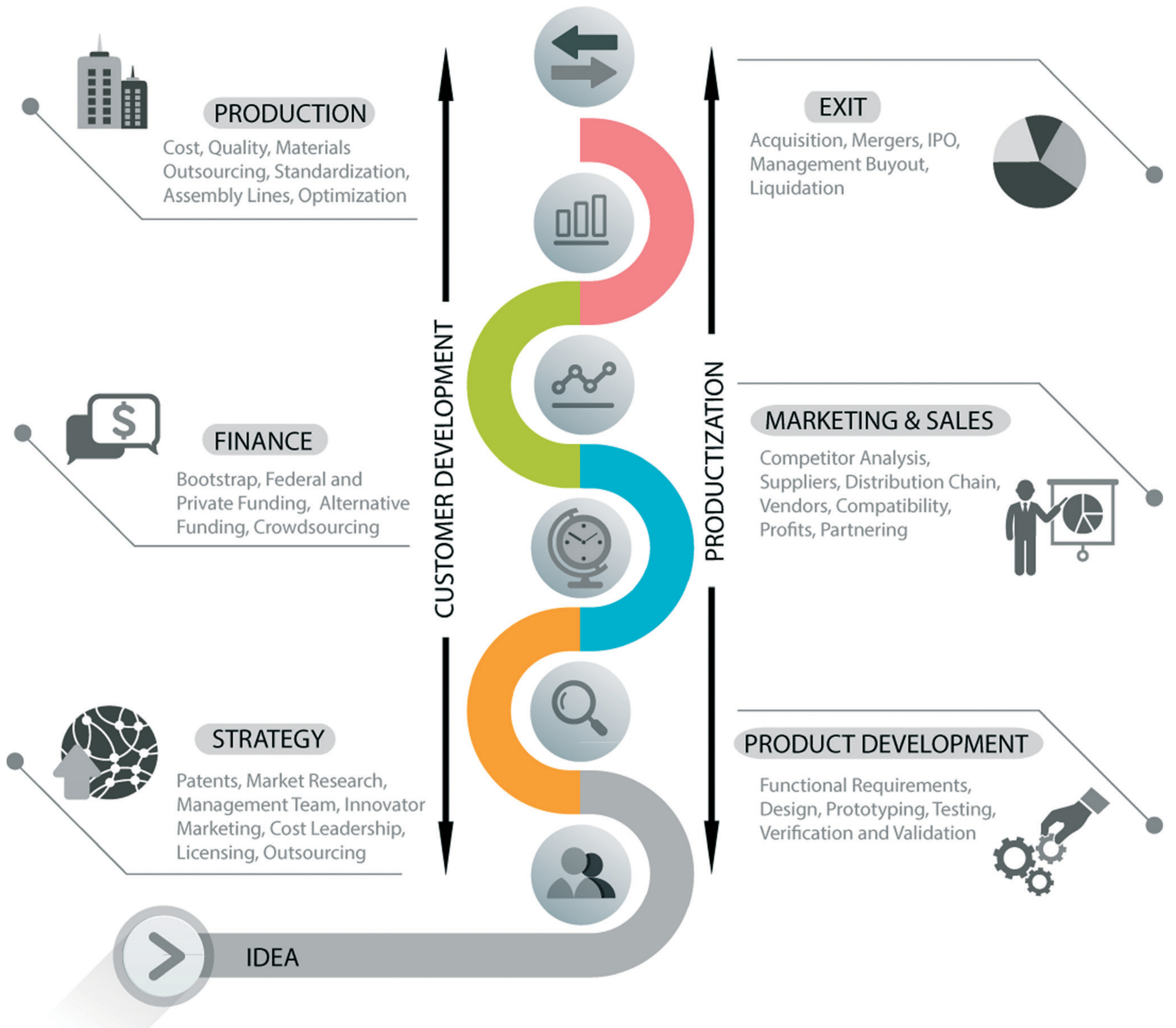

Fig. 2 Roadmap for the commercialization of inventions in high-tech businesses.

stated that the university has adopted an aggressive commercialization strategy over the last decade. The university spins off about 10 companies per year, and 20–40 students pursue entrepreneurial careers each year. However, MIT has historically been focused on the advancement of industrial science and commercialization of inventions. In 2013, they launched the Innovation Initiative, which is an institute-wide program that focuses on expanding MIT's innovation capabilities to solve critical challenges in medicine, environmental issues, and energy. Across the Atlantic, the University of Cambridge established Cambridge Innovation Capital (CIC) to in invest in high-growth technology companies in the Cambridge high-tech cluster. CIC utilizes a longer-term investment approach to support businesses through to maturity without having to provide early exits for investors. These examples are indicative of the commercialization awareness in academic institutions that has become an integral part of knowledge-based economies.

Here, the evolution of a university spin-off company from idea to exit is discussed, and technology transfer strategies are outlined. Potential pitfalls are identified, and practical strategies to create a successful startup company are described. These strategies are supplemented with case studies that describe failed and successful startups. Furthermore, this article investigates the role of innovation-driven enterprise, where the entrepreneurs focus on global markets. While a substantial amount of innovation in high-tech industries exists outside of the academia, this article discusses the university entrepreneurship.

2. The startup company

Entrepreneurship involves obtaining IP protection, developing and adopting a commercialization strategy, turning the proof-of-concept technology into a marketable product, financing the business, marketing the product, and determining an exit strategy.[29] The co-founders should accordingly determine the vision of their company and products that address the specific needs of a market.

2.1. Intellectual property protection

The first step in commercialization is protecting IP. Academic researchers can consult their university's technology transfer office (TTO), which can assist in determining the scope of the patent and developing its claims. Once the TTO and the academic(s) mutually agree to proceed with a patent and no prior art is found, TTO assigns the project to an in-house or outside attorney to prepare and file a patent application. The claims are then drafted according to the proposed business plan. TTOs arose to bridge the gap between the differing incentives of the researchers and the firms. University and government laboratories are incentivized by the maximization of impact of the research results. Firms that use this knowledge, on the other hand, are typically driven by maximization of profit and commercial measures.[30]

The United States government creates economic incentives for universities to commercialize their research. IP is thus commonly awarded to the university rather than the individual. Prior to 1980, inventions that resulted from federally funded research were controlled by the government. After the passage of the Bayh-Dole Act, however, the ownership of this IP was handed to the universities and businesses to foster commercialization.[4,31] Therefore, in the United States, TTOs are typically an integral part of the institution. Researchers should consult the TTOs as early as possible so that sufficient time can be spent developing the patent before publication. While most TTOs in the United States provide licensing advice, some institutions such as Cornell's Center for Technology Licensing also provides consultation in startup commercialization and marketing.

In Europe, most academic patents are assigned to companies, followed by universities, public research organizations, and individual inventors.[32] However, the distribution of patent ownership, their respective legal norms on IP and institutional policies differ across European countries.[33] With the exception of Italy and Sweden, the IP rights are not assigned to academic inventors.[34] In Europe, some TTOs are subsidiaries of universities. At the University of Cambridge, for example, the academic inventors can choose to opt out of working with Cambridge Enterprise Ltd.[35] In this case, Cambridge Enterprise does not manage the IP and licensing, and IP rights are assigned to the inventor. This option also allows the students to own their IP unless bound by a third party agreement. As another example, the Swedish government has attempted to foster innovation by spending $3.8b on research and development (R&D) in 2014.[36] However, the success of their academic-based startups is limited, and the United States patenting model is suggested to be more effective in promoting the commercialization of academic research.[37]

The number of patents granted to universities in the United States increased from less than 300 in 1980 to 5700 in 2013, while licensing revenue generated by these patents rose from $160m in 1991 to over $2.6b in 2013.[38,39] The life sciences accounted for the majority of incoming revenue, outgoing licenses, and startups.[40] This pattern is also evident across Europe as well as Australia and Canada, indicative of the increasing importance of the role of TTOs in commercialization.[41] Regardless of the model, IP protection should be developed in parallel to research. Although it is not required to provide experimental data for filing a patent application, the concepts should be tested and validated to obtain blocking patents.[27]

2.2. Commercialization strategy

Technology entrepreneurs must formulate and implement a commercialization strategy that determines the ultimate performance of the business. Table 1 presents selected entrepreneurship and commercialization strategies, their key attributes and the founding team's respective levels of

Table 1 Entrepreneurship and commercialization strategies and their keys attributes, and respective levels of commitment and time horizon for the business

Strategy	Key attributes	Asset commitment (%)	Time horizon (years)
Sale/licensing of IP	Cede the right to innovation; remain independent	10	1
External development aimed at acquisition	Focus resources externally; no longer independent	15	1–2
Internal development (including external cooperations)	Retain the equity and independence	90	5–10+

commitment and time horizon for the business. This table primarily covers high-tech technologies such as medical, veterinary, environmental diagnostics, and analytical devices, and it excludes long-term technologies involving drug discovery. The timeframes can be shorter or longer depending on the type of product and market involved. While inexperienced innovators may have a "build it and they will come" mentality, experienced entrepreneurs and investors understand that the innovation itself, regardless of its scientific merit, is only a piece of product development, which determines the company's ultimate commercial success. Commercialization typically follows one of three primary strategic paths: (1) sale or licensing of IP, (2) external development focused on acquisition, (3) internal development of a startup aimed at an initial public offering (IPO), or a mix of these strategies.

If the inventor does not want to be involved in the commercialization process, he/she can sell the rights to the innovation to another company. The inventor may choose to offer the company technical assistance in exchange for a set cost, royalties, or other agreement. IP can also be licensed if the inventor wants to maintain ownership of the patent(s) but does not have the commitment or time to be involved in the company. Although the terms of a licensing agreement vary for each technology, firm, and environment, the defining feature of this arrangement is that both parties remain independent while cooperating in commercialization of the technology.[42] An advantage of this strategy is the limited involvement of the founder(s) in terms of time and resources; however, the technology may never be brought to market in this scenario if the third party is interested in using but not necessarily commercializing the technology. Standard license agreements include negotiated financial terms such as annual fees, a royalty on product sales, reimbursement of patent costs, and possibly a minority share of equity in the startup.[43] Additionally, license agreements include non-financial terms such as the degree of exclusivity (*e.g.*, nonexclusive, exclusive, or restricted by field of use), reservations of the rights for the federal government, and performance (diligence) requirements for having the capability to develop the technology.

Another strategy of commercialization is developing the startup externally with the goal of eventually being acquired by another company. In this strategy, the innovator relinquishes the independent operation of the startup and gives the rights to commercialization and control of the technology to a third party. The innovator recognizes that s/he needs immediate access to assets to achieve presence in a new market, such as manufacturing economies of scale or gaining access to a complementary technology or product for the startup's portfolio. For this type of strategy, the innovator is not willing to commit the time necessary to develop these assets internally but generally has the financial means to acquire these assets externally. For example, rather than spending the time to develop and optimize a manufacturing process, the innovator may hire an external manufacturer to mass produce the product until the startup is acquired by a larger company. Therefore, the innovator in this case is willing to spend more on the convenience of shorter development times.

Internal development is costly and requires the largest time commitment. In internal development, the innovator must be prepared to commit up to 90% of his/her available assets. The innovator must be able to sustain the development effort through the life cycle of the business with financial returns potentially only being realized after over 5 or more years. In this scenario, the innovator and his/her management team continues researching, fabricating, and optimizing designs and processes. Internally, the researchers may de-risk the technology as they develop it further, making it more attractive to investors. However, most startups do not have the available funding to bring the product to the inflection point, where adding a small amount of time and resources results in a significant improvement in performance. Contracting relationships often form during this stage, including joint ventures and strategic alliances, and outsourcing may be used to gain access to additional assets. While each type of external partnership involves different terms, every form of cooperation impacts investment of cost and time of the startup in downstream commercialization.

The commercialization strategy of a company is affected primarily by the company's vision, business philosophy, the stage of technological development, market risk, competitive activities and window of opportunity. Ultimately, the optimal commercialization strategy depends on the innovator's background and willingness to invest time and resources to have an independent company and desire to maximize commercial availability of the innovation.[44]

2.3. Productization

Product development involves taking an idea to manufacturing. Productization is the process of analyzing the customer needs in a target market, designing the product, and developing manufacturing capability.[45] Productization requires turning intangible services into standardized outcomes aimed at mass markets. The manufacturer should aim to create a standardized output that enables scalability. Additionally, the company should create an extended product that provides complementary assets, delivers customer value, and is easily comprehended by customers. The aim of the productization is to package the high-tech device or service so that the customer can understand the context, benefits, and the outcome in advance. Productization includes describing, improving, manufacturing, and continuously developing the technology to maximize the customer benefits. In this way, productization links new product development and marketing.

Productization can be categorized as inbound (ability to make) and outbound (ability to sell) approaches. The inbound productization involves systemizing the offering delivery process and its outcome within a company.[46] For example, product data management methods can reduce routine engineering work and help the product reach the market quickly.[47] Reducing the routine work *via* creating existing templates, modules and platforms can allow more room for innovation within the company. However, a high-tech company should strike a balance between standardization and customization. Considerable development effort is needed to transform a prototype into the technical maturity of a core product, where the development work should be the main focus of inbound productization. While testing programs may initially deal with functionality, product development focuses on robustness and reliability. Technical aspects of productization may include final design specifications, material selection and sourcing, production tools, assembly instructions, manufacturing strategies, testing, quality control, and certifications.[45] While proof of concepts and functional prototypes are necessary during development stage, they are not sufficient for a company to have a product. Hence, the productization aims to create a product portfolio that is amenable to mass-customization. Ideally, entrepreneurs should create a platform technology that is compatible with customizable products. Hence, the company can use existing infrastructure to manufacture a variety of products and conserve capital costs.

Outbound productization aims to increase the visibility of the completeness of the offered product or service for the customers. It also increases the value of the product perceived by customers. Other factors such as brand, product shape, and training can add value to the product. Hence, at the early stages of the new product design, end customer requirements should be understood by the company, and the products should be designed for the target market's needs. In creating the extended product, platform thinking and mass tailoring should be utilized to offer a broader product portfolio.[48,49] However, focusing on the core technology may lead to overengineering the product. A product represents the totality of the physical product and the service, as well as perceptions, usefulness, desirability and convenience since all these factors play an important role in the purchasing decision. Creating the concept of the extended product needs to be incorporated to the early stages of product development, where the tasks need to be performed in cross-functional teams. Therefore, the technology represents a potential opportunity, the core product is the realization of this potential, and the extended product is a marketable product with high performance, customer value, and worth. In this context, the customer can compare the offering to other products in the market and judge whether the price and benefit ratio justifies the purchase.

Creating interfaces between R&D, marketing, sales, and manufacturing teams is required to achieve the key premises behind productization.[50] The outputs of internal productization include the deliverables for the costumer and the strategy to organize the process of creating these deliverables. The outputs of outbound productization is a well-defined offering, the ability communicate the innovation to the customer by showing that the company understands its customer requirements and create the product accordingly. Productization can also reduce the costs associated with inefficient customer-specific tailoring of the products by revising the offering and adding modularity. Another benefit of productization is to create a synergy between research & development and marketing teams and create a common language to discuss their problems with each other. The outbound productization allows the company to evaluate the extended product and services to persuade the customer to make a buying decision. Hence, productization can be utilized as a framework to analyze extended product creation in a systematic way. For example, the Dolomite Centre Ltd. (Royston, UK) specializes in the productization of microfluidic technologies. It recently commercialized Mitos Dropix Droplet Splitting System under exclusive sub-licence with Drop-Tech Ltd. (Cambridge, UK).[51,52] Dolomite has also partnered with Sphere Fluidics (Cambridge, UK) and commercialized their PDMS picodroplet handling chips (Pico-Gen) and surfactants (Pico-Break/Glide/Surf).[53]

3. Funding

3.1. Financing in the United States

Companies need financial support and capital for research, product prototyping, manufacturing, licensing, maintaining their patent portfolio, accounting fees, marketing costs, and payroll expenses. Co-founders should estimate these various costs of startup expenses at every stage of company development, which involves different levels of risk and investment (Fig. 3). Even in the idea phase of the startup, expenses start to accumulate; thus, co-founders should use accounting worksheets to plan the startup costs. In these lists, companies should analyze expenses, assets, and financing options. Expenses cover legal fees, consultants, insurance, and overhead fees. Assets may include cash, inventories, and equipment. Expenses are deductible against income, so companies can reduce taxable income. Assets, however, are not deductible. Thus, companies should allocate the startup costs into

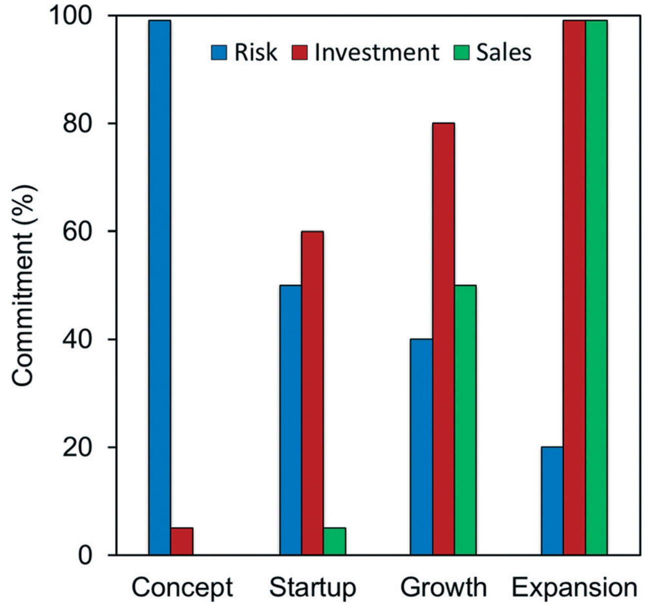

Fig. 3 Companies experience multiple stages of growth ranging from (1) concept, (2) startup, (3) growth to (4) expansion or late phases.[58–60]

the proper categories to avoid complications with taxation. Furthermore, at this stage, co-founders should conserve money by seeking discounted vendors for raw materials and working out of shared spaces in low-cost locations.

At the early stages of a startup, the co-founders possess 100% of the company. However, investors typically obtain a piece of the company, known as equity, in exchange for their investments.[54] Therefore, the more funding that a company accepts, the more the shares become diluted, and shareholders become co-owners of the company (Fig. 4). Although co-founders may own a smaller percentage of the company at later stages, outside investment allows the company to grow, and the value of individual shares increase dramatically.[55,56] Importantly, investors expect a considerable return on their investment. Typically, to offer competitive advantages, companies should project "10× return" to the investors within at least 2–6 years of growth depending on the industry.[57] For instance, in the early stages of venture investment (series A), a company raises $1m in exchange for 20% equity in company shares. This creates a company value of $5m. For example, with 10× return, companies should plan to reach a $50m valuation within 5 years. However, these business models should include realistic sales and marketing plans according to the feasible industry scales. Such business plans claiming 10× return to the venture investors will be an effective way of attracting more funding to startups.

Financing options depend on the growth stage of the startup company.[61] In the concept phase (seed), federal grants, family and friends could be the initial sources of funding. Investors face high risks at this stage, even if the capital investment is below $250k, rendering it challenging to attract private sources of funding. Therefore, co-founders can accept cash from family and friends at this stage either as a gift or in exchange for 5–10% equity. In this phase, co-founders devise a proof of concept of the technology and establish a business model with a financial plan. The funding in this stage is needed primarily to hire new employees to accelerate prototyping. Usually, the founder offers sweat equity (~20–50%) to the new co-founder in

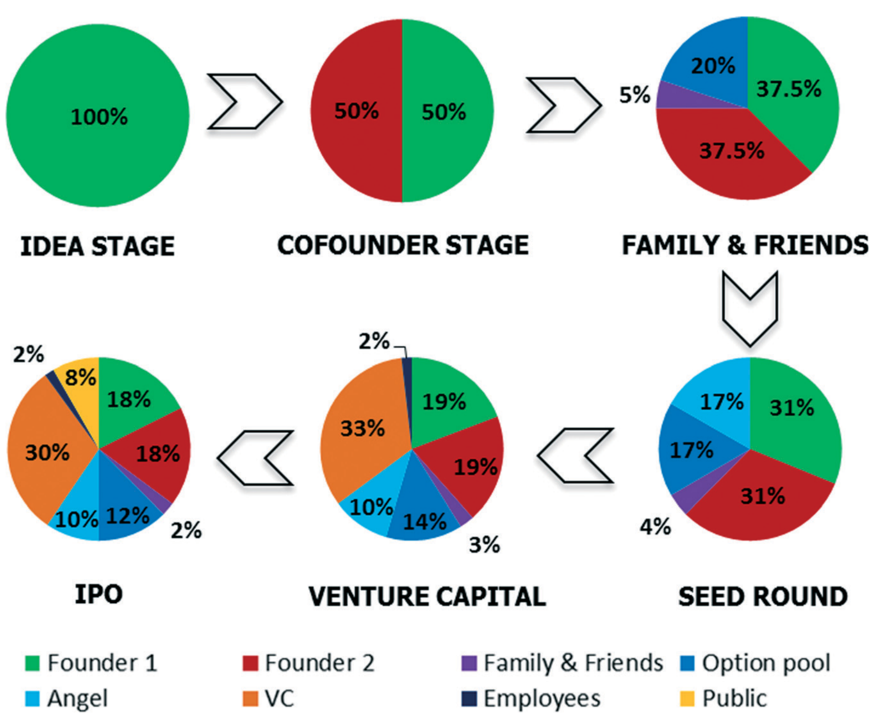

Fig. 4 An exemplary distribution of shares from startup to IPO stage.

exchange for work. If the co-founder owns less than 50% of the shares, s/he may be less motivated to put effort and time toward company development.

In the second financing stage, or medium-growth stage A, co-founders have access to angel investors and some of the venture capitalists who are interested in investing in a feasible product that can penetrate into an attractive target market.[61,62] At this phase, risks become lower and specific financing demands (>$500k) are well defined to pass to the next growth stage. Although the risks are lower, more capital is required to scale up the business operations, and a company can raise millions of dollars though venture capitalists and angel investors. During this round, incubators (*e.g.*, Cambridge Biolabs, Lab Central, Cambridge Innovation Center), accelerators, and excubators (paid incubators) may offer working space and advisors, sometimes in exchange for 5–10% equity. During the venture capital round, the company should have a fully functioning prototype.[63] Typically, the VCs invest more than $500k. Most lab-on-a-chip companies raise $10–50m by the time their first product receives regulatory clearance.[26] Case Study 1 about Microchips Biotech, Inc. presents a microfluidic drug delivery company that has raised $81m from VC and grants. The venture capital network also depends on the geographical and strategic location of the startup company. For instance, some universities generate more successful startups compared to others due to their strong academic and venture relations[64] or proximity to a biocluster.[65] While angel investors and VCs can be a great source of funds, the co-founders should be cautious and also consider the amount of equity they wish to retain during this round. The co-founders might save 20% of the equity for future employees as a part of an option pool.

There are several options after this stage; for example, the co-founders can decide to attempt to start making profit, sell the business, go to venture capital round B and C, or attempt an IPO.[66] This strategy allows raising money from the public by selling shares in the stock market. At this stage, all the investors in the company hold restricted stocks. Before selling the stocks, they have to be verified by the government which ascertains whether the public can safely invest in the company. This process is accomplished by preparing the IPO documentation through investment bankers who are the lead underwriters and sell the stocks to clients. The investment bankers typically receive ~7% of the money raised in IPO.[67]

The company may also choose to obtain funding from entrepreneurship competitions, grants, loans, or explore crowdfunding opportunities for projects that directly appeal to public. For amateur high-tech entrepreneurs, accessing to angel investors, resources, as well as mentorship is an overwhelming task. Therefore, for university entrepreneurs, there are many "business plan competitions" that bridge the gap between young scientists and high-profile investors.[68] Typically, a collaborative network in between universities and industrial partners regulate these business competitions. Organized by Oxbridge Biotech Roundtable, one recent competition is OneStart that has awarded $150k, free lab space, and mentorship to teams.[69] Additional entrepreneurship competitions include MIT 100K, The Global Moot Corp at UT Austin, LeanModel (San Diego, CA), Cleantech Open, FinCapDev, and Rice Business Plan competition (ideal). Furthermore, philanthropists, including Bill & Melinda Gates Foundation, release competitions and opportunities for biotechnology entrepreneurs. Case Study 2 about Diagnostics for All (DFA) presents an example of funding a startup through entrepreneurship competitions.

Federal government grants are mainly awarded in scientific, medical and environmental research, in particular for high-tech startups or high-growth firms. Table 2 shows potential funding resources for a startup company. The proposed grants need to be aligned with the federal R&D objectives, and the technical merits and the benefits of the venture should be geared towards the local and national economy. However, these grants are tightly controlled and allocated to businesses that are on the same agenda of a government agency such as the Department of Defense in the United States. There are other grant opportunities offered by states and local governments such as discretionary inventive grants; however, they are also aligned to agency goals and are limited to larger companies. An attractive grant opportunity is Small Business Innovation (SBIR) grant overseen by the Small Business Administration (SBA).[70,71] In 2010, SBIR awarded ~$2b, half of which was allocated to businesses employing less than 25 people. This grant is limited to United States-based businesses with more than 50% American ownership. Case Study 3 about Optofluidics, Inc. describes an example of funding a startup through federal grants.

Regulated by SBA, the microloan program provides less than $50k to startup businesses.[72,73] The funded microloans, however, average $13k.[74] The operation structure of these loans includes intermediate administers that determine eligible borrowers. This funding can be spent in the forms of working capital, inventories, supplies, furniture, machinery, and equipment, although it cannot be utilized to pay existing debts. Companies are allowed to pay an SBA microloan within up to six years based on the interest rate determined by United States treasury. Getting a small business loan has become difficult after the financial crisis in 2008, and the lingering credit crush. This type of funding requires the bank to evaluate a financial track record showing the ability to repay the lent money.[75] The fundamental difference between this type of funding and the investors is that banks are not interested in equity investments in small businesses. However, alternative lending represents a costly, but quick and hassle-free strategy to obtain necessary funds. The business owners should demonstrate that their business is not a risky investment to the loan officer. Additionally, if the business model is proven and the company is making profits, the owners can make a case by also providing their resumes, references, prior track records, and history of paying back loans or investors. Having a high credit score is also a determining factor in obtaining loans from banks. There are also United States SBA loans that can be easier to secure

Table 2 Funding resources for a startup company in the United States, and the European Union and its associated countries

Type	Source	Program	Amount	Description	Territory
Federal	Small business administration	Loans	Max up to $5m average >$300k	General, micro, equipment, real estate, disaster	US
Federal	State departments (NIH, NSF, NASA, EPA)	SBIR/STTR	$100k–$1.3m	Phase I-II-III	US
Private	Banks	Loans & cards	$350k–$3.5m	Debit	US
Private	Business networks	Angel investor	$150k–$2m	Equity capital	US
Private	Business networks	Venture Capital	>$500k	Equity capital	US
Private	Business networks	Customers and suppliers	Negotiable	Per agreement	US
Private	Business networks	Entrepreneurship competitions	$10k, $100k, $150k and more	Per agreement	US
Private	Business networks	Donations	Negotiable	Per agreement	US
Private	Internet networks	Crowdsourcing	$7k–$6m	Per agreement	US
Politico-economic union	SME instrument/European commission	Grant	€50k–>€2.50m	Phase I-II-III	EU and associated countries
Politico-economic union	European investment bank/InnovFin	Loan and guarantee	€25k–€7.5m (SME) €300m (large companies)	Per agreement	EU and associated countries
Politico-economic union	FET-open/European commission	Grant	€2m–€4m	Per agreement	EU and associated countries
Politico-economic union	COSME/European commission	Grant	€2.3b in total	Per agreement	EU and associated countries
Politico-economic union	Eurostars	Grant	€1.14b in total last call: €150m	Per agreement	EUREKA countries and the EU

than a standard bank loan. This type of loan is indirectly funded by SBA that offers a guaranteed loan to the bank, which can issue the loan to the business to reduce the risk of the bank.

Another method of raising funds for a startup company is crowdfunding that involves pitching a new idea or service, often accompanied with a prototype, to the public through a social media campaign such as Kickstarter, Inc.[76,77] This campaign shows the idea, how it is developed, and why it is functional or fun. In recent years, the crowdfunding industry has raised more than $3b, and it is projected to grow to up to $90b by 2025.[78] Crowdsourcing operates on the basis of donations, investments, and rewards (Table 3).

If none of these fundraising avenues are successful, some founders fund their companies from their personal belongings, savings, inventories, and consulting to other companies. This approach, known as bootstrapping, may be risky especially for entrepreneurs with family responsibilities as there is a considerable risk that the business faces difficulties resulting in bankruptcy. Despite these challenges, bootstrapping might still be an option if some basic guidelines are followed. First, these self-funded startups should aim for their first sales at the early stages of their operations. This can facilitate some momentum in the startup both financially and psychologically. Second, these startups should minimize their spending and conserve as much as cash

Table 3 Types of crowdsourcing

Funding type	Crowdfunding source	Platform	Description
Public	Kickstarter	Donation	Small volume
Public	Indiegogo	Donation	Small volume
Public	WiSeed	Donation	Single holding from individual investments
Public	DoDo funding	Reward	Biotech investments
Public	Seedr	Equity investment	Minimum 10% equity
Public	Consano	Donation	Focus on healing diseases
Public	Poliwogg	Equity investment	Life science companies as investors with $1–4m
Public	Crowdfunder	Investment	Larger volume
Public	Rockethub	Donation	Extra promotion *via* FuelPad and LaunchPad
Public	Somolend	Debt-investment	Loaner through banks
Public	Appbackr	Donation	Mobile app development
Public	Quirky	Donation	Influence sharing
Scientific	Petridish.org	Donation	Scientific research
Scientific	Experiment.com	Donation	Scientific research

possible. Garage startups are examples of these models, where they save from costs that are related to the expenses and assets. An effective bootstrapping approach is to run the startup as a consulting company to fund the development of the product.

3.2. Financing in Europe and its Associated Countries

Startup funding can be obtained through direct and indirect financing. Direct funding includes grants from the European Commission that do not require an exchange of equity, while indirect funding includes loans and equity shareholders through banks, private investors, and venture capitals. Some of these funding options need custom planning for each EU member country, as the funding decisions depend on the local conditions of financial institutions. More than 90% of businesses that apply for EU funding fall into the category of small and medium-sized enterprises (SMEs).[79] In the EU standards, medium sized companies typically employ less than 250 people with up to €50m turnover, while small sized companies are composed of 50 employees bounded to €10m turnover. The European Commission initiated an Executive Agency for Small and Medium-sized Enterprises (EASME) to manage several EU entrepreneurship programs. EASME aims to create a business-friendly environment through promoting entrepreneurship, internationalization, networking, and providing access to finance. Some of these EASME programs include the SME instrument funding under Horizon 2020, Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME), the EU program for the Environment and Climate action (LIFE), European Maritime and Fisheries Fund (EMFF), Fast Track to Innovation (FTI) Pilot, Intelligent Energy program, and the Eco-innovation initiative.[80]

The Horizon 2020 is a €80b initiative that aims to support and encourage research and entrepreneurship in the European Research Area and Associated counties from 2014 to 2020.[81] This initiative also supports Pan-European research infrastructures, promotes open access, and encourages gender equality. Together with its initiatives around societal policies, Horizon 2020 supports early stage high-risk visionary science and technology projects performed under SMEs. Thus, Horizon 2020 dedicated an SME Instrument funding scheme that aims to fund projects involving information and communications technology, nanotechnology, and biotechnology.[82] This funding strategy allows SME businesses to develop their ideas, and build prototypes, validate the products, obtain customer feedback, and commercialize their products. The program will invest a total of €3b in high-potential SEMs to develop ground-breaking products or services until 2020. The different phases of this program include business innovation grants for feasibility assessment purposes (Phase I), business grants for innovation development and demonstration purposes (Phase II), and support services to facilitate access to risk finance for commercial exploitation (Phase III). Future and Emerging Technologies (FET) program is another collaborative funding opportunity under Horizon 2020.[83] FET-Open funds breakthrough and early ideas with minimum three project partners from EU countries. This initiative provides up to €4m financial support to any potential technologies without topical scope restrictions. Recently, European Investment Bank Group and the European Commission under Horizon 2020 launched InnovFin – EU Finance for Innovators.[84] This program consists of integrated and complementary financing tools and advisory services that cover the entire value chain of research and innovation for SME and large organizations. The funding is available to EU as well as countries in the vicinity of Europe. By 2020, InnovFin will offer €24b of debt and equity financing.

Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME) is another EU program that offers €2.3b until 2020. COSME support SMEs to (i) access equity investment and loan funds, (ii) improve access to markets, (iii) create framework conditions for the competitiveness and sustainability of Union enterprises, and (iv) promote entrepreneurial culture by creating favorable conditions for business formation and growth. COSME facilitates startup funding through the Loan Guarantee Facility (LGF) and the Equity Facility for Growth. Through COSME LGF, European Investment Fund offers direct and counter guarantees for financial intermediaries such as banks and leasing companies to provide an incentive loan and lease finance to SMEs.[85] While the direct guarantee is issued by the bank to the beneficiary, a counter guarantee involves the bank requesting a foreign bank to issue a guarantee on their behalf. In case of invocation of the bank guarantee, a counter guarantee ensures that the customer is liable for any expenses for attorney, interests on delayed payment, taxes and other levies. COSME guarantees allow SMEs, which cannot access the traditional banking system, to obtain to debt finance. Additionally, the LGF includes securitization of SME debt finance portfolios. Since 2007, over 240 000 SMEs have benefitted from this initiative in the European Union and affiliated countries. The second part of the COSME is the Equity Facility for Growth, which invests in funds that offer venture capital and mezzanine finance for expansion and growth. These funds are distributed based on the commercial potential of the product and growth potential of the startup. This program has funded €2.3b in equity investments since 2007.[85]

Additionally, Eurostars is another program that supports high-tech small and medium enterprises, which develop innovative products, processes and services.[86] This program has a budget of €1.14b until 2020, and it provides funding for transnational innovation projects that can be rapidly commercialized. Eurostars is supported by €861m of national funds from its member countries and is further funded by €287m from the EU, so the funding decisions are made on a country-by-country basis. In the Eurostars program, the participants have partners from two or more Eurostar countries. The participants of the program are in 34 EUREKA countries (*e.g.*, Russia, South Korea, Canada and South Africa), and the European Union.

Table 4 Regional dependence of entrepreneurial condition

Regional condition	Factors
Access to finance	The availability of resources covering equity, grants, subsidies, and debts for small and medium companies
National policies and government programs	Regulations, taxation, and direct assistance applied to the emerging companies
Entrepreneurship education	The training for entrepreneurship starting from high school
R&D transfer	The penetration speed of R&D to the commercial opportunities
Commercial and legal infrastructure	The presence of legal and commercial services promoting small and medium companies
Market regulations	The dynamics and openness of markets for startups
Physical infrastructure	Smooth access to land, space, utilities, transportation at competitive prices for enterprises
Cultural and social norms	The acceptance of startup activities in society and culture

SMEs have access to the Enterprise Europe Network that covers 600 member organizations and more than 50 member countries for creating businesses in the EU. This European network supports SMEs to determine financing strategies, find international business partners, and obtain advices for diverse issues including EU laws and standards.

3.3. Financing for Global Entrepreneurship

Entrepreneurship dynamics are linked to the unique ecosystems that differ across different regions of the world (Table 4). These ecosystems are composed of conditions that influence the business creation and growth.[87] Entrepreneurial conditions are mainly shaped by conditions in different regions (Fig. 5).[88] For example, business regulations may improve the business opportunities, or hinder the business plans. Economically developed countries such as North America and Europe provide improved financing options and infrastructure as compared to other developing regions such as Africa.[89] On the other hand, national policies and government regulations in Africa are as supportive as the developed countries. Interestingly, one common problem is that the entrepreneurship education at schools is low in almost every part of the world, necessitating new policies that can enhance the self-motivation of students for promoting personal initiatives.[88,90] In comparing North America and Europe, regulations and policies are more supportive in Europe, while the financial sources, physical infrastructure, and cultural values weigh stronger in North America.[88,90] From the perspective of VC investments, United States alone brings higher capital to the new companies as compared to Europe.[90] However, only a small portion of new startups receive VC funding. Therefore, other informal funds from various resources play an important role as the backbone of financial operations in all countries. Under the light of these regional analyses that span a wide range of entrepreneurial parameters, co-founders should carefully decide on their commercialization and funding strategies.

4. Marketing and sales strategies

Marketing high-tech products is fundamentally different than traditional industries due to: (i) higher R&D investments, (ii) increased uncertainties, and (iii) intense competition for new products.[91–93] Small- and medium- size high-tech enterprises with high-profit potential (*e.g.*, biotechnology) have high risks.[94] Such companies should not only create value, but also capture the created value.[95] This ability depends on the company's capability in creating and sustaining competitive advantages.[96] Positional advantage in the market is an important stream of the competitive edge.[96–98] The brand name

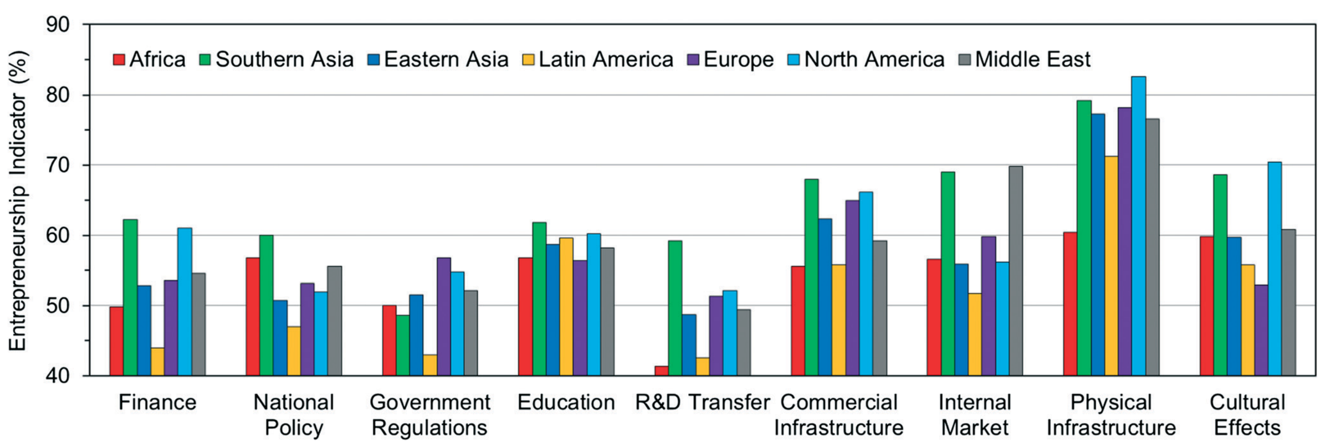

Fig. 5 Entrepreneurship indicators or conditions that influence the creation and growth of companies in different parts of the world.[88,90]

and the status of the company are key factors in maintaining the competitive advantage.[99] When the product life cycle is short, market awareness and competitor analysis are critical in maintaining the positional advantage.[100]

The company can position itself in differentiator/innovator or cost leadership strategies. The cost leadership strategy is unrealistic for startups and early-stage companies since this approach requires increasing economies of scale and achieving high-volume advantage through promotion and price subsidization.[101] This requires startups to innovate and exploit first-mover advantages. For example, Bioanalyzer (Agilent Technologies) was launched in 1999 to provide sizing, quantitation and quality control of DNA, RNA, proteins, and cells on a chip.[102] The device as an early mover to the field had a successful product lunch. There are several reasons why innovator strategy is more advantageous than cost leadership strategy. The first reason is that new products have low demand, which does not require large production capabilities. Second, this strategy allows shifting to new technologies faster at lower costs compared to large companies.[103] The innovator strategy requires wide market awareness, which is the market's familiarity with the company name, reputation, brand, and the products.[100] However, market awareness may not be directly related to the profit increases.[104]

In high-tech industries, hardware is constantly upgraded producing obsolete products, and the customers have limited time to understand the benefits of a new product. Marketing a high-tech product requires understanding the customers. Ideally, several factors such as customer base, the purchase decision, and its timing should be identified. Customer purchase decisions are based on the rate of technology adoption, categories of adopters, and the chasm. The rate of technology adoption is based on the benefits for the customer. Hence, the businesses should analyze customer perceptions of benefits compared to costs. Another factor in marketing high-tech products is compatibility. Customers seek similarity to existing user interfaces as the learning curve is a challenge and commitment for the customer. Another consideration is the complexity and compatibility with other products, for example, a device that operates through USB and does not require coding is a convenience for the customer. For example, MinION (Oxford Nanopore Technologies) in a handheld DNA sequencing device that operates through USB. The use of the product should be simplified to the most basic level at the least sample preparation or initial operation steps. For instance, i-STAT (Abbott) and the LABGEO PT10 (Samsung) require an unprocessed drop of blood to operate. If this cannot be achieved due to complexity, the businesses should offer training and education in using the product through online training programs or on campus demonstrations. Additionally, observability also plays a role in the rate of adoption. This factor involves the consumer's ability to assess the benefits and may be independent of the seller's marketing approach. The factors listed are hurdles to overcome in achieving effective marketing. Hence, businesses should arrange their marketing strategies to offer compelling reasons for overcoming customer's uncertainty and skepticism. Traditional marketing strategies assume that the customers understand the usefulness of the products and know how to evaluate them. However, the businesses should educate the potential customers to reduce the barriers in purchasing decisions.

Marketing and sales are two distinct processes that are closely intertwined and work together to increase company revenue. While large firms may have employees handling marketing or sales in different departments that work in parallel, startups do not have the finances to hire specialized employees and often fail to differentiate between the two. Both marketing and sales are necessary for the success of a business, and strategically combining efforts on both fronts will lead to substantial business growth. Marketing targets large groups or the general public while sales focuses on smaller groups or individuals. Furthermore, marketing creates sales opportunities based on customer values. On the other hand, sales converts consumer demand to match the product. Marketing involves identifying a customer base, developing products for meeting meet the demand, creating a general awareness about the product, and building a brand for the product to generate leads or prospects. To raise awareness about the product, marketing may consist of advertising, social media campaigns, public relations (PR), and online marketing. At the heart of the high-tech marketing is the ability to communicate the benefits of the product to customers. This involves the ease and clarity of communicating the incentives to own the new product to the prospective customers in terms that the consumers understand. The terminology and the message should be carefully selected to communicate an engineering concept to biologists, medical professionals, and purchasing staff in academia and industry. The ultimate success of a marketing plan requires researching the prospective customer base, specifying the consumer demographics and demand, and utilizing targeted marketing messages.

While marketing is typically indirect and acts at a distance through the media, sales is human driven and consists of direct interpersonal interactions. Sales converts the prospects obtained by marketing into purchases. Thus, sales operates on much shorter timescales that involve finding a target customer, building a relationship through interpersonal interactions including one-on-one meetings, networking, emails, and phone calls, and converting the potential customer into a paying a customer. The success of the sales plan is driven by the quality of the salespeople in terms of their experiences, training, skill sets, and personal contacts. Therefore, startups should hire the salesperson with the right relationships for the target market.

Most high-tech products and lab-on-a-chip devices are in the development state or in an early stage of their product cycle. Hence, they are targeted toward business-to-business (B2B) transactions, including universities, research institutions, and companies. The majority of B2B companies are driven by sales as opposed to marketing. In products targeted to B2B transactions, the sales volumes are low as compared to business-to-customer (B2C) transactions. The smaller customer base is typically comprised of committees of buyers who are more easily accessible through sales teams. The buying committee has a rigorous decision-making process that involves the assessment of technical aspects of the product or the service and the inspection of the device to reduce the risk of buying a frivolous product. Therefore, these interactions are usually relationship driven and stem from face-to-face interactions. Since the transaction size of the sale is typically larger in B2B companies, the building of trust during these meetings plays an important role. In B2B transactions, buyers are often experienced and understand the benefits of the product in terms of cost and specifications. The buyers are also well aware of the technology trends and the range of competitive products in the market. On the other hand, most B2C companies are driven by marketing to reach the masses. Since media is an effective way to advertise to potential customers, early stage marketing tactics involve the use of the internet. ESI† describes early stage marketing tactics.

Jessica Livingston, a partner at startup accelerator Y Combinator, advises startups to focus their efforts on sales rather than marketing.[105] Specifically, startups are advised to seek out a core group of early adopters that should be involved in the development of the product to ensure that the product meets consumer needs; once the technology becomes an extended product, these early adopters should be the focus of sales. The early adopters often collaborate and communicate across industry boundaries, and allow spreading the presence of the product horizontally.[106] Additionally, sales should target key influencers in the market, including brands, bloggers, and reporters.

Startups are under financial constraints, and this necessitates the use cost-effective marketing tactics. The co-founders should define success using a metric with a direct correlation to company growth, such as number of new users or a certain revenue each month and ensure that everyone on the team is working toward this metric. Then, the team should set a budget and focus resources toward avenues that have proven successful historically in the target market or with competitors. A variety of tactics should first be tested with smaller budgets. Those that contribute to company growth should then be allocated a larger portion of the budget.

The marketing of new high-tech products is an important aspect of commercialization strategy. While it is important to generate revenues, the resources should be directed to having a market focus. High-tech equipment requires learning costs on the end user and generally adopted to use for a long time. Hence, this requires the customers to get used to the technology and recover the investment in the high-tech product. Therefore, rapid introduction of improved versions of a device or service can make the customer regret the purchase and delay the new purchases. Hence, it is in the interests of the company to introduce the new products in a timely manner and avoid excessive pace of product development.

5. Exit strategies

An exit strategy allows the business owners to decrease or eliminate their equity in the company to recover the initial investment with/out return.[107] The sooner the management team plans for the exit, the more rewarding the exit is likely to be. Additionally, preparing an exit takes time, and these options require forethought and preparation. Hence, the management should consider the end goals and strategize the exit plan to maximize the benefit for stakeholders and employees. Assessing the market condition is also critical in determining the exit strategy. For example, the demand for the products of the company, acquisitions between investors, and the presence of strategic buyers affect the exit strategy. Hence, the inventors should engage with private equity partners, commercial lenders, investment bankers and financial professionals to assess the trends in the market. The range of exit strategies includes acquisition/merger, taking the company through an IPO, management buyout, and turning the company into a lifestyle business. In addition to the main exit strategies, dual-track approaches should be also considered. For example, marketing the company to both investors and potential strategic buyers can be pursued to capitalize the most attractive exit strategy. While the public market investors are interested in the business as a whole and the prospects for growth, the strategic buyers might want to assess specific aspects of the company.

The owner sells the company to another business by negotiating the price, which involves the seller to pay in cash, stock, or a combination. The owner should choose a strategic fit, which will allow the buyer to expand into a new market, and offer a new product to their existing customers. Such customers might include companies that require critical capabilities that are more costly or take longer if they developed themselves. One issue with this approach is that the acquired management might be locked up into working for the combined company, which might let them go at some stage. The buyer might not retain the management team, or make substantial changes in the company's operations, staff, and business lines. The seller should make the company appealing to the acquisition candidates by developing the compatible products that they match with the prospective suitor's products and fit into product portfolio. For example, Solexa Inc. (Hayward, CA), a spinoff from the University of Cambridge, developed a single molecule sequencing platform, which was compatible with Illumina's DNA colony sequencing technology.[108,109] In 2006, Solexa was acquired by Illumina for $650m in a stock-for stock merger to complement its genotyping and gene expression platforms.[110] In acquisitions, the liquidity is quite high due to the sale of all or the most of the stock. At the end of the sale, the seller is likely to lose the control of the management. One disadvantage of this approach is that if the prospective buyer is no longer interested in the company, the company might end up with a specialized product. In summary, this approach might allow the seller to make more money than other approaches if multiple bidders are involved. Another key to sell a business involves analyzing the capability of the competitors or the buyers to develop the technology internally and understand their patent position. Hence, the seller should set a realistic price to sell the business at a peak price.

A merger is similar to an acquisition although the main goal is to bring together two companies (rather than one company acquiring the other) to obtain a strategic market position or obtain a customer base and create rapid growth or expand to new markets. The difference between a merger and acquisition is that a merger consists of consolidation of two companies into a single entity, whereas acquisition involves a larger company to take over another company, which may result in the smaller company to dissolve or operate under the parent company.

The initial public offering is rare, rigorous, and one of the most attractive exit strategies. It involves selling a portion of the company in public markets. This approach allows the management and the investors to remain in place and operate the company. If the company is funded by investors with a track record of taking companies to public, the company has higher chances. Additionally, the IPO exit is correlated with the total amount of venture financing and company total sales.[111] However, after the IPO, the company is subject to regulations such as Sarbanes-Oxley requirements, while the performance of the company is scrutinized by institutional investors and financial analysts.[112,113] Case study 4 about RainDance Technologies, Inc. describes a microfluidics company that positioned itself in the genomics market to be profitable and filed for IPO.

The management buyout approach involves recapitalizing and selling the business to the next generation of managers or employees. In this case, the seller finances the sale and allows the buyer pay it off over time. The buyer can finance the transaction through a combination of private equity and/or debt collateralized by the company's assets. One approach is a low-money-down deal, which allows the owner to earn more money than closing. This approach results in immediate liquidity to the seller and shareholders while allowing the company to stay as a private enterprise. An advantage of this approach is that the buyer is likely to preserve the business values, and the transition is smoother.

The lifestyle company approach involves reducing the equities of the company by increasing the personnel salaries regardless of the performance of the company. The activities of the company are kept at minimum, but the shareholders remove a comfortable share from the equities. However, taking out too much money can hurt the company in the long term, and upset investors. Additionally, the way the money pulled out might have negative tax implications. For instance, a high salary is taxed as ordinary income; however, an acquisition can bring money in capital gains.

The reason that a startup company is founded typically influences the exit strategy, and it depends on the objectives of the people who run the business. Nevertheless, as the stock of the owners is diluted by the angel investors and venture capitalists, all the shareholders must reach a consensus to plan an exit strategy. One important consideration is that the inventor must decide whether s/he wants to manage the business. For example, in management buyouts and IPOs, the original team might play the same roles after the transaction; however, in a strategic acquisition, the new owner might replace the management team with its own employees. Hence, strategic acquisition is a good option for the companies struggling with succession-planning issues while management buyouts and IPOs are preferred when the teams want to stay in control of the business. Another significant consideration in choosing an exit strategy is the evaluation of the liquidity needs. For example, while a strategic acquisition often generates an immediate cash payment, IPO is likely to result in a share lock-up agreement, which does not allow selling the shares for up to six months. Additionally, in management buyouts, the seller may receive the liquidity over time. Furthermore, since all shareholders must agree upon the exit strategy, the entrepreneurs should look for partners that will not pressure to sell the company soon, and allow making a decision on the right exit strategy over time. The company's future potential should also be considered before making a decision about the exit strategy. For example, the shareholders might not require immediate liquidity and consider the company's future growth potential. Hence, this influences the exit strategy, which might allow the seller to retain an ownership interest. For example, IPO allows keeping a substantial interest in the business. This also applies to the management buyout, which allows for participating in the growth of the company. On the other hand, an acquisition will generally greatly reduce and eliminate the sellers influence in the future direction and performance of the business. Another consideration in IPO strategy is the Sarbanes-Oxley agreement, which is bureaucratic and costly process to protect investors from corporate accounting fraud.[112,113] In preparation for an IPO, these steps are taken early on, which involves forming an independent board, arranging an independent audit, and modifying the reports to meet required standards.

While liquidation is not necessarily an exit strategy but rather a terminal endpoint, it is a common end of many startup companies. This process requires a company to cease operations, sell the assets and redistribute the proceeds to creditors, employees, and shareholders according to priority of claims. Any proceeds from the assets must be paid to the creditors first; however, the shareholders are always paid last. In the long term, liquidation might jeopardize the client list, reputation of the entrepreneur and the business relationships. A company goes out of business by ceasing operations and liquidating its assets. After the liquidation, creditors are given priority to recover their investments. However, if the company does not have assets, it can file for bankruptcy to avoid further harm by lawsuits that try to collect the debt from the corporation. The creditors may sue the officers as well as the corporation, and the defendants have to appear in court. Not appearing in a lawsuit results in a judgment against the defendant with consequences such as liabilities. Bankruptcy is a slow and inexact legal action that allows a company or individual to pay the debt to creditors by liquidation according to priorities in the Bankruptcy Code. There is clear guideline whether a failed business should file a liquidation (Chapter 7) or rehabilitation (Chapter 11) proceeding; however, this decision is based on the value and type of the assets, creditors, and the management team to oversee the bankruptcy process.[114] In contrast to the direct liquidation in Chapter 7, Chapter 11 (corporate bankruptcy) involves restructuring the company and continue to operate while paying debts. Chapter 11 preserve assets better, and it allows creditors to recover more money as compared to Chapter 7.[115]

Filing bankruptcy may protect assets from creditor action and preserve value for the payment of the taxes. In bankruptcy, the court appoints an official who administers the debtor's bankruptcy estate. The trustee is responsible for the liquidation of the assets, returning equipment, managing the creditors, and allowing the management to leave the company. Under the Bankruptcy Code, the trustee can sell the leases to recover value for the creditors, which is not possible outside bankruptcy.[114] Furthermore, automatic stay prevents creditors from diverting cash, which otherwise might be used for paying taxes, salaries, and guaranteed debts. The bankruptcy has advantages over liquidation such as obtaining increased value for the assets. It also maximizes the recovery and the exposure of management or investors can be limited by addressing debts. Furthermore, the assets can be sold to insiders in fair prices. There are also downsides filing a bankruptcy. For example, bankruptcy may prevent the management to move to a new position in another company due to the reputation that follows, and may also increase the likelihood that a creditor sues individuals.

6. Reasons for startup failures

The number one reason for startup company failure is the lack of market for the product (42%).[116] To overcome this challenge, entrepreneurs should focus on the customer development simultaneously during product development to addresses a niche market. Fig. 6 lists other reasons for failure, including lack of sufficient capital (29%) and an incompetent team (23%).[116] Furthermore, premature scaling has been cited as another significant reason of startup failure.[117] When the initial commercialization strategy does not work, the ability to pivot to a different strategy is key to the success of a startup.

6.1. No market need

A primary reason for the lack of translation of technology to a product is the absence of a true market need. For example, a range of proof-of-concept device exists in the microfluidic literature, though the field suffers from the lack of commercially successful products.[28] Disruptive technologies may lead to products with benefits that are not obvious in the short term. Marketing these high-technology disruptive innovations requires companies to adopt strategies that may seem counterintuitive as compared to those associated with the marketing of a sustaining innovation.[118] For example, microfluidic laboratory assays have long term benefits of reduced volume of samples and rapid analyses. However, benchtop instruments are capable of performing equivalent assays, and hence laboratories are unwilling to shift to new products unless there is a compelling advantage. Such high-tech products have a limited customer base in the short term. Therefore, established enterprises may not enter into a licensing agreement, and a startup may not have sufficient funds to sustain a delayed entry into the market. Additionally, the startup may need a longer period of time to validate their target market than the founders initially expected. This underestimation could lead to scaling up prematurely and ultimately lead to the company's demise. Thus, entrepreneurs should avoid investing into scalability of the product before the product is fully developed. Similarly, companies that have acquired customers should not immediately act on feedback or scale in response to their initial success before validating the market size.

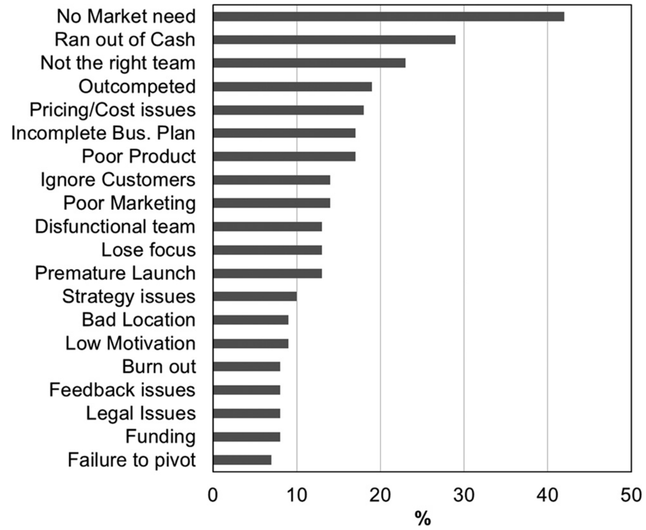

Fig. 6 Reasons of startup failures. Adopted from ref. 116. CB Insights.

Rather than attempting to find a market for their existing product, entrepreneurs should consider an immediate market need when developing their technology. Market-driven startups have strong and consistent growth, whereas product-driven startups eventually reach a point of slow or stalled growth since they do not have the capability to respond to the dynamics of the marketplace. Products that solve a previously unanswered question and target a niche market have a greater chance of successful commercialization, while frivolous products will often not advance beyond the innovator technologist customer base (Fig. 7). ESI† describes Roger's diffusion of innovations theory for high-tech products. Less served markets segments have higher penetrability, but offer lower industry prestige. While many startups focus their

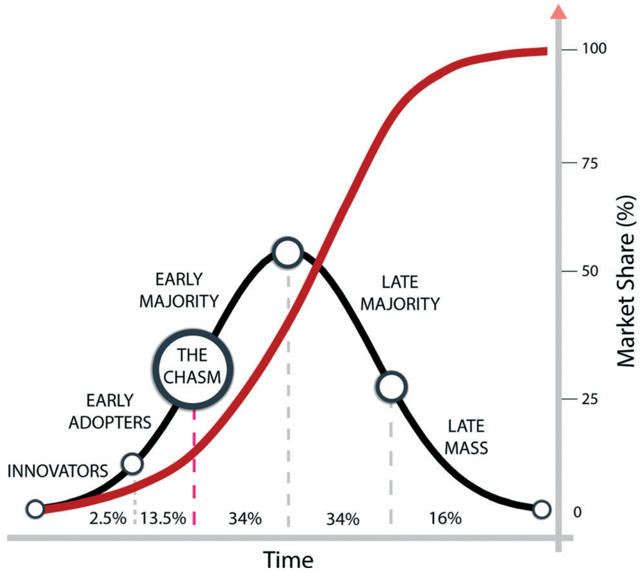

Fig. 7 Roger's diffusion of innovations theory.

resources to entering saturated markets, this may not be the correct strategy in the markets dominated by leading companies. When entering the niche markets, the startups need to question the reasons a similar product does not exist, check their assumptions, and evaluate whether there is a market demand for their product.

Understanding the competitor's performance and the current state of the target market is necessary to build a sustainable business. If a product is ahead of the market, it will not be successful because the customers are not yet ready for this particular technology. Entrepreneurs should also be able to predict trends to ensure that the market for their product will still exist in the near future. Even if the product is designed with the market in mind, the initial prototype may not satisfy the market need, and the product needs to undergo a number of iterations to fit the product to the market. This iterative process forms the basis for the concept of the lean startup model.[119] The lean startup is a validated learning approach that measures and shortens product development cycles by obtaining customer feedback. The concept of validated learning involves implementing an initial idea and quantitatively measuring its effect. This process is followed by a series of iterations until metrics indicate that a specific goal is achieved. Sometimes the product needs to be redesigned completely, indicating that the team did not successfully validate the ideas with customers during the development phase.

The products need to be marketable toward the end user. A common failure of high-technology entrepreneurship is that the innovators often neglect the process of productization. Even if entrepreneurs develop a new technology that has a market need, it will not be commercializable if it is not an extended product that is easily adaptable by the customer. For example, a lab-on-a-chip device should be able to stand alone or be compatible with existing equipment, require no expertise in lab-on-a-chip systems to operate, and offer a substantial advantage rather than an incremental improvement on comparable products. Additionally, the product should be as simple as possible without losing functionality. A common pitfall is for teams of technical founders to overengineer their technologies. However, adding "nice to have" features that do not improve the core value delay the product launch and shrink the time that is needed for building a customer base.

While determining the specific target market, it is important at the design stage to consider the composition of the target customer base. For example, the customer base of a next generation sequencing library preparation system consists primarily of research institutions and biotechnology companies; however, point-of-care diagnostic devices such as the i-STAT system (Abbott Laboratories) are marketed toward hospitals. It is also crucial to determine who would pay for the product. In the case of the diagnostic device, the cost of the supplies necessary to run the assays could be absorbed by the hospital, the patient, or paid through medical reimbursements. The market size and available funds must be sufficient to counteract the costs associated with launching the startup. Before attempting to sell a product or service, the entrepreneurs should run a competitive analysis of the industry, and realistically determine the company's offerings. This may require collecting constructive, objective criticism from potential customers. To ensure the marketability of the product, entrepreneurs should create surveys and alpha test groups to gather information about their customers and the factors that affected their prior purchasing decisions. Although alpha tests are predictive, they do not guarantee the eventual market penetration. The product should have a compelling value proposition to cause the customer to commit to purchasing.

Most entrepreneurs are overoptimistic about marketing deadlines and acquiring customers. It takes more than having a website, product or service to acquire customers. The promotion of the product should begin before the product is finalized. For example, the development status of the product can be discussed in the media and blogs to promote the technology for obtaining early reviews and create enthusiasm about the product. The company's website may even include a form for preorders. Hence, the marketing plan should be implemented at least three months before the launch date. Furthermore, the lifetime value of a customer should be higher than the cost of acquiring the customer. This means that the company should be able to acquire customers for less money than they will generate in value of the lifetime of company-customer relationship. Hence, it is often important to develop commercialization strategies that allow scalability to acquire and monetize customers and at a higher degree than the cost of acquisition.

6.2. Lack of sufficient capital

Another main reason that startups fail is that they exhaust all working capital and cash reserves.[120] Only 4% of companies reach more than $1m in revenue, and 0.4% of all businesses achieve $10m in revenue.[121] The funding requirements should be planned at early stages in the startup to gain key infrastructure and maintain a cash flow for day-to-day operations. Venture capitalists are more likely to invest in a company that has already raised initial seed funds. The Director of Technology Licensing at MIT, Lita Nelsen, stated that one of the largest barriers in the commercialization of academic research is to getting investors to take the risk in an undeveloped and unproven technology.

Entrepreneurs should meet with potential venture capitalists and angel investors at the early stage of product optimization to evaluate initial financial performance. During these interactions, investors look for three main qualities in a startup team to decide on a long-term commitment of funding. Investors want to see the developmental and financial progress of the company. Founders should be able to show the evolution of their success in business with sufficient initial capital that can at least cover the liabilities. These records will prove whether the company has achieved steady growth over time or not. To create even faster momentum, these startups should also setup network of alliances with established companies to access resources including knowledge transfer and shared equipment use.[122] Based on this network, investors will feel more confident in approaching a startup for funding opportunities.

Investors are mostly interested in strategic business plans that can impact large target markets.[123] The entrepreneurs should quantify the impact of their visionary products in terms of measurable metrics. They will then need to come up with a unique business model that converts concepts to a profitable product. Instead of changing the business model several times throughout the development, companies may focus on a "killer" product[124] or a platform technology using an effective business model.[125] Besides focusing on their own vision, the entrepreneurs should avoid losing perspective, and they should seek feedback from venture capital firms and validate their commercialization strategy. However, not all companies are required to have a killer application, but can be based on generic products. For example, microfluidic ChipShop GmbH (Jena, Germany), founded by Claudia Gärtner and Holger Becker in 2002, provides generic and bespoke lab-on-a-chip devices, and services for manufacturing, standardization, and product development.

A primary reason that startups lack sufficient funds and are unable to raise more is that the next milestone was not achieved before the company ran out of cash. The management team should be cognizant of how much cash is available and whether the funds are sufficient to realize the next milestone. Additionally, the management team needs to recognize when to conserve funds and increase spending for financial benefits. The valuation of a startup does not scale linearly with time. At the early stages of product development, management should reduce operating costs and eliminate unnecessary spending. A common mistake is to hire extensive marketing and sales staff when the product is still incomplete and does not meet the market need. An additional financial consideration is being cautious about the expansion of operations after initial success if the business model is not validated. Furthermore, expansion to new and bigger office spaces in upmarket city locations is costly and can have significant impact on the budget. Extension of the business into locations that stretches the logistic capabilities can dramatically increase overhead expenditure. While the funds should be spent conservatively during the initial stages of the startup, once the business model is proven, and the current state of the market and customer base are well-understood, it is necessary to invest a significant amount of capital to reach the milestones and increase the valuation of the company. Case study 5 about Smart Holograms Ltd. presents a biosensor/security company that expanded before proving its business plan resulting in its eventual demise.

Financial management provides a set of tools and techniques that enable the business to control and manage money. Monthly financial reports and management accounts should be prepared, and entrepreneurs should be well versed in financial jargon. During the early stages of the company, the management team can utilize an accounting package to track finances. As the startup grows, and more money is available, they can then consider employing a part-time book-keeper followed by a full-time accountant.

6.3. Incompetent team

The third leading reason why startups fail is due to incompetent management. Poor teams are often weak in strategic areas of company development. For instance, they may build a product that does not meet the market need while carrying out a partially developed commercialization strategy. They are typically limited in executing tasks, managing finances, and remaining on schedule. Importantly, an incompetent management builds weak teams, leading to the inevitable failure of the company. A successful management team is comprised of individuals who are passionate about the venture, motivated, organized, and interpersonally strong.

Investors look for experienced management teams that have a strong track record in industry.[126,127] Ideally, the management team should have experience in technology and have background in the development and maturation of startups.[128] Such knowledge is required in project and personnel management, forming and implementing the mission/vision statements, and the execution of the commercialization strategy. Hence, hiring experienced management or receiving mentoring can improve the chances of the company to be successful. Additionally, startups should present biographies of team members in their pitch presentations to the investors, creating the first convincing impression that the company is based on experience and a sound scientific foundation. It is desired to reach a balance between "friends" and "big names" in the field. As part of the team, the structure of the board of directors and their qualifications should also be outlined. It is recommended to limit the term of the members of the board of directors to keep the direction more focused at early stages, and not allow any member to influence the company to make decisions for his/her personal benefit. The governance principles of management should also be clarified.

In addition to the entrepreneur and the chief scientific officer, management teams should include a strategist, a tactician, a financier, and consultants.[126] The co-founders of these companies should set out the vision of products that address specific needs in the market. The strategist holds research and marketing expertise, and should help position the company into commercial partnerships considering the competitive nature of the business. With a project management background, the tactician should take care of the daily operation principles of the company to meet the deadlines. The tactician should also channel the product according to the regulatory needs of the government and the Food and Drug Administration (FDA). The financier should have experience in banking to help raise capital and aim to increase the stock price for the company as early as possible. The team should designate one person to be responsible for executing the company's critical items of focus and ensure that the company is on track to meet the next target milestone. The management team needs to frequently evaluate the goals of the company and the current progress toward reaching them in addition to assessing the company's mission and vision. Furthermore, the team should constantly question the market need, the impact of the product, the position of the competition, and the strategies toward securing a competitive advantage and commercially successful product.

The startup requires individuals with diverse backgrounds to provide a balanced point of view. For example, technical founders are often motivated in creating interesting technologies that can improve their life styles. However, marketing personnel are needed to ensure that the product is commercially viable and meets the current market need. Balanced teams with one technical founder and one business founder raise 30% more funding, have 2.9× more user growth, and are 19% less likely to scale prematurely than teams with solely technical or business-heavy founding members.[117]

According to Steve Hogan, whose Silicon Valley-based firm Tech-Rx is hired to assist failing startups, the most common reason why companies fail is that they are founded by sole first-time entrepreneurs.[129] The sole founder has many associated difficulties. The company may face issues acquiring investments because a sole founder may be seen as less trustworthy or lacking interpersonal skills. Additionally, creating a startup is a difficult task that is too time-consuming for one person to manage. Benefits of having co-founders include having colleagues with different perspectives to brainstorm ideas and troubleshoot problems. Co-founders can also boost confidence and morale and provide motivation at low points in the company. According to Startup Genome Project, solo founders take 3.6× longer time to reach scaling stage as compared to companies with two founders. Similarly, solo founders are 2.3× less likely to pivot their commercialization strategy.[117] However, it is important to ensure that the co-founders are likeminded in their entrepreneurial aspirations. The partner must be completely committed to the startup, be able to give an equal amount of time or money as the solo founder, and be willing to take financial risks. It was found that successful startups had founders who were driven by impact rather than money or experience.[117]

Lastly, the importance of connections and mentorship should not be underestimated. Each team member should build their own network of influential connections. Connection to mentors, key influential users, industrial partners, analysts, media outlets, and business alliances aid in marketing and play a role in the ultimate success of the business. It was found that investors' assistance in the startup had little or no effect on the company's operational performance. However, having mentors have significantly influence a company's performance and the ability to raise additional funds. Management teams that have helpful mentors and track metrics effectively raise 7× more money and have 3.5× improved user growth.[117]

6.4. Unable to pivot and overpivoting

The ability to pivot the business model until it is proven according to Steve Blank's customer development model can be useful to enter a rapidly expanding or changing market.[130] Customer development is a systematic approach to understanding customer values, and it consists of four steps: (i) customer discovery, (ii) customer validation, (iii) customer creation, and (iv) company building. Co-founders should pivot between the first two stages through a series of iterations to find the right business model. These steps ensure that end-user demand is created and the business is scalable by measuring expected customer behavior against the current market. Hence, customer development should be developed in parallel to the product development.

It is imperative to be able to adapt to a backup plan or new strategy to overcome unexpected challenges. When the initial strategy fails, the management team should be able to quickly pivot to different strategy. While the fundamental technology cannot be changed, the team should shift their application to prevent wasting time, resources, and money. This rapid change requires the management leadership to make quick and efficient decisions and clarify the vision of the company. If this decision-making process leads to delay in meeting the milestones on time and interruptions in operations, the startup will likely fail. Since investors expect rapid returns on their investment, time is a valuable asset during the initial phases of a startup company. Although the initial choice of commercialization strategy does not define a company's performance, generally pivoting to an alternative strategy at a later stage can greatly affect the chances of the business to successfully exit. Startups that pivot their commercialization strategy once or twice can raise 2.5× more money, have 3.6× improved user growth, and 52% are less likely to scale prematurely than startups that do not pivot or pivot more than two times.[117]

7. Case studies

1. Microchips Biotech, Inc. (Lexington, MA) was founded in 1999 as a spinoff company from Robert Langer's laboratory at MIT. The company develops implantable pharmacy-on-a-chip devices that can wirelessly release drugs in a controlled manner.[131] Their technology holds immense potential as pain-free, controllable drug delivery and biosensor technology, in particular for those with chronic diseases such as diabetes and osteoporosis. For example, the development of pharmacy-on-a-chip devices can significantly improve the lives of diabetics, who have to prick their fingers and inject insulin up to five times a day. The company received early funding from Waltham-based Polaris Partners, and Medtronic, and it raised about $75m in venture capital and grant funding, and it has not had a product past the FDA approval for medical devices or booked any revenue.[132] In 2012, the company published its first trial results that showed that their pharmacy-on-a-chip technology could deliver 20 doses to patients suffering from osteoporosis.[133] However, in the same year, the company shut down its research facilities due to lack of funding. The number of employees of MicroChips, which once reached 40, decreased to two in 2013. Recently, the company received a $6.2m funding from Bill and Melinda Gates foundation to develop an implantable electronic birth control device. This funding allowed the company to return to its financially stable status and increase its employees to ten as of 2015, and the company recently hired its fifth CEO. After pivoting to the area of contraceptive implants, the company aims to deliver its first product by 2018.

2. Diagnostics for all (DFA) (Cambridge, MA) was spun out from George Whitesides' laboratory at Harvard University in 2007. DFA as a non-profit company aims to commercialize paper-based microfluidic tests for applications in resource-limited settings.[134,135] DFA has a for-profit subsidiary called Paper Diagnostics, which aims to partner with companies to develop tests for use in developed countries. The proceeds from Paper Diagnostics are invested back into the nonprofit branch of DFA. Whitesides is of the opinion that non-profits such as DFA are needed as large companies in the market are unwilling to lower costs, so academics have taken this issue to their own hands.[136] DFA won Harvard Business School Annual Business Plan Contest and MIT $100k Entrepreneurship Competition in 2008. In the same year, DFA received a 5-year grant from the Gates Foundation, as subcontractor for the development of a Critical Organ Function Test for the liver. The company received funding over $10m from British Government, USAID and the Defense Advanced Research Projects Agency (DARPA) to expand it technology portfolio to applications in HIV testing and environmental monitoring, and diagnostics for the assessment of immunity status against tetanus and measles to support vaccination. The company has conducted two field trials in Vietnam and Kenya in 2012 and 2013, respectively. In 2014, DFA received $1m from Massachusetts Life Sciences Center to fund the development of an Ebola diagnostic test. DFA has pivoted multiple times since its foundation due to the diversity of its funding sources. The company has not materialized a product as of May 2015; however, it represents a unique non-profit model, where the results can make a positive impact in the developing nations.

3. Optofluidics, Inc. (Philadelphia, PA), founded in 2011, is a spinoff company from the group of David Erickson at Cornell University. Optofluidics develops instrumentation for analysis and manipulation of nanoparticles used in the life and physical sciences. At the time of the formation of the company, Erickson's group was primarily involved in photonics and microfluidics. After the publication of a high-impact article,[137] they decided to commercialize the technology that offered nanomanipulation capabilities. His team has filed about 30 patents over the last 10 years through Center for Technology Licensing (CTL) at Cornell. A portion of these patents have been licensed by Optofluidics and subset of the company's broader portfolio. The CTL also optimized their claims and assisted Erickson's team to create commercialization and marketing strategies. At Cornell, faculty are allowed to dedicate 20% of their time to external matters. This allowed Erickson to spend this time on creating and supporting the company. Its co-founders applied for a NSF Small Business Innovation Research (SBIR) grant to obtain seed funding for the company. The NSF SBIR program had several matching programs for external funding that helped them attract early stage private investors. This also allowed the co-founders to maintain significant equity in the company.

Since its establishment in 2011, Optofluidics has worked with investors and development partners such as Bio-Advance, the NSF, the Defense Advanced Research Projects Agency, and the Ben Franklin Technology Partners. The investors guided Optofluidics to sharpen their exit strategy, in which the company targets to generate certain amount of sales before exiting. The company's marketing approach is directed to promoting the product and increasing the visibility of the business to larger corporations. In this process, they constantly communicate with suppliers and strategic partners. Erickson emphasized that the desire to start a company is an important characteristic of an entrepreneur. Having a startup throws academics to the bottom of a business hierarchy. He advises that having an entrepreneurship mind should start early on in the academic career, and having conversations with other entrepreneurs, getting a sense of a business model around the technology, building a customer base, and understanding the exit strategy. In 2012, Optofluidics received Philadelphia Life Sciences startup of the year award.

4. RainDance Technologies, Inc. (Billerica, MA), was founded in 2004 as a spinoff company from the group of David Weitz at Harvard. RainDance develops solutions for genomic analyses and non-invasive biopsy applications. RainDance's direct competitors are Agilent Technologies (A), Illumina (ILMN), and Qiagen (QGEN). Their core technology is based on microfluidic lab-on-a-chip devices and digital droplets.[138] The company holds about 175 patents in its patent portfolio, and approximately 400 patents from strategic deals. Their Digital Droplet technology allows the analyses of cell-based and cell-free biomarkers in cancer, infectious disease and inherited disorders. The company's main products are the RainDrop® Digital PCR System, ThunderBolts™ Cancer Panel, which analyzes 50 gene sequences including tumor suppressor genes and drug resistant targets, and ThunderStorm® Next-Generation Sequencing Content Enrichment Systems, a high-throughput system for production scale laboratories. Their customers include academic and translational research institutions, cancer centers, bio-banks, commercial laboratories, pharmaceutical and biotechnology companies, agricultural and industrial companies, and government institutions.

In its first six years, the company focused on its core technology and developing its capabilities while demonstrating over 40 different capabilities in proteomics and genomics, particularly in single cell applications. At this stage, the company built a strategic partnership with Sanofi to apply their core technology to drug screening and began establishing a customer base. In 2010, company's board of directors appointed S. Roopom Banerjee as the President and CEO. Banerjee's first task was to set a clear vision, reorganize the management and scientific teams, and identify a customer base. His efforts focused on strategic partnerships that enabled RainDance to move beyond technology development and into the commercialization of its products. On the basis of market trends and growing healthcare needs, RainDance targeted a number of applications for automated testing of biomarkers in cancer research. The commercialization strategy of RainDance targeted the research community by creating open source cross-platform chemistries and establishing compatibility with existing digital PCR and next generation sequencing technologies, a rapidly developing field in which \$10b has been invested over the past decade.

To attract investment, the management team pitched the unique attributes of their core technology, the qualifications of their scientific team, and the opportunity in the market. They also emphasized the strategic position of RainDance with quantitative data from their own research as well as published journal and conference articles by their early customers. To attract further investment, they established a substantive value proposition by showing long-term ability to supply innovative products. Since its foundation, RainDance raised \$125m from equities sales, and \$20m in proceeds from debt facilities and investors. It received \$20m in its Series E equity financing in April 2013, and in September 2013 Capital Royalty Partners invested \$35m to support commercial expansion of RainDance's product portfolio.[139] RainDance filed for a \$60m IPO on May 12, 2014, and its revenues increased 78% to \$30.6m from \$17.2m in 2013.[140–142] In addition to its success in financing, RainDance initially executed an innovator marketing strategy with a unique market position but adopted a cost leadership strategy as their sales started growing. RainDance also deployed an aggressive direct sales team that engaged with customers, and their supply chain was supported by distributors worldwide.

Banerjee indicated that the hardest challenge to commercialization is the transformation from a technology into a fully-functioning product. To maintain the company's position in the market, the management team should optimize their patent portfolio and build strategic partnerships to expand within the vertical and horizontal markets. Banerjee believes that the successful exit of a company depends on three main factors: (i) employing a management team that can move from vision to execution, (ii) strategically building a team by hiring top talent, and (iii) successfully managing its finances. In his opinion, entrepreneurs should assess the performance of their company and always be willing to upgrade their team constantly. Hence, this requires the ability to evolve the business and make quick decisions to meet the product delivery milestones.

5. Smart Holograms Ltd. (Cambridge, UK) was a spinoff company, founded in 2001, from Christopher R. Lowe's laboratory from the University of Cambridge. The company aimed to commercialize its holographic sensing technology combined with microfluidic devices for applications in point-of-care diagnostics, environmental monitoring, and security (brand protection and product verification). The company's technology was based on an equipment-free holographic sensing platform, which consisted of diffraction grating embedded functionalized hydrogels.[143–150] As the hydrogels swell and shrink in response to an analyte, the wavelength of the diffracted light is correlated with the concentration.[151–155] Based on its holographic platform, the company developed its Verify-EYE technology for the counter (OTC) pharmaceuticals, food, and cosmetics. The company also aimed at developing glucose-sensitive catheters for monitoring the concentration of glucose in blood in real time. The company received a proof-of-concept grant of £25k from the University of Cambridge to assess the feasibility of creating a new technology, and further received funds from the university's Challenge Fund (£250k), the Small Business Research Initiative operated by the Biological Biotechnology and Biological Sciences Research Council (£216k), a contract from a leading pharmaceutical company (£400k), and venture-capital funding from Portion Capital (£5m).[156] In 2008, Smart Holograms employed over 40 personnel in the UK, held 40 filed/granted patents and seven filed trademarks, and signed co-development deals with blue-chip industry leaders. However, the rapid expansion of the company before identifying a market segment resulted in the depletion of its financial resources in 2009. After ten years, the number of its employees decreased to three and the company directed its efforts toward the development of its hologram-on-a-catheter biosensor. As the company entered 2012, it was no longer able to pay its patent maintenance fees, and it was eventually shut down in 2013.

8. Conclusions

Technology startups from academic institutions have become a major driving force behind high-tech clusters and the global economy. Hence, academic institutions have created technology transfer offices to exploit the knowledge for creating high-value products. However, optimization of commercialization strategies can enable the inventors and academic institutions to extract the maximum value from the inventions and know-how.

The process of turning an idea into a product begins with IP protection, where building an IP portfolio around the core technologies creates a competitive advantage. The protected idea is an unrealized technology, however, and does not hold a value until it is transferred into an extended product, which requires formulating a commercialization strategy. If the technology is licensed by a startup, entrepreneurs should then develop commercialization, financing, marketing and exit strategies with several contingency plans to mitigate the uncertainty of technology.

The initial technology should undergo productization to turn the proof of concept into a viable, commercial product. The most critical step in creating a product is to check the assumptions about customer behavior. Hence, customer development through obtaining feedback from potential customers and validating the commercialization strategy should be carried out in parallel with product development. Entrepreneurs should not wait for the customers to come to them; they must take the lead.

In product development, a typical startup requires multiple investment rounds including seed funding and venture capital. Having a motivated team, a global market need, and a working prototype with validated customer base can increase the potential for obtaining investment. Investors will be more likely to invest in a company that has already raised initial seed funds. The funding opportunities for the upcoming rounds should be sought in advance, and the startups need to bootstrap to reduce the outgoing cash flow. However, a balance should be struck between taking too much or less investment.

Entrepreneurs should also have a marketing plan, with a specific strategy to cross the chasm and gain the attention of the early majority customer base. Even products that are scientifically sound with an obvious unmet need may not be able to cross the chasm without effective marketing if, for example, the global market demand is prohibitive.

Entrepreneurs should plan an exit strategy, such as an acquisition, merger, or IPO. This requires maintaining a vision and questioning the company's vision while making the company's technology attractive to large corporations and the general public. Achieving a clear vision is an interactive process in product and consumer development, which requires pivoting the commercialization strategy multiple times. The execution of these tasks can only be achieved with strong leadership that can make quick objective decisions.

The difference between successful entrepreneurs and those who are not boils down to the concept of productivity. To achieve this skill set, entrepreneurs may need to fail many times to refine their work habits and test their will to create an extended product that will serve the society. Hence, successful entrepreneurs are persistent and are motivated by impact of their ideas. To become productive, all successful entrepreneurs understand that time is the most important commodity, and they apply the best of their ability to achieve every single milestone in the shortest time possible to create a positive social impact.

Author contributions

A. K. Y. designed the project and wrote the manuscript. L. R. V. contributed to Commercialization Strategies, Marketing and Sales, Reasons for Startup Failure, and A. F. C. contributed to Financing and Funding Sources. S. H. Y, L. R. V., and A. K. made intellectual contributions and edited the manuscript.

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