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ARTICLE

Do maritime innovation centers produce results?

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Abstract
Over the last decade, numerous innovation centers, accelerators, and incubators have been developed globally to facilitate startup firms within the global maritime sector or as it is a part of what is called the "Blue Economy." Several of these industry-focused centers have a venture funding connection as part of their offerings. The intent is to spur development of new technologies to be incorporated within the maritime logistics industry or totally reinvent processes that have been in place for decades. Ideation competitions have been developed in some instances and entrepreneurs are urged to participate in programs that will provide networking opportunities and access to funding. Despite this development, the number of maritime startups that reach minimum viable product for introduction and investment remains small in comparison to other industries. This study will examine the current state of maritime innovation centers around the world and consider the value of these programs in the evolution of the industry toward digitization.

Keywords Maritime technology · Accelerators · Blue Economy · Marine industry · Supply chain

1 Introduction

The maritime world is a globally competitive, complex, multi-billion-dollar industry. Given its importance as the means of conveyance for over 90% of cross-border trade, there has been much attention paid to efforts to revitalize the marine industry as an engine for innovation and technology. The demand for innovations within maritime businesses is driven by external forces such as compliance requirements, sustainability initiatives, and internal management decisions on the need to introduce new technologies and "disrupt" longstanding practices within the industry. The need to incorporate more technology-driven changes within an industry that has

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often been considered "slow-footed" has created interest in how to introduce and promote new startup ideas like those in sectors such as financial services and healthcare management. Startups in digital ship operations and management technology have grown markedly at this writing (Hamanaka 2022).

To facilitate the development of startups, there has been a growing interest worldwide in the establishment of pitch competitions, incubators, accelerators, innovation centers, and maritime clusters to bring together entrepreneurs, industry influencers, and investors to accelerate adoption of transformative technologies for maritime-related businesses. The maritime industry is considered a segment of the "Blue Economy" for sustainable use of ocean resources as a source of economic growth, improved livelihoods and jobs, and ocean ecosystem health (Smith-Godfrey 2016). This comes at a moment in time when multiple technologies are moving out of the realm of mere ideas to actual implementation. They include leveraging big data, automation, artificial intelligence, decarbonization initiatives, blockchain, additive manufacturing, Internet of Things, self-guiding transport, and other means that can serve to unlock massive potential and create new ways to design and move global goods and services.

Despite all that has been written about the Blue Economy (Wenhai et al. 2019; Smith-Godfrey 2016), including an influential OECD report on the ocean economy (OECD 2016), there has been a lack of understanding by many investors of the significant potential economic benefits of better utilization of the oceans and more efficient supply chains. The maritime sector is still largely unknown to the larger investment industry due to its small size relative to other larger economic areas with higher potential returns. Maritime transport represents a global industry that encompasses ships, ports, and all the ancillary industries attached including finance, insurance, logistics, and technology but with little visibility to the general investor community. The globalized nature of the industry and the small, insular, close-knit number of key firms within it have made it difficult to achieve scale for startup companies seeking to innovate within the maritime environment, despite calls for a transformation of the industry to embrace digitalization and environmental sustainability.

This paper seeks first to answer how maritime startups can benefit, if at all, from startup development centers and whether these entities lead to startups gaining investment and becoming mature firms. Numerous programs have been started by both public and private interests to spur new technologies. Startups that make successful exits are celebrated by venture capital funds and several high-profile startups are backed by large private equity firms. The most successful firms for investors turn into *unicorns*, firms with a valuation of over $1 billion. While these are applauded within the industry, there is much evidence to suggest that the number of successful maritime startups relative to the number of supporting entities such as accelerators is quite small (Failory 2022). At present, the average time for a startup to make it to an exit is 9–11 years (Abdullah 2019; Chubb and Zangrando 2019). This is considerably longer than the 5-year rule of thumb for venture capital's desire to exit.

Maritime startups are not uniform. There are distinct developmental differences between software and analytic ideas and artificial intelligence (AI) innovations that are technology related and hardware innovations that require more specialized equipment. We suggest that software solutions tend to reach public notice and

investment sooner than equipment-oriented startups that have less visibility outside of the industry. Startups within the global supply chain and logistics sphere have had significantly more visibility over the COVID-19 pandemic period (2020–2022) due to high profile efforts to mitigate congestion at ports (Vartabedian 2022).

Secondly, we suggest that there are systemic issues within the marine industry and startup centers that must be dealt with to allow for a more robust development of new startup technologies, akin to that of fintech and biotech for example. Development of attractive maritime solutions to warrant serious investment is in the interest of the overall world economy. Within the United Nations, 17 sustainable development goals (SDGs) adopted in 2015 are #7 Affordable and Clean Energy; #8 Decent Work and Economic Growth; #9 Industry, Innovation, and Infrastructure; #11 Sustainable Cities and Communities; and #13 Climate Action that are directly affected by what maritime startups might be able to achieve (Stig Pedersen 2018).

Third, we posit a division of innovation industries into Hard, Soft, and Mixed classes. We look at how investments in the recent past have flowed into these classifications, and where. Financiers and investors need to be sold on the value of investment in maritime equipment and services rather than on software, despite the slower time to return. Properly chosen investments might yield a more certain return than software investments that may build clientele earlier but come up against a need for expensive support later on.

Fourth, we look at the dispersion of accelerators throughout the world and where maritime ports are in relation to accelerators. Accelerators are essentially a developed economy solution and tend to be located near financial centers. Ports, however, are in both developed and underdeveloped areas. This imbalance reduces the likelihood that innovations will be helped by accelerators at ports in underdeveloped nations. Yet ports are where innovations to deal with a host of logistics issues could well be valuable.

Fifth, we suggest a way for innovation centers to promote incipient startups with proof-of-concept solutions for the maritime industry such that they can be widely introduced and fast tracked for industry pain points in search of new technologies to provide solutions.

We conclude with some thoughts on how the startup maritime technology has evolved over the last decade.

2 Startups and assistance

Section 2 deals with the nature of startups and accelerators, especially in relation to maritime and supply chain industries. We discuss the different types of innovation spaces and current means of startup identification. We identify the interest groups and their relation to the maritime industry. While barriers to entry are minimal, there is real competition for promising maritime startups. What types of startups attract the most money flow? Who are the investors? What types of investors prefer each type? Which startup business models match with which kinds of funding and which type of client company?

2.1 Maritech

The perceived problem of introducing innovation within the maritime industry is that it is still operating in a traditional environment and is being surpassed by other industries with greater ties to the tech or financial community. High development costs, strict compliance regulations, and a risk averse mindset on the part of ownership have previously hindered innovation efforts (Konrad 2019). The maritime business, like other operationally oriented businesses, has the typical operational mindset to save money rather than waste it. Since many innovations do not become viable products, investing in them is risky.

Researchers have suggested the need for more collaboration within the industry and introduction of organizations from outside the industry (Doloreux and Malancon 2008; Perunovic and Vidic-Perunovic 2011). The greater maritime industry has high barriers to entry and has remained closed and insular to many new entrants. Recently, there have been suspicions of collusion and price fixing that resulted in new legislation: The Ocean Shipping Act of 2022 in the USA (Ocean Shipping Act of 2022). Innovation in the maritime industry has been traditionally based on experiential learning and incremental innovations where each new product tends to be a development of a previous successful effort. Rather than reinventing and disrupting the industry, many entrepreneurial efforts are linked to how to optimize what is already in place (Anonymous investor conversation 2022).

Developments in digital technologies have lowered costs and have led to major improvements in some industries. Two of note are financial services with *Fintech* (refers to the integration of technology into offerings by financial services companies to improve their use and delivery to consumers) and *Biotech* (a science-driven industry sector that uses living organisms and molecular biology to produce healthcare-related products). The term *Maritech* has been used by some for *defining* the future of global shipping through transformation, often digital, but also through improved operational systems. Digitization of the industry is underpinned by platform technologies, defined as a group of technologies that are used as a base upon which other applications, processes, or technologies are developed. In computing, a platform is the basic hardware (computer) and software (operating system) on which software applications can be run, which could be on a desktop or a massive data center on the internet-connected "cloud" (Yijan et al. 2021).

The boom of tech startup businesses coming from the Silicon Valley area of Northern California in the last three decades and other worldwide tech hotspots has resulted in enormous publicity and wealth for founders of successful startups. With low barriers to entry, individuals with software coding skills or hardware design skills could build startups into scalable, innovative ventures through the introduction of *minimum viable product* (MVP), products with enough features to attract early-adopter customers and validate a product idea. Within the realm of the IT industry, the ethos was to build a product quickly with a *value proposition*, an innovation, service, or feature intended to make a company or product attractive to customers. To become successful, there would often be multiple failed attempts and a high failure rate of startup operations.

The risk-averse maritime shipping industry with high-value assets and long depreciation schedules has been less able to innovate new ideas quickly (Tijan et al. 2021; Zangrando and Chubb 2019). Startups with roots within the IT industry lack a deep understanding of tasks within the maritime industry. They create "solutions" but are not sure how the problems are viewed by maritime users and consumers. With that said, the industry C-suite leadership is fully aware of the need to introduce new technologies and innovations or risk losing business to large new entrants such as Amazon that are highly technology-driven (de Yonge 2021). High public supply chain problems afflicting the shipping industry since the COVID-19 pandemic began in 2020 have spurred greater interest in maritime technology (Miller 2022).

The maritime industry is quite concentrated geographically. There are a few large firms, and there are only a few places in the world where clusters of maritime firms are based (Ollivier 2021). These often are located around ports, or around centers of capital such as New York City, Boston, San Francisco, London, Copenhagen, Shanghai, Hong Kong, and Singapore. Maritime innovators, driven by the need to solve specific operational problems, are more often near major seaports or logistics centers. This geographic pattern is unlike that of chip manufacture and innovation. The innovators are often collocated with the production centers, or at least historical production centers. Silicon Valley in the 1970s to 1990s was home to a significant number of large chip manufacturing factories. Later, chip manufacture itself has dispersed through the world; however, some of the firms have remained headquartered in Silicon Valley. The same can be said of such centers as Taiwan, China, Korea, and Japan. Entrepreneurs were very close to the target customers and could relatively easily develop relationships for testing or proving the technology they were developing. One advantage of software entrepreneurship is that its center of activity has relatively less need to be located close by the potential users. Hardware innovation needs to have convenient test beds as it develops its solutions, with plenty of opportunity for trial and error in real situations.

2.2 Incubators, accelerators, innovation centers, and clusters

An assortment of different venues exists for maritime startups to develop innovations. What is beneficial for each startup will be different and will have much to do with their geographic location and access to expertise to develop prototypes, a potential interested customer base, and access to capital. At this writing, there is a lack of collaboration between these venues, although there has been much discussion about the need for doing so (Gothburg 2022).

Incubators—Business incubators and accelerators serve a similar purpose for startups as reefs in an ocean serve for young marine creatures. A reef provides a sheltered space for marine creatures early in their lives. Incubators and accelerators provide a safe haven for young companies to test their business models, build relationships, and access cheap resources. This allows the startups that live within these institutions to focus on growth before they go it alone. The concept of a business incubator providing office or maker space has been in place for a considerable time, with a number of incubators constructed for economic development purposes,

commercialization of technology developed in academic institutions or research institutes, and private ventures focused on selecting and supporting high-potential ventures (Lukosiute et al. 2019). Most incubators are run as non-profits charging nominal fees for space and generally do not take equity in the startups they host.

Accelerators on the other hand provide active mentoring to cohorts of ventures during a limited time. This may include investment in exchange for equity (Cohen and Hochberg 2014; Pauwels et al. 2016). An accelerator helps a business with developing a marketable product or service in its more adolescent stages. This is a more intense phase of growth, and most accelerators are typically only several months long in duration. Accelerators are more likely to take some equity in the companies that they host in exchange for the services they provide (legal, human resources, finding investors, accounting, etc.). A number of established companies within the maritime industry have developed accelerators loosely tied to the corporate parent with the objective to involve promising startups in close coordination with overall corporate ventures (Garcia-Herrera et al. 2018). The line dividing incubators and accelerators has become blurred over time and there are no hard and fast rules that characterize each, with a number of entrants operating both as an incubator and accelerator. There are also distributed accelerator hubs that are connected by Zoom and other video platforms.

Innovation centers can operate somewhat as a hybrid of the incubator and accelerator, providing some space or point of contact like incubators, but also incorporating hands-on education and mentoring, referrals, or introductions. Innovation centers often have individuals with a deep knowledge of the industry in leadership positions and connections to "early seed" investors including specific maritime venture capital funding. A problem that innovation centers often have is developing a business model that provides a source of sustainable funding for their mission to facilitate maritime startups. Some centers have relied upon paid events such as meetups or ideation competitions while others have quasi-government backing. Finally, some centers have internet sites with information available only to paid subscribers (note: one of the authors of this paper founded a maritime innovation center in 2017 that has since been closed).

Marine clusters have been created in some regions of the world to leverage interconnected companies and associated stakeholders within a geographical area. For obvious reasons, seaports have served as natural hubs for clusters due to their infrastructure and businesses that they support. Smart cities, urban technology groups, and specific collaborations based upon ports, climate change, and larger Blue Economy initiatives such as aquaculture have also incorporated marine startups within their framework. Incubators and accelerators may work as part of the marine cluster (Floysand et al. 2012).

2.3 Conferences, meetups, hackathons, and ideation competitions

Within the startup ecosystem are several different venues to pitch ideas to the public and potential investors. The maritime world has numerous conferences worldwide that are utilized for information sharing and networking of individuals within the

field. Most of them are held on an annual basis and will have noted speakers, panel discussions, exhibits, and new technologies exhibited. There are a few with startups at the core of what they do: the annual SLUSH entrepreneurship event in Helsinki for example. Several conferences/events have incorporated a "demo day" to pitch ideas and attract investors. Competitions with industry judges determine the best ideas with winners sometimes getting money but more often, it is about gaining visibility. Mentors for projects may also arise from these events.

More formalized sets of regular events are often called *meetups* and designed to bring together a group of people sharing a common interest. A meetup is usually initiated and arranged around a specific group focus. The tech community in the USA and Europe utilizes meetups to network and share information. Since the maritime industry is smaller, it often will be grouped with logistics and supply chain meetups. Startups and early-stage companies are encouraged to pitch their ideas at meetups.

A *hackathon* is collaborative event often associated with the IT world but now introduced within the maritime sector as well. These day-long or longer events will involve programmers, software developers, designers, product managers, domain experts, and others who will collaborate intensively in teams on a software project. The goal of a hackathon is to create a functioning software or hardware product by the end of the event. An API (Application Programming Interface) is often developed. Projects are judged by a panel of experts and winning ideas can often be well rewarded.

Ideation is the process of generating and developing new ideas to solve a problem or improve a product, process, or service. Public and private sector organizations commonly engage in ideation with the public or their customers. Challenge and prize competitions can gather ideas from the public, including experts, academics, students, and the private sector, on how to solve a problem. Sometimes the ideation phase is the first of several stages, where ideas are refined for specific requirements. In both hackathons and ideation competitions, data sets, use cases, and problem descriptions are needed to focus teams on industry needs. Startups often will design products for perceived needs that do not exist yet in the marketplace, rather than the key *pain points* needing solutions by industry.

2.4 Investors and funding techniques

Raising money and building the support to get an idea off the ground are challenging in any industry but particularly within the maritime industry. Several incubators and accelerators within the supply chain logistics area will provide limited funding for startups to develop their business models. Within the maritime field, there is a small number of investors who have industry knowledge and can provide adequate capital for early-stage startups. Meeting these investors often involves getting invited to one of the numerous maritime-themed conferences in the USA, Europe, and Asia that have events created for startups to pitch ideas to concentrated groups of investors. The recent global pandemic limited conferences to virtual presentations; however, the background of the entrepreneur and the experience of the team can be a means to

gain introduction. In addition, there is a series of steps that most startups undertake to realize the capital needed for development.

Angel investors are usually high net-worth individuals who provide capital for a business startup in exchange for some type of equity and are the first place other than personal connections that founders will pursue. Angel investors will provide support to startups at conception (lead investment) and will vary in their rigor and due diligence prior to providing capital.

Venture capitalists (VCs) are investors employed by a risk capital company where they invest other people's money and angels invest their own on their own terms. Angel investors can act very quickly whereas VCs will require meeting the expectations of multiple partners before making a decision on whether or not to invest. Often VC partners or decision-makers are former founders of successful startups. They may or may not have expertise in the domain of a new startup they evaluate.

Angel investors will have varied time horizons over which they expect to recover their investment. VCs usually have a predetermined time frame over which they expect to *cash out*—be able to return investors' money with a profit. The cash-out usually happens when the startup firm is either bought be another firm, or "goes public" via an initial public offering (IPO) on a public stock exchange. Both types of investors understand that the probability that a given startup will return their money is small; they are successful when an occasional startup they back is relatively highly successful, returning much more than the averages suggest.

Early-stage investors and seed capital—Early-stage investors are people and companies who provide funding for startups when projects are just beginning or still in development stage. They provide "seed capital" to new businesses to provide enough funding to get the venture started and prove the business concept. Entrepreneurs typically need to develop a strong business plan, do market research, and design product to meet the needs of potential customers. Given the speculative nature of many ideas, early-stage investors may require a large stake in the company, given the high potential of failure, to get to proof of concept or prototype for introduction to customers willing to test a new product.

Venture financing usually takes place in "rounds," which have traditionally had names and a specific order. There is a seed round, then a Series A, then a Series B, then a Series C, and so on to acquisition by another firm or IPO. None of these rounds is required and, for example, sometimes companies will start with a Series A financing (almost always an "equity round" as defined below). Most seed rounds are structured as either convertible debt or simple agreements for future equity (SAFES, see below). Some early rounds are still done with equity, but they are the exception.

Corporate venture funding involves larger companies investing in and supporting entrepreneurs, such as taking minority equity stakes, either directly or through venture capital funds, as well as other innovation tools, including incubators, accelerators, and developing internal innovation—"intrapreneurship." Several of the major maritime firms now provide corporate venture funding as part of their overall business.

Convertible debt is a loan an investor makes to a company using an instrument called a convertible note. That loan will have a principal amount (the amount of the investment), an interest rate (usually a low rate of 2% or so), and a maturity date

(when the principal and interest must be repaid). The intention of this note is that it converts to equity (thus, "convertible") when the company does an equity financing. These notes will also usually have a "Cap" or "Target Valuation" and/or a discount. The effect of the cap is that convertible note investors usually pay a lower price per share compared to other investors in the equity round.

A *SAFE* (Simple Agreement for Future Equity) allows startups to close with an investor as soon as both parties are ready to sign an agreement and the investor is ready to wire money. The SAFE saves legal fees and reduces the time spent negotiating terms of investment. There are no expiration or maturity dates. SAFEs have become one of more common investment vehicles in startup investing because of the transparency and simplicity for agreement between founder and investor.

Crowdfunding involves online efforts to collect money from a group of donors to raise capital. There are a growing number of vehicles to raise money, with well-known sites such as Kickstarter and Angi and smaller more specific sites such as Indiegogo and SoWeFund.

SPAC—A special purpose acquisition company (SPAC) is essentially a shell company set up by institutional investors with the sole purpose of raising money through an IPO to eventually acquire another company. Startups with actual sales and activities would be the best candidates for this type of fund raising. SPACs have no commercial operations; the only assets are money raised in its own IPO, and additional funds contributed to the SPAC by private investors. This looked to be a new means of raising capital in high-growth sectors like technology until scrutiny over valuations and who is benefitting created uncertainty for investors (Klausner et al. 2022).

Grants from research foundations—The National Science Foundation (NSF), Office of International Science and Engineering (OISE), and similar entities provide small amounts of funding for innovators to test out market applications for their products. These are usually startups developed within university-based research settings with concepts vetted through publications, intellectual property protection, or government agency support.

Deal flow is a term used by investment bankers and venture capitalists to describe the rate at which business proposals and investment pitches are being received. Investment firms need a deal flow to be able to guarantee their investors a decent return. Specialists will look at where deal flow has come from and where there is an existing relationship. Established incubators and accelerators are looked at for possible deals. A *curated deal flow* stems from the need for investors to procure knowledge from individuals with skills and expertise within the field who can identify worthwhile startups for further investment (Jain 2022).

Changing business models—The maritime industry is driven by a focus on operational efficiency and system integration. There are very few truly new business models in the maritime sector but the potential for change is more apparent with the need to provide solutions to difficult problems such as decarbonization. A key reason why disruptive business models are noteworthy is the potential payoff if they succeed. Disruptive innovations tend to force competitors to change their system of working, which may impose serious costs for them. Among the most valuable of the new business models is Maritime IoT (Internet of Things). It is predicted that the

connected ship market will more than double in the next 10 years to over 14 billion dollars in value, a 225% growth by 2030 (Gomersall 2021).

Unicorns—In the entrepreneurial ecosystem, a unicorn is a company that reaches a value of one billion dollars via some of the stages of its capital-raising process. The sectors of healthcare, e-commerce, fintech, biotech, and internet software are the most dominant in terms of number of firms reaching unicorn status (see Section 2.5 for more detail). The maritime industry is experiencing a great deal of digital transformation that will propel firms involved in this aspect to become highly valued. The problem with many innovations in the maritime sector is that a high degree of capital expenditure is necessary to start activities with longer-term investment time horizons and smaller profit.

2.5 Recent startup investment flows

We analyzed a dataset U, obtained from Crunchbase (CBI), a data source for start-ups and investors (CBI 2022), detailing unicorns from 2007 through 2021. From Pareto plots for 2016 through 2021, we analyzed the investment valuation flows and counts of unicorns in different industries identified by CBI. Pareto plots clearly indicate the industries accounting for the top 80% of count or valuation. Examples of plots for 2021 appear in Fig. 1a and 1b. These plots reveal how investors regard the strength of the industry for investment and the choice of industries over the years.

The Supply chain industry is where non-software maritime investments might be found. The proportion of non-software investment in supply chains is not clear, since some software platforms, such as load matching, visibility, and brokering platforms, could be classified as supply chain. Supply chain appears at the bottom in 2016–2017. It rises to fourth in count in 2018, the highest place it appears. While there was an uptick in supply chain investing again in 2020 during the COVID-19 congestion news, in 2021 it is sixth highest and just makes the top 80%, far below fintech, e-commerce, health, and internet software, though close to cybersecurity. We next classify industries and discuss the patterns in more detail.

3 Innovation class and industries

The type or class of innovation is important in determining what kind of accelerator or incubator is useful for the startup enterprise. For our purposes, innovations can be in one of two classes, hardware and software, which we call Hard and Soft for short. Soft innovations involve the use of computer algorithms as a primary source of the use case interaction and the value added; they may include substantial changes in systems, practices, and routines at the adopting organization. While the names of these software-based innovations may change, the premise is the same. Such techniques as artificial intelligence, optimization, analytics, data mining or data management, and internet or cloud-based business systems fall into this group.

Hard innovations involve the use of electric, mechanical, or other equipment to assist people in logistics activities. These would include robotics, equipment such as

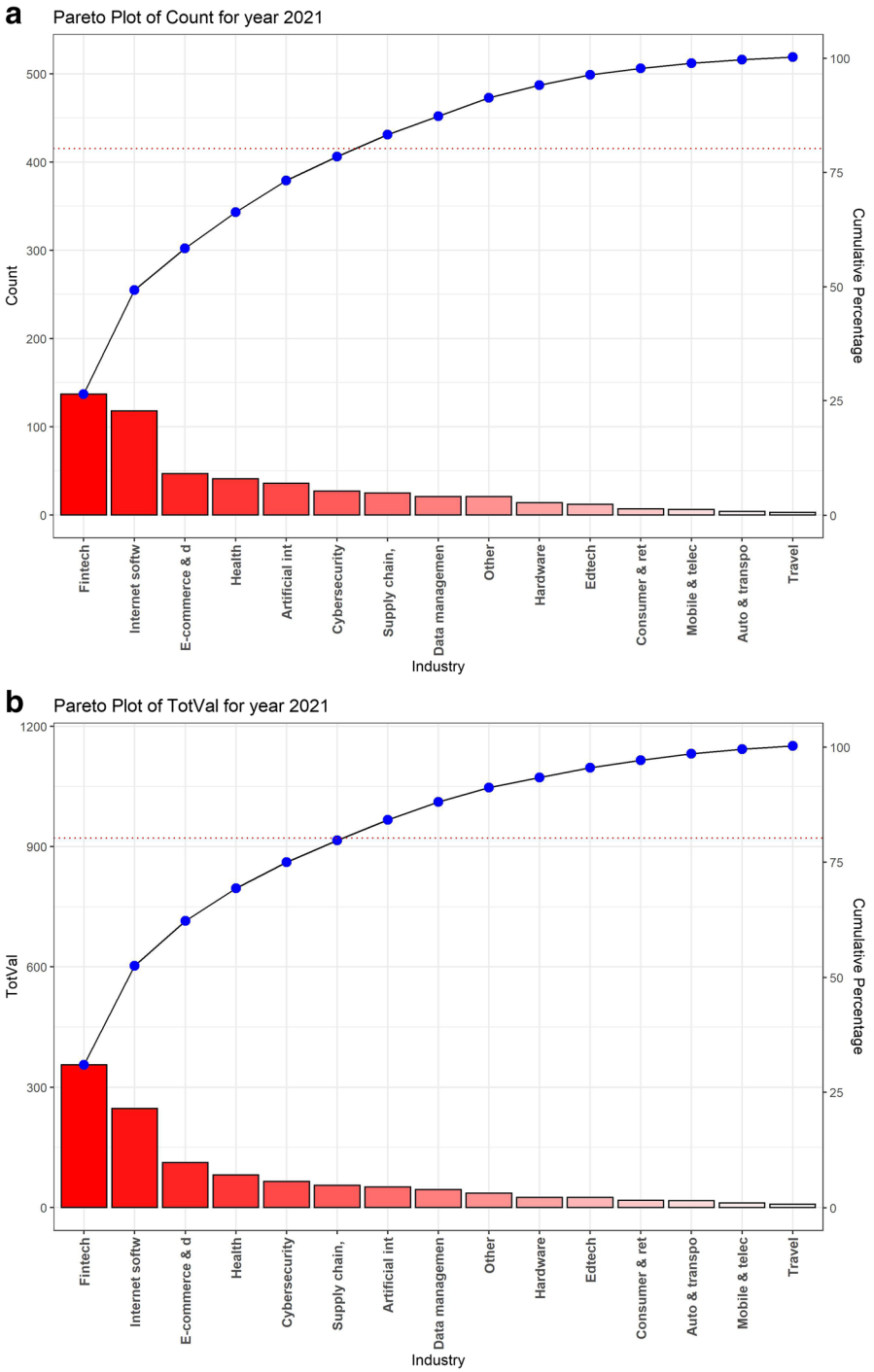


Fig. 1 **a** Pareto plot of count of unicorns by industry, 2021. **b** Pareto plot of total valuations of unicorns by industry, 2021. Source: author calculation from CBI (2022)

movers and cranes, on-board equipment such as sensors, or devices and systems for navigation, communication, and maintenance.

Of course, some innovations include both hard and soft components and a binary classification is overly precise. For instance, an IoT sensor firm may supply both the sensors, hardware, and the software and communications to track and visualize them. Similarly, there is sometimes not enough information about how an innovation operates to say whether it is primarily hard or soft. An example might be an e-commerce innovation, or a mobile or telecommunications innovation. In the absence of details, we might not be able to say if it is Hard or Soft primarily. We posit a "Mixed" classification to capture some of this ambiguity.

3.1 Modeling innovation class

How can we model innovation class? We analyzed dataset U, which contains over 1000 unicorns. Unicorns are appropriate to choose because they have realized products and actual customers using them. Their market valuation shows that investors are willing to bet on their continued and possibly greater success, and they show that investors have found the innovations compelling enough to invest money to help them create markets.

The schema for U contains columns giving Company, Valuation, AddDate (date added to the unicorns list), Country, City, Industry (one of several fixed terms), and SelInvestors (some selected investors in this unicorn). Some of these industries are readily classified as Hard or Soft. Others are not clear. We divided them into three classes: Hard, Soft, and Mixed, using this rubric, and added this column to the data in U. Our classification appears in Table 1.

Many criticisms can be made of this classification, and it is not accurate in many cases. For example, a company producing e-commerce software might be misclassified as Mixed, while a company classified as health might really be producing software rather than testing equipment. We believe our classes are biased toward the Hard and Mixed end of the spectrum, meaning that some of the Hard and Mixed enterprises should be classified as Soft on the basis of product content.

3.2 Class and investment

Based on our class identifications, we show Fig. 2 to demonstrate how the innovation classes have fared in recent years. The data support our conjecture that venture and investment capital prefer Soft class firms.

The Soft class began to dominate unicorn valuations in 2017 and has expanded since then. We interpret this to mean that Soft class firms have an easier time obtaining funds, because they require funding to turn into unicorns. Hard class firms peaked in 2018, and then again in 2021.

Figure 3 shows that the preponderance of investments and therefore valuations are relatively small. Soft firms are preferred and reach the higher valuations in general, but even with a log plot, the large valuations are scarce and small ones predominate (Fig. 4).

Table 1 Classification of industries in U. Source: author based on CBI (2022)

Industry in dataset U	Class assigned by authors
Artificial intelligence	Soft
Auto and transportation	Hard
Consumer and retail	Hard
Cybersecurity	Soft
Data management and analytics	Soft
E-commerce and direct-to-consumer	Mixed
Edtech	Soft
Fintech	Soft
Hardware	Hard
Health	Hard
Internet software and services	Soft
Mobile and telecommunications	Mixed
Other	Hard
Supply chain, logistics, and delivery	Hard
Travel	Hard

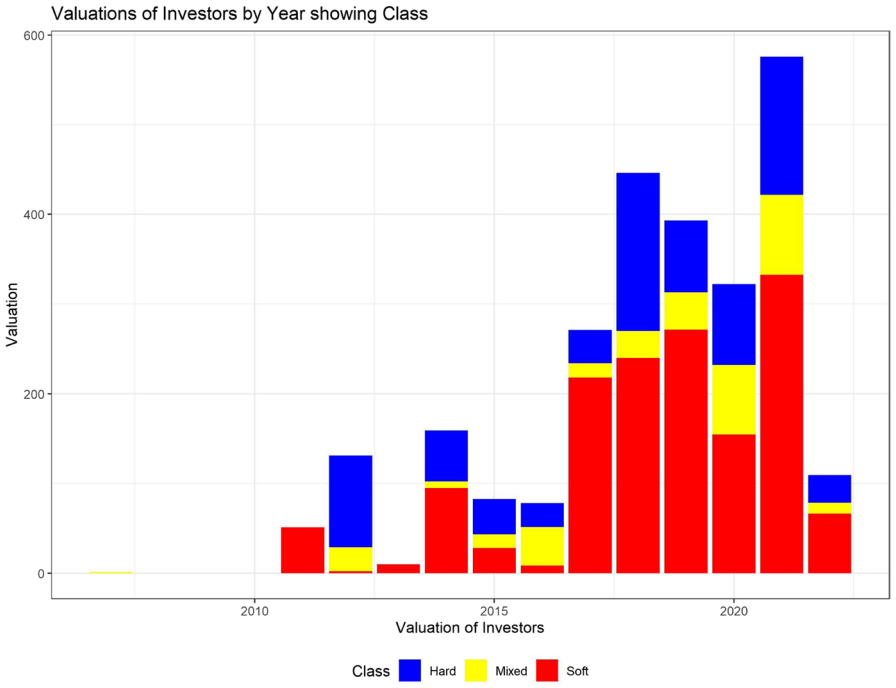


Fig. 2 Unicorn total valuations by class and year. Source: author's calculations

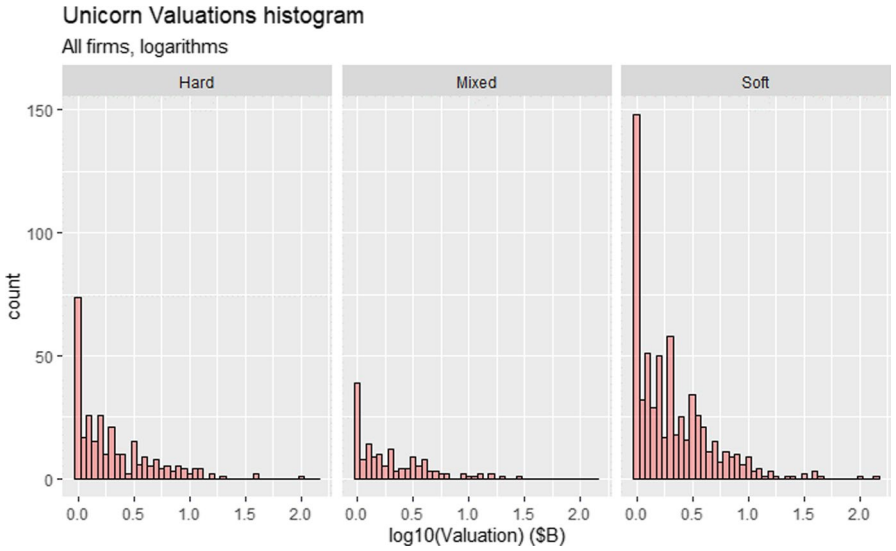


Fig. 3 Unicorn valuations by class histogram; x-axis is $\log_{10}$ (valuation, so that 2.0 represents $100B valuation). Source: author calculations from CBI dataset

The propensity to small investments and valuations is shown clearly here, regardless of class. A regression of $\log_{10}$ (valuation) on time shows decreasing valuation over time. Another way to show this is to plot the totals of valuation by quarter over the period of the dataset. We see this in Fig. 5. It also makes clear that the Soft class has dominated since 2017. The current trend seems to be lower valuations, and more firms.

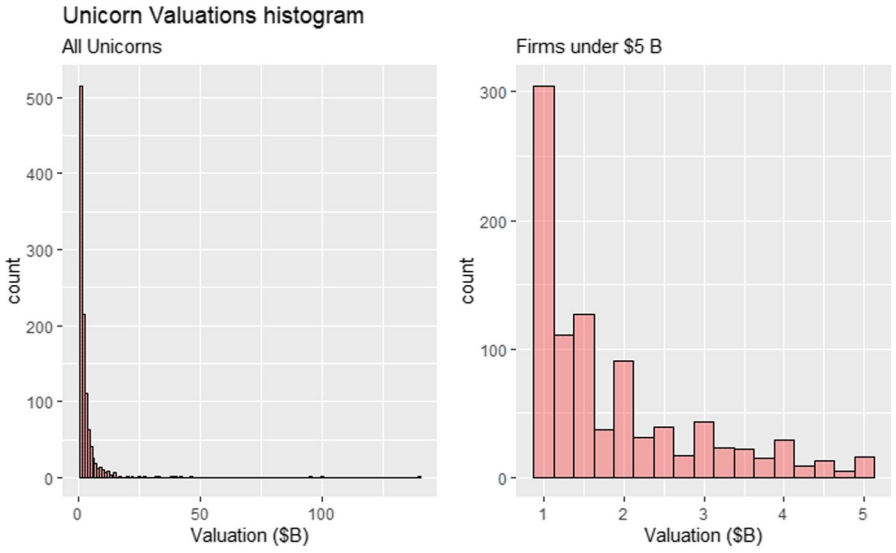


Fig. 4 Unicorn valuations, all, and less than $5B. Source: author calculations from CBI data

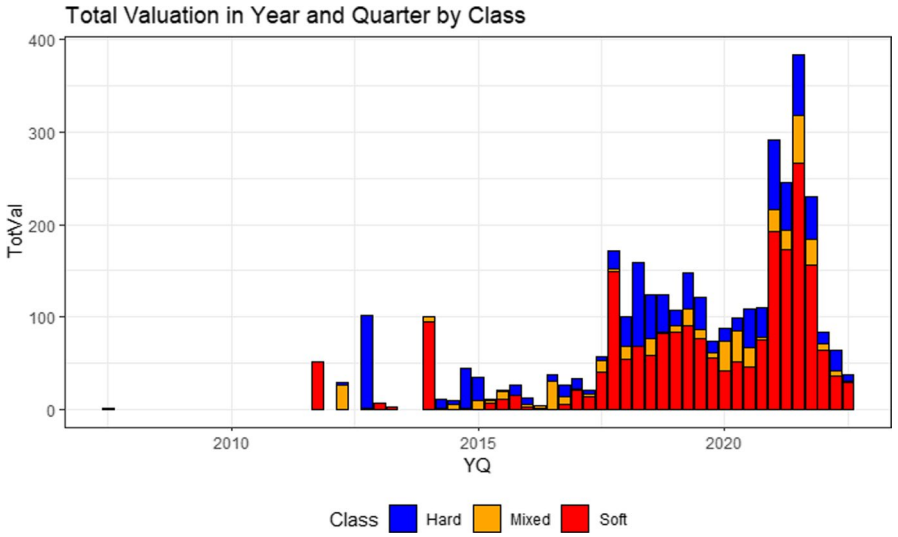


Fig. 5 Unicorn total valuations by quarter and class. Source: author calculations from CBI data

3.3 Where does investment go?

At this writing, investment in maritime startups has gone to one sector above all the others, digital technology applications that provide visibility. This would include data analytics, machine learning, and artificial intelligence technologies. For instance, in Chicago over the last 3 years, there have been quite a few logistics tech startups (WBC 2022). But the funding is mostly for software-related firms (Table 2).

Our research suggests that successful unicorns in maritime/supply chain tech are quite small as compared to fintech, internet software and e-commerce startups, and several other classes. Investors in new technologies have a bias toward software innovations, the Soft class variable, due to their ability to be introduced and scale faster than hardware innovations where a test bed is often required.

Many of the issues facing the maritime industry are difficult to build solutions around that are scalable to the appetite of traditional venture capital. Maritime hardware technologies need a maker and/or testing space that is usually on the water as well as extensive testing iterations and a working prototype before market adoption can even be considered. While some non-university incubators/accelerators have the

Table 2 Chicago logistics tech investments in the last 3 years. Source: (WBC 2022)

Growth capital raised by segment	2019	2020	2021
Freight tech	$95.3 M	$704.6 M	$1.06B
Warehouse tech	$0.7 M	$1.1 M	$8.6 M
Last mile delivery	$4.3 M	$91.2 M	$31.7 M
Sensing, telematics, and hardware	$1.3 M	$1.5 M	$30.7 M
Other e-commerce	$4.5 M	$68.0 M	$205.5 M
Other supply chain software	$56.3 M	$20.2 M	$40.5 M

requisite resources to assist startups, there are often laboratory facilities or specialized tooling needed that is only present in a handful of global locations.

Given that venture capital will not find many startup maritime logistics firms that fit the typical profile for an attractive investment, it may be useful to consider what are the criteria for success. Innovations that truly drive change in long-standing business procedures in the maritime industry can only be successfully introduced over a period of years, not quarters. The most successful maritime innovation, the ocean container, was first introduced in 1956. It would take fully two decades from introduction before containerization was adopted on a widespread basis and another decade before ocean vessels were completely reconfigured for large-scale movements (Levinson 2016). The most beneficial capital investments for the industry must be provided to small "bootstrapped" firms that can provide workable solutions for the industry (Johnson 2022). Key areas of interest within the maritime industry looking for market solutions are shown in Table 3.

3.4 Industry, class, and investment size

We graphed total valuation of unicorns from database U by industry and year in Fig. 6. Market valuation of unicorns is flowing toward fintech and internet software in 2021. Supply chain only makes a significant entrance in 2021, its first jump since 2018.

Table 3 Maritech areas of innovation interest. Source: author

Innovation area	Incomplete description
Trade facilitation	Freight forwarding, customs broking, and trade document management
Ship operations	Applications for safety, efficiency, visibility, or crew welfare
Ship management	Crewing, training, bunkering, and fleet optimization tools
Port management	Port optimization tools, cargo handling systems, community systems, and collaborative management platforms
Robotics and process automation	Automated yard and loading/unloading equipment
Decarbonization	Alternative fuels, renewable energies, propulsion methods, and auto-generated reports on SOx emissions for vessels with scrubbers
Fuel and bunkering	Pricing, locating, ordering, measuring, contracting
Cybersecurity	Protection against threats to onboard and supply chain software and hardware
Compliance	Leveraging big data for compliance with port state authorities and customs
Augmented reality	Remote troubleshooting through smart devices
Drone delivery	Drone delivery of supplies replacing launch vessels
3D printing and 3D scanning	In-port 3D printing of marine products (e.g., spare parts)
Autonomous ships	Control and management of ships combined hard and soft innovation
Internet of Things	Connected and monitored vessels and cargo
Blockchain applications	Single source of validated transactions in conjunction with other innovation areas
Process automation	Order automation, robotic process automation, and chatbots

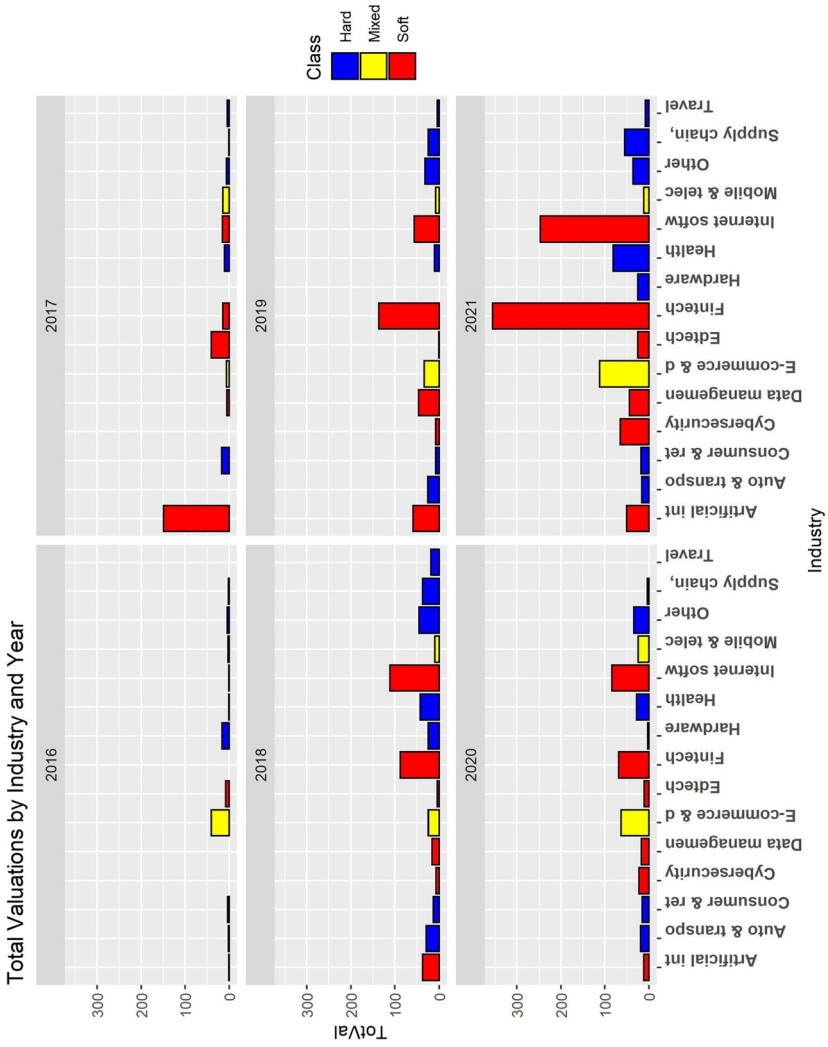


Fig. 6 Total valuations by industry and year. Source: author calculations from CBI data

4 Location

4.1 Proximity to maritime settings

The nature of innovation has implications for the location of an innovator, and by analogy an innovation center suitable for it. Software development and hardware development have different needs.

4.1.1 Software development

Software development can occur in places remote from the potential users. The internet makes it easy to test iterations and use cases. Software development tends to cluster near sources of talent as well as near user decision-maker headquarters and sources of funding.

Talent clusters in the field of information technology grew organically in the USA, in areas such as Silicon Valley in California, Route 128 near Cambridge/Boston, and the Research Triangle near Chapel Hill, NC. Spin-off ventures have propelled recent growth in additional areas such as Austin, TX, and New York City. Incubators and accelerators have served as "test beds" for their technologies in these locations. The same is true in Europe and Asia with the Silicon Valley model being followed in numerous countries (Clott 2020). The agglomeration of firms, nearby universities, finance, and organizations for collaboration has been studied and documented by numerous researchers (Nathan and Overman 2013; Porter 1998).

4.1.2 Hardware innovations

The global shipping industry needs hardware as well as software innovations. Test beds for assets tend to be in maritime-specific areas such as Hamburg or Oslo with already established engineering firms where prototypes can be developed. Unlike software, a significant investment is usually necessary to move hardware to fruition, e.g., a minimum viable product, a configuration that will actually perform the physical work expected of it. The location geography supporting those needs for maritime tends to be related to existing seaports with nearby water access. In contrast to maritime software innovations, the hardware developments emphasize optimization of existing technologies rather than posing new business models. Firms in the Hard space tend to be more tightly coupled with user partners who can provide a testbed. They will also tend to be monitored more closely by users with an operational mind set—meaning each expense is carefully considered before being spent. There is thus more conservative investing linked closely to progress at each step of the development. This distinction makes Hard innovations more likely to require proximity to a port or yard or other maritime logistics operating center.

Many technological innovations do not get off the ground because potential entrepreneurs (the founders or innovators) are trying to get into an insular industry without an "in," a personal connection to the practitioners or subject matter experts (SMEs) who are potential users or designers of use cases for the industry firms who might be clients. The need for that "in" is due to the need to access deep industry knowledge. The relation

between proximity to ports and the "in" factor is not clear cut, but closer proximity would certainly be an advantage, and its advantage would be greater for Hard innovators.

Maritime software and hardware innovation has also developed from "Silicon Valley type" spin-offs to areas that are often adjacent to major global maritime business concentrations. A feature of many maritime startups is founders who come from consulting and IT positions within the maritime industry. Key support for maritime software needs to be aligned with the innovating firms, as well as with those who might take a financial interest. Several maritime ports in Europe as well as Singapore have recently developed innovation hubs where incubation and acceleration spaces are located. This may lead to the problem of too many innovation centers competing for too few maritime startups as compared to other sectors of the economy (Rua 2022).

4.2 Visualization: are accelerators near ports?

To identify accelerators and incubators, we located database A, containing over 2500 of them, from around the world, from Cerdeira (2022). To simplify terminology, we will call observations in this dataset accelerators. For ports, we used the World Port Index (NGA 2021), which we call database W. We prepared an interactive map showing accelerators in red and ports with a HARBORSIZE of either large (coded as L) or medium (coded as M) in blue. One can zoom, pan, and choose an OpenStreetMap layer which shows elements like streets, towns, roads, and cities. The map can be viewed at this link: http://drbrucehartman.net/innovation%20centers/Accelerators%20and%20Ports.html

4.3 Proximity analysis

We conducted a detailed analysis of proximity by calculating the number of accelerators within a radius of 20,000 m of each port. We used the haversine formula of geodetic distance to measure the radius. The position of each accelerator/incubator is given by geocoding latitude and longitude of the city and country in the data, using the OSM geocoding facility, rather than the exact position of the installation. We used OSM geocoding capability (OSMF 2022) for database A. Ports have latitudes and longitudes specified in the database W and presumably reflect the port location accurately.

We chose 20,000 m, which is approximately 12.43 miles. This seemed like a distance close enough to allow meaningful long-term collaborative interaction on the ground with maritime and port users, yet far enough to allow choices of different types of space for entrepreneurial organizations. Based on one author's (Hartman) experience in Silicon Valley entrepreneurship situations, that distance would allow visits within a day even considering traffic conditions near ports yet would allow choosing a location not physically at the port. A total of 30,000 m or 18.66 miles might be too far. Future research could study the frequency of accelerators as it depends on the radius; obviously, a larger radius would catch up more accelerators. However, since we only know their location by city, there is some error.

One fact that emerges immediately is that accelerators are a product of the developed world. Ports, however, occur in both developed and less developed areas. We made histograms showing the quantity and density of accelerators near ports for different nations and areas.

The following figures show the frequency of accelerators near large ports worldwide, and for the USA, UK (coded GB), and EU. Tables show the ports and accelerator counts for the highest few.

First, for the world, we plotted the fraction of large ports with the given number of accelerators. For visualization, we omitted all ports with over 32 accelerators. Table 4 shows the omitted ports, a short list in only a few places; two financial centers in the USA, one in the UK, and Singapore and Tokyo, also financial centers with many incubators of all types.

Figure 7 shows that over 50% of the remaining large ports have no accelerators, and just about 80% have no more than 1.

In the USA, we have several ports with a high number of accelerators, since the accelerators concentrate in these large high-tech cities. Figure 8 shows the distribution of ports with number of accelerators, removing those with more than 40 accelerators. Both Brooklyn-New York and San Francisco-Oakland are hotbeds of entrepreneurial activity, and those ports have 121 and 104 accelerators, respectively, in the radius. The next highest, Boston, has 39.

Tables 5 and 6 show similar data for the UK (coded as GB) and China-Hong Kong. In Norway, only Oslo with 11 accelerators nearby occurs. No histogram is needed; there are too few.

Figure 9a, b, and Table 7 show similar data for the EU countries. Over 23 ports, about 55%, have no accelerators nearby. Only 10 ports have over 3 accelerators nearby. No port in the EU has more than 25 accelerators.

Note that many large EU ports have at least one accelerator, but many of the high-frequency ones are also tech innovation centers and financial centers. It is not at all clear that the accelerators in Barcelona for example are oriented toward marine hardware. They might foster marine-related startups, but most likely in the Soft class.

Table 4 World ports excluded from density plot. Source: author calculation

Ports excluded from histogram			
Port_name	Index_No	Country	Count
Brooklyn	7630	USA	121
New York City	7640	USA	121
London	31470	GB	116
San Francisco	16300	USA	104
Oakland	16340	USA	104
Johor	49982	MY	43
Keppel (East Singapore)	50000	SG	43
Jurong Island	50017	SG	43
Tokyo Ko	61380	JP	40
Boston	7250	USA	39

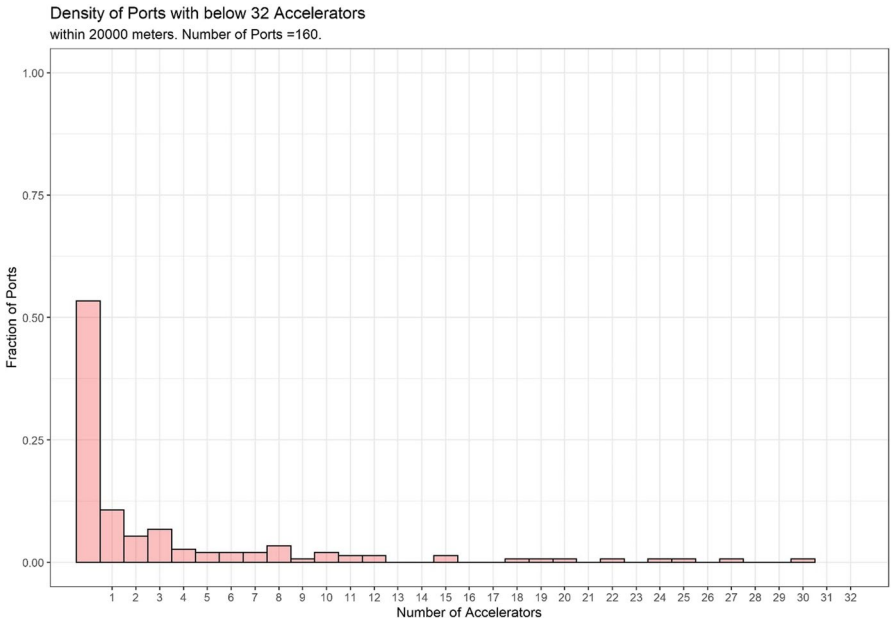


Fig. 7 Counting world ports with accelerators. Source: author calculation

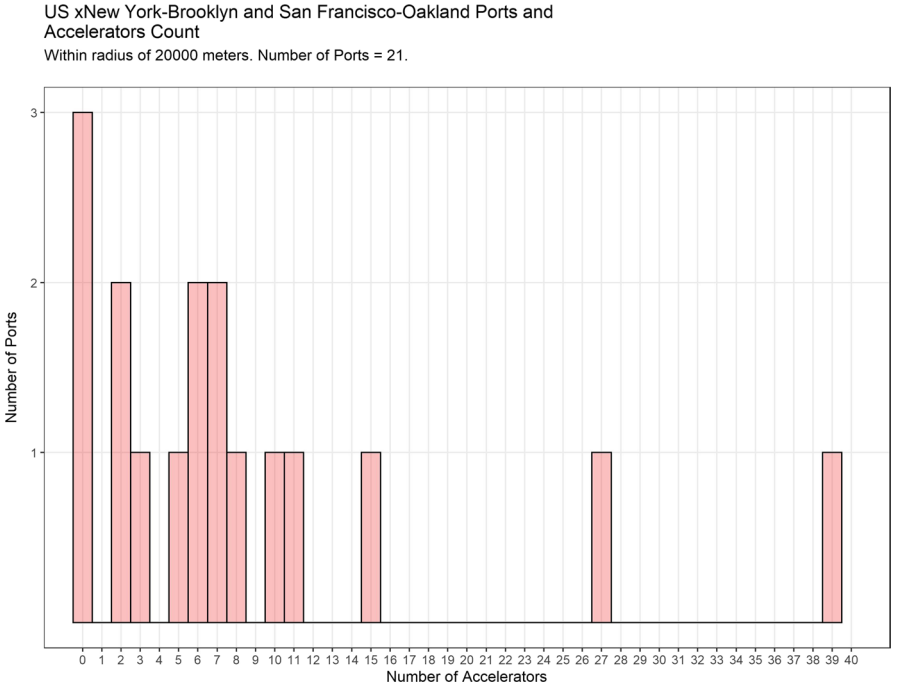


Fig. 8 US port and accelerator distribution. Source: author calculation

Table 5 UK ports and accelerators. Source: author calculation

Large ports for UK			
Port_name	Index_No	Country	Count
London	31470	GB	116
Manchester	34700	GB	3
Southampton	35580	GB	1
Liverpool	34690	GB	1
Dundee	32170	GB	1
Teesport	31720	GB	1
Belfast	33770	GB	0

Copenhagen in Denmark (country code DK), a nation with substantial maritime interests, has 10 accelerators and is therefore likely to find accelerators helping Maritech firms. Amsterdam and Rotterdam in Netherlands (NL), also major port cities, have 19 and 4 accelerators, respectively, and should rank high in fostering Maritech startups.

Of Mediterranean Asia and Africa areas with large ports, Istanbul (TR) has 15, Beirut (LB) 4, Alexandria (EG) 2, and Izmir (TR) 1. No others have any close accelerators. Israel (country code IL) is an interesting case. There are quite a few accelerators in Israel, but no large or medium size ports. Thanks in large part to one maritime innovation center, the DOCK, based in Haifa, Israel is developing a maritime tech ecosystem with worldwide partners.

Future research could try to identify which specific accelerators tend to foster marine industry startups, Hard or Soft.

4.4 Proximity findings

Accelerators tend to be in developed economies. Those near ports concentrate in financial centers, rather than maritime centers, though some of those financial centers also have large ports. And over 50% of all ports have no accelerators near them. So, a relatively small number of places are most likely to host Maritech firms. For software tech firms in the maritime and logistics arena, this may not constitute an obstacle. For Maritech that requires testing on ships or maritime logistics installations, the shortage of accelerators to serve them represents a lost opportunity, both for the maritime industry and for financial interests.

Table 6 CN-HK ports and accelerators. Source: author calculation

Large ports for CN-HK			
Port_name	Index_No	Country	Count
Hong Kong	57840	HK	24
Shanghai	59970	CN	8
Dalian	60250	CN	1
Qingdao Gang	60140	CN	0
Tianjin Xin Gang	60190	CN	0
Lon Shui Terminal	57775	CN	0

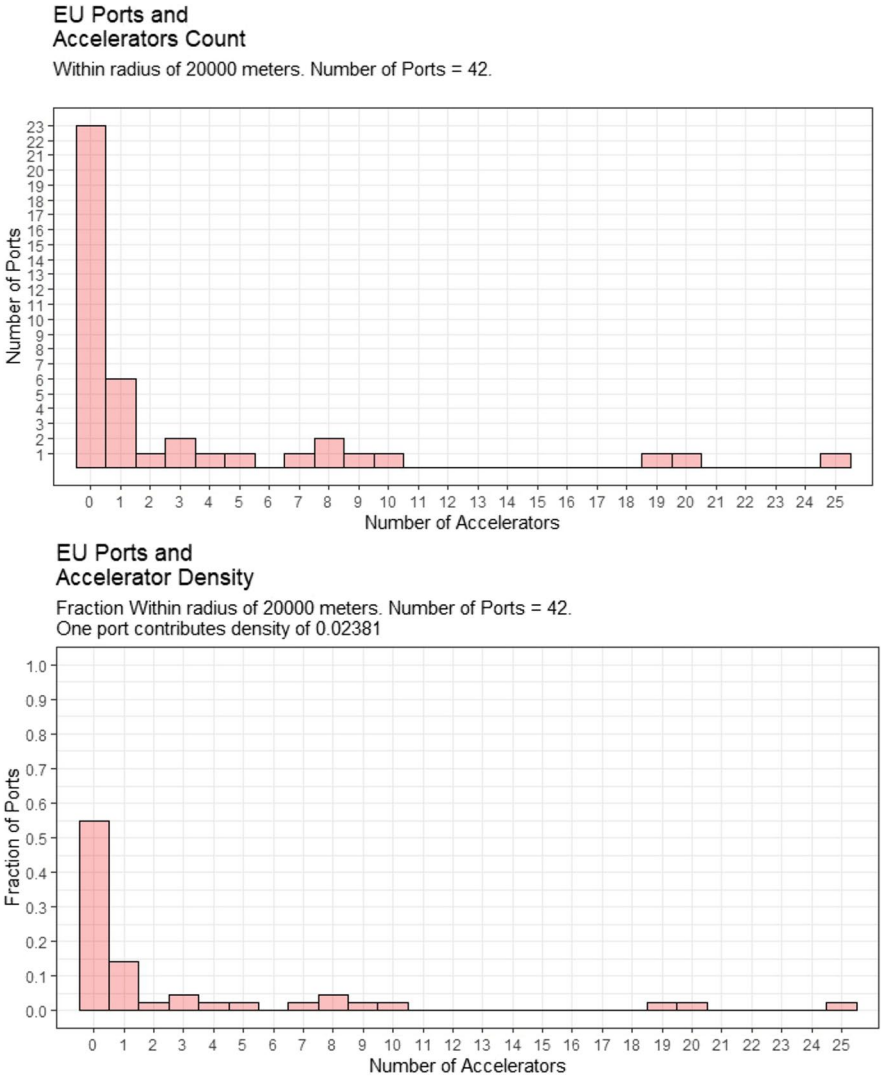


Fig. 9 **a** EU ports and accelerators, count histogram. **b** EU ports and accelerators, density histogram. Source: author calculations

5 Capital flows and innovation centers

We suggest startups need to be measured both by financial success of the inventors and investors and by their contribution to meeting and exceeding needs in the maritime supply chains they address. Understanding that capital flows where the returns are (and that is not quickly in maritime startups), there needs to be some new thinking about what types of assistance an innovation center can provide. Venture capital funds specific to maritime technology are few and most startups are thinly capitalized with a need to develop a positive business case to present to prospective customers before adoption.

Table 7 EU ports and accelerator counts; all ports with at least one accelerator. Source: author

Port_name	Index_No	Country	Count
Barcelona	38550	ES	25
Lisboa	37990	PT	20
Amsterdam	31060	NL	19
Kobenhavn	29230	DK	10
Tallinn	28480	EE	9
Hamburg	30780	DE	8
Helsinki	28190	FI	8
Stockholm	25380	SE	7
Piraievs	42230	GR	5
Rotterdam	31140	NL	4
Riga	28610	LV	3
Malmo	24210	SE	3
Port of Rouen	35850	FR	2
Napoli	39960	IT	1
Oulu	27520	FI	1
Tarragona	38540	ES	1
Kotka	28230	FI	1
Antwerpen	31250	BE	1
Goteborg	24020	SE	1

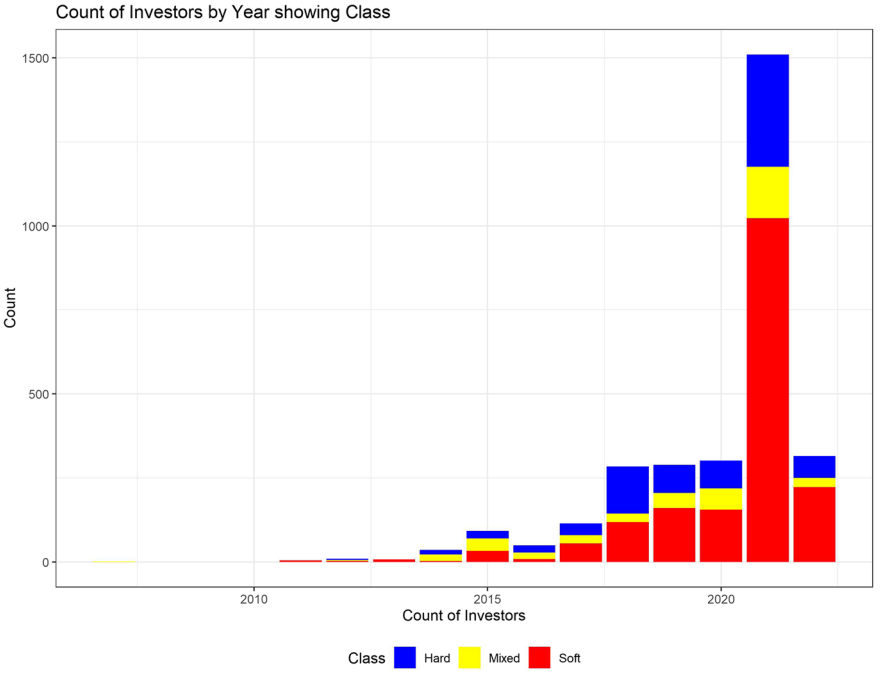
The maritime market is too small and too slow for most VC firms. Traditional incubators and accelerators will often take on cohort groups in limited rounds only after startups commit to working out of a specific location for a period (1 month or more). There is also a finite number of startups that are mature enough to justify the more advanced services of accelerators. Ascertaining market demand for product is also a prerequisite of for-profit accelerators under pressure by VC investors to have deal-flow.

5.1 Investors and class of investment

Figure 10a shows the count of investing firms over the past few years and Fig. 10b the valuations they created. It is easy to see that the count and valuations have grown, but Soft industries have benefitted from greater investment. Investment firms have a big tendency to favor Soft investments, especially today. The number of investors has also grown greatly. Still, we will argue that a few firms make the vast quantity of investments.

Figure 11 shows the major investors and the counts and valuations of their investments. For clarity, we limited each list to the top 20 or so in terms of total valuation invested in unicorns. Table 1 shows industries and their classifications.

In Table 8, we report counts of investors with the mixtures of classes of industries chosen. The data come from the plots in Fig. 11. The progress to essentially all red, or Soft, investments is striking. Most of the Hard investment is coming from China. In 2016, most investors chose either Hard or Mixed investments. Large investors were from China or were investing there. To reach the top investors, the list took valuations bigger than only $0.65B. Investors chose mostly soft investments thereafter.



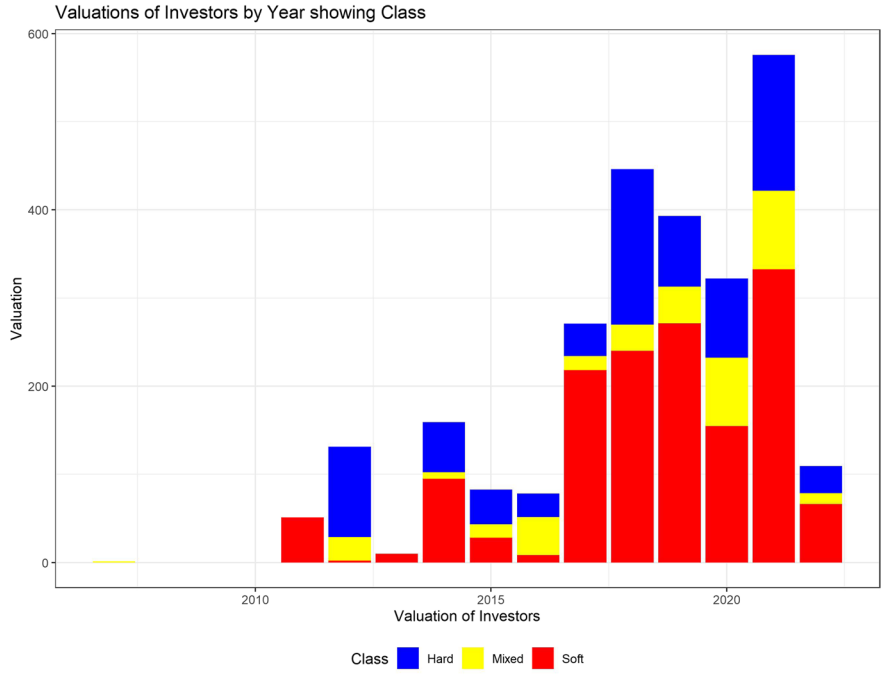


Fig. 10 **a** Count of Investors by year, with class in color. **b** Valuations invested by investors by year, with class in color. Source: author calculation from (CBI 2022 [1])

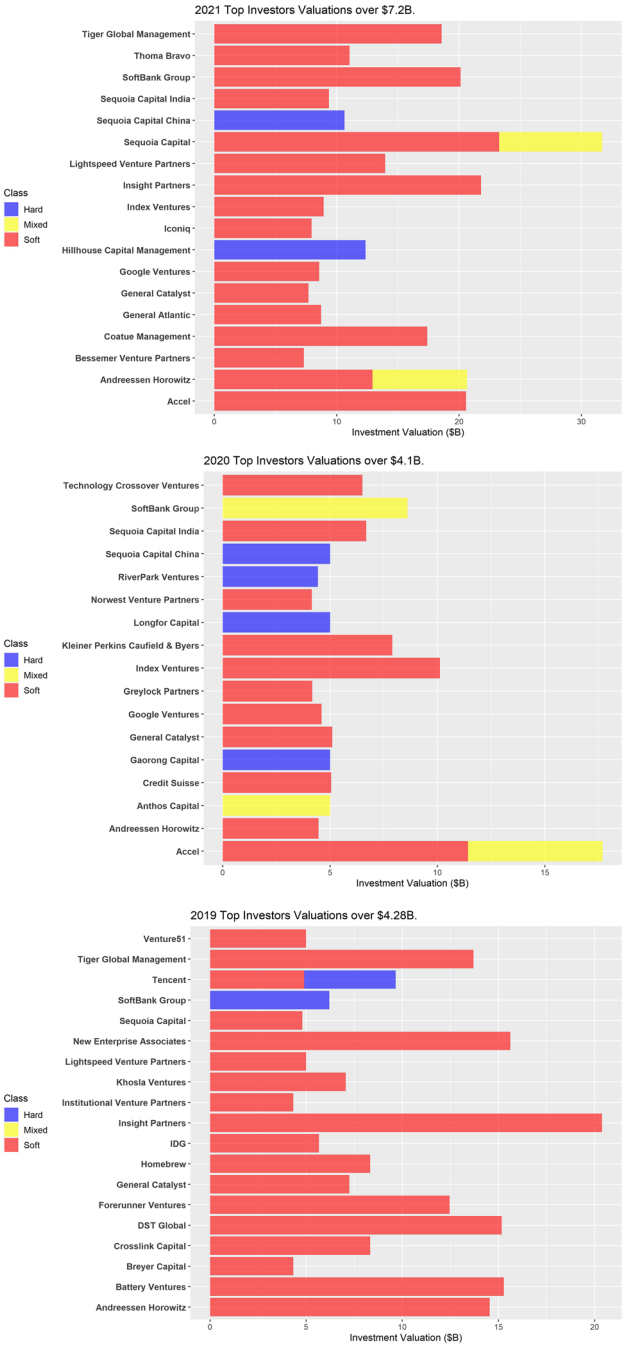


Fig. 11 Top investors and valuations 2016–2021. Source: author calculation from CBI (2022)

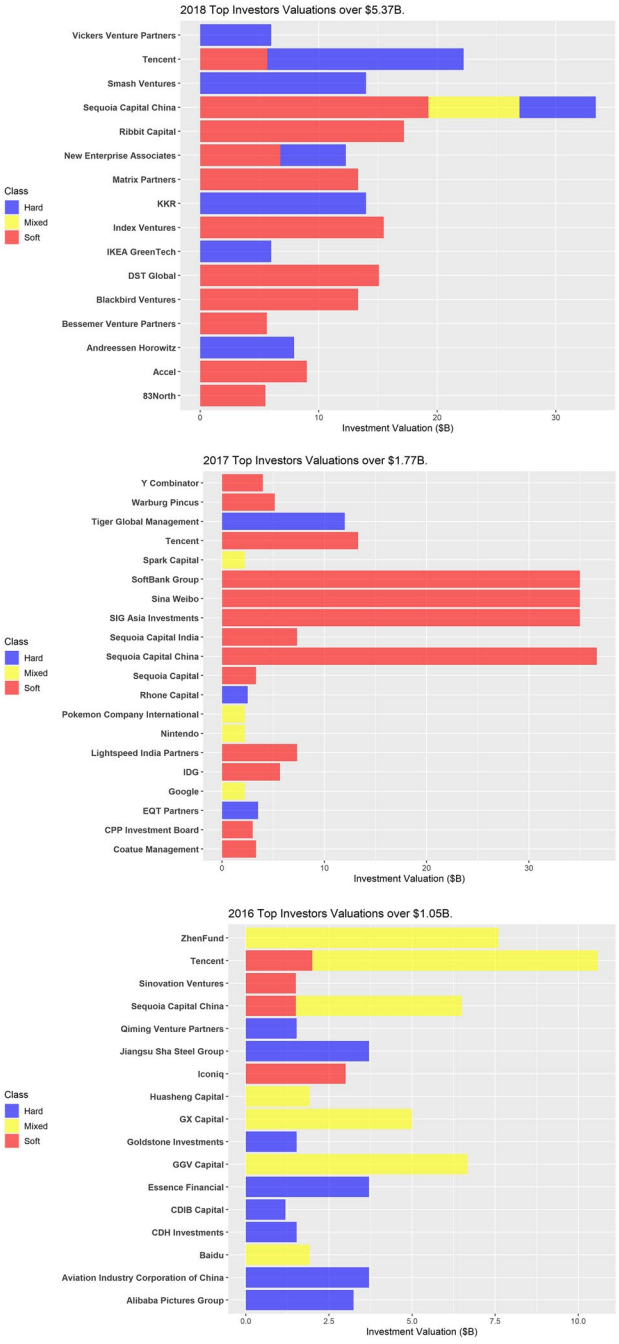


Fig. 11 (continued)

Table 8 Top investors 2016–2021. Source: author calculations from Fig. 11 plots

Year	Investors	Hard	Mixed	Soft	Hard and Mixed	Soft and Mixed	Hard and Soft	All classes	Min valuation ($B)
2016	27	11	11	1	1	2	0	0	0.65
2017	27	6	4	17	0	0	0	0	1.43
2018	24	6	2	13	0	0	2	1	4.25
2019	28	3	0	23	0	0	2	0	3.19
2020	24	3	6	13	1	1	0	0	3.38
2021	25	4	1	15	0	5	0	0	5.13

5.2 Innovation centers and maritime

In comparison to other sectors of technology adoption, the maritime industry is risk averse. Embracing entrepreneurship and implementing new technologies are not yet a standard despite many industry executives who will suggest the need to do this. Firms in general, and maritime firms in particular, may not have developed a culture of innovation. Some at present are trying to foster innovation from within. Examples are Maersk and CMA-CGM. Collaborating with startups at early stages lacking proven business plans suggests opportunities for business angels or connectors with specific industry knowledge, not connected to a single corporation particularly, to assist maritime hardware startups. A new type of entity known as a venture builder (VB) provides a possible way to assist in developing new business concepts. The VB is a focused unit of multidisciplinary practitioners who have (or claim to have) the necessary industry knowledge to assist firms in launching new companies or products (Massi et al. 2022). VBs are set up by Sovereign Wealth Funds or pension funds to identify promising firms and nurture them over a period up to 10 years. This affords startups the opportunity to incrementally build ideas in much the same ways that "skunkworks" have been utilized in aerospace and other industries to come up with advanced systems that could potentially reconfigure the maritime sector.

It is difficult to count and track young companies worldwide like startups although there are a handful of firms who try to do just that (Paluch 2021; Thetius 2022). Incubators, accelerators, innovation centers, venture capitalists, and private investors worldwide have proliferated over time. A list of these firms, a description of stated roles, and geographic locations are in the Appendix 2 of this paper.

6 Findings

There is a plethora of accelerators around the world but mainly clustered in large cities and/or high-income countries. Financial and IT technologies are where the bulk of venture capital money is invested. Supply chain technologies have recently had more VC investment, but this is overwhelmingly in software-related solutions for visibility and for tracking either cargo or ships or containers to provide improved delivery estimates.

The number of maritime accelerators is small relative to the total number of accelerators. Accelerators dealing with the maritime industry are clustered near major port cities. Despite the number of accelerators dealing with the maritime industry, the number of startups that reach unicorn status worldwide is quite small.

Accelerators, maritime or not, considered worldwide, are not in position to support maritime Hard innovation. There are certain clusters where a port happens to be near a large group of accelerators: London, Los Angeles, San Francisco, Singapore, Hamburg, Lisbon, Barcelona, Shanghai, and Hong Kong. Some of those accelerators might be expected to bring about startups with a maritime focus.

Hard maritime innovations are likely to need a test-bed closely connected to a user organization; this means that funding is less likely to come from an accelerator and is more likely to come from an internal source in a maritime-related concern, rather than from the VC and private capital market investors that accelerators feature.

Patient money is what is needed, because the innovation impact will be more like a decade than the 5-year venture capital horizon. What could change that? Government intervention providing support or tax breaks specifically for hard innovation in maritime might be useful. An example could be the recent Bipartisan Infrastructure Law passed by the US Congress and signed into law in April, 2022 (FTA 2022). It provided funding to ports and other maritime resources, and other entities, for activities of their choice to improve their infrastructure. Unfortunately, it did more for port infrastructure projects than for generating innovative approaches to the maritime sector's needs.

International regulation of shipping could provide impetus and already has in some areas. In fuels for instance, the spread of HSFO vs LSFO has created lots of Soft innovations to arbitrage the purchase and use of these fuels. But Hard innovations such as scrubbers, ammonia and hydrogen fuels, and electric propulsion are still driven from individual firms' investments, with not much venture money or support. The innovators in this field are often equipment manufacturers or engineering firms.

Industry-led corporate startups and "inside" innovation centers are another approach (Garcia-Herrera et al 2018). These will be more suited to the Hard innovations, as the corporate connection can easily supply locations to test at. Some issues with these include:

- Ownership of the intellectual property produced, which may reside with the sponsor and not the innovator.
- Bias on the part of the sponsor toward certain kinds of solutions, stunting the development of truly innovative approaches to the problem.
- Internal lack of skill in formulating problems and use cases in a manner conducive to innovators.
- Unfamiliarity with the fast repetitive design methods used by startups to test and reject ideas.

While a corporate-based startup has some obvious advantages, there is a very real possibility that internal arrangements may stifle the very innovation that is looked for. How many entrepreneurs want to work in a big company? What is "ideal" and what is the reality of how innovation occurs can be far different.

7 Conclusion

In this paper, we have attempted to provide some insight into maritime innovation and the entities that were created to facilitate startup firms. Due to numerous external shocks, most prominently the COVID-19 pandemic, global supply chains and the maritime industry that serves them were under worldwide scrutiny with many startups benefitting from the increased attention by the investment community. With interest rates immediately following the pandemic at historic lows, many government monetary policies made borrowing money extremely cheap. Capital moved into riskier assets with supply chain solutions vetted by individuals with little understanding of the overall maritime logistics industry. As our research shows, enormous amounts of capital were raised by a handful of North American and European freight tech companies with a focus on software that would optimize middle and last-mile technologies (Sharkey 2022).

We cannot say with certainty that startups with high valuations will not be successful and transformative. What we can say is that the maritime industry would benefit from a greater focus on hard assets that when fully developed and perfected will create a more sustainable future for mankind. This can only occur through an unprecedented level of collaboration between accelerators, incubators, firms, and governmental agencies.

Our research suggests that maritime startups with longer pathways to actual implementation be the recipients of increased funding and assistance through innovation platforms designed to assist them. It may be that most such platforms with the taste for this kind of investment are privately funded, often by maritime corporations and organizations (Savelsberg et al. 2022).

There are a few maritime organizations that have developed their own incubators; CMA-CGM with Zebox and Maersk in partnership with the Massachusetts Institute of Technology (MIT) are among the most prolific at this writing.

We think the value proposition for innovation centers is not very useful for maritime startups. Space to work and access to general business advice are not important lures for founders' teams, whether hard innovation or soft. They can easily be found elsewhere. They probably do not yield any loyalty of maritime startups to the locality they are in. They could offer value for some founders who do not have ready access to the benefits; however, they do not tend to help with the need for early capital.

Accelerators, because they usually offer some access to angel and early funding, have a more attractive value proposition for marine startups. Soft innovations may attract the capital faster. But these have less need to be near a port, so an accelerator near a financial center might work for them. Hard innovations may or may not get the capital they need through an accelerator; it is often not sufficient. But a maritime startup that can choose an accelerator near a port could make use of the proximity to cultivate relationships with potential customers associated with the port. So having more accelerators close to ports would be a benefit to some startups. But our analysis shows that accelerators and incubators mainly locate near financial centers rather than ports.

Thus, currently accelerators and incubators tend to reduce diversity in creation of startups. They favor startups that can benefit from being near a financial center, port or not. This fact tends to place teams from underdeveloped areas and from areas without a large port or other commerce center at a disadvantage.

The phenomenon is not unique. Sports prospects, such as in basketball or football (soccer in the USA), face the same kind of discrimination. Favor of selection comes more easily if you go to a sport-favoring training center, or if you are located near a major team headquarters. These serve as innovation centers. However, if we look at current rosters in the National Basketball Association (NBA), many players did not start with those advantages; they came in through lower leagues by showing their capability in direct competition. Focusing on the innovation centers produces some results, but not as diverse a group of innovations as is needed.

We think there is a special requirement for the maritime space to focus on Hard innovations, as the soft ones will have an easier path. Hard innovations take longer to develop, need locations and test-beds close to maritime facilities, require more direct interaction with potential users, and have a longer payback period for investors because they cannot sell without a well-developed after-sale service function.

Our research suggests that maritime startups with longer pathways to actual implementation be the recipients of increased funding and assistance through innovation platforms designed to assist them. It may be that most such platforms with the taste for this kind of investment are privately funded, often by maritime corporations and organizations.

Government and public authorities could do more to foster innovation by providing extra funding focused on startups creating Hard innovations for the maritime sector, leaving aside the soft innovations.

We would allow funding for Mixed innovations, such as container tracking hardware, ship management sensors and software, and automatic guidance hardware and software. But the agency should develop criteria for the proportion of Hard content required to make the innovation fundable by their grants.

Innovation is hard. It requires a commitment by maritime players already in the arena as well as by new innovators, and by government and non-governmental players who benefit from better performance by maritime transport. It is about mindset as much as money, to be open to innovation and look for it more broadly than inside firms, without preconceptions of how things should be done. The innovators are ready to respond with their best efforts.

Appendix 1. Maritime accelerators and incubators

The table below gives some maritime-related accelerators. We characterize them by the type of innovation they favor.

Table 9 Maritime accelerators. Source: author compilation

Marine accelerator	Location	Website	Type
Alaska Ocean Cluster Initiative	USA—Anchorage	https://www.bsfaak.org/alaska-ocean-cluster-initiative/	Ocean technologies/Blue technology
Alchemist Accelerator	USA—San Francisco, DE—Munich	https://www.alchemistaccelerator.com/	Industrial IoT FinTech/Cybersecurity Climate Tech Digital Health Diversity
Alta Sea and Braid Theory	USA—Los Angeles	https://altasea.org/, https://www.braidtheory.com/	Regenerative Aquaculture, Renewable Energy, Blue Technology, Underwater Robotics
Anthem Venture Partners	USA—SoCal	http://anthemvp.com/	Biotech, Fintech, Platform, Semiconductor
Baltic Sea and Space Cluster	PL—Gdynia	https://balticcluster.pl/	https://balticcluster.pl/wp-content/uploads/2013/01/BSSC-CLUSTER-2.jpg
Betatron Venture Group	SG—Singapore, HK—Hong Kong	https://www.betatron.co/	https://www.betatron.co/portfolio
BlockLab	NL—Port of Rotterdam	https://www.blocklab.nl/	Blockchain for energy and logistics
Blue Maritime Cluster	NO—Alesund	https://www.bluemaritimecluster.no/gce/the-cluster/about-us/	Design, construction, equipment, and operation of advanced vessels for the global ocean industries
Creandum	SE—Stockholm DE—Berlin GB—London USA—San Francisco	https://www.creandum.com/	https://www.creandum.com/portfolio/
Cleveland Water Alliance	USA—Cleveland	https://clevelandwateralliance.org/	Create a clean water innovation ecosystem that harnesses technology, spurs the economy, enhances education, and drives research

Table 9 (continued)

Marine accelerator	Location	Website	Type
Cove Ocean	CA—Nova Scotia	https://coveocean.com/	https://coveocean.com/propel/
DeltaX Ventures	CO—Puerta de Cartagena	https://deltaxventures.com/en/home/	Technological solution that solves the challenges of the logistics chain of international trade
Eastern Pacific Shipping	SG—Singapore	http://accelerator.epshipping.com.sg/	Corporate Accelerator: Immersive tech Commercial optimization Environmental preservation Cyber security Safety Advanced materials Artificial intelligence Fuel efficiency Augmented reality 3D printing Virtual reality IoT
Entrepreneur First	SG—Singapore Bangalore Berlin Hong Kong London Paris Singapore Toronto	https://www.joinef.com/locations/singapore/	Access to leading advisors, the opportunity to pitch for pre-seed funding from us, and a network of the world's best investors to break down the barriers to founding https://www.joinef.com/companies/
Envoy Group	USA—Irvine, San Diego, Chicago	https://www.weareenvoy.com/	Consultancy—Connected Customer Experiences, mostly digital marketing
Flagship Founders	DE—Berlin	https://flagshipfounders.de/	https://flagshipfounders.de/portfolio The digital transformation of the shipping industry

Table 9 (continued)

Marine accelerator	Location	Website	Type
Force Over Mass Capital	GB—London BE—Antwerp	https://www.fomcap.com/	B2B technology innovation (Industry 4.0, Artificial Intelligence, Fintech) https://www.fomcap.com/portfolio/
Greentown Labs	USA—Boston Houston	https://greentownlabs.com/	North America's largest climatetech incubator
GCE Ocean Technologies	NO—Bergen	https://www.gceocean.no/	Bluetech innovations
GPO Fund	USA—Silicon Valley	https://www.gpofund.com/	Growth stage companies in North America and Pacific Rim
Investable Oceans	USA—New York	https://www.investableoceans.com/	Blue Economy startups
Katapult Accelerator	NO—Oslo	https://katapult.vc/ocean/	Ocean tech startups
Lloyds Register Safety Accelerator	UK—London	https://safetytechaccelerator.org/	Fully dedicated technology accelerator focused on safety and risk in industrial sectors
Maritime Alliance	USA—San Diego	https://themaritimealliance.org/	Promoting blue tech and blue jobs
Maersk Growth	DK—Copenhagen	https://www.maersk.com/growth	Digitize, democratize, and decarbonize supply chains by backing new business models and technologies
Maritime Blue Ocean Accelerator	USA—Seattle	https://maritimeblue.org/blue-accelerator/	Focused on helping maritime industry startups learn how to scale and grow
Maine Aquaculture Business Incubator Program	USA—Maine	https://www.maineaquaculture.org/business-incubator-overview/	Assist in developing economically and environmentally sustainable aquaculture opportunities in Maine
Marine Industries Science and Technology Cluster (MIST)	USA—Univ of Southern Mississippi	https://www.mistcluster.org	Supporting growth of the State's autonomous marine and related technology sectors

Table 9 (continued)

Marine accelerator	Location	Website	Type
Marine Money	USA—Connecticut	https://www.marinemoney.com/	Tracking the companies that can provide the clean tech solutions the industry needs to meet its decarbonization goals
Next Logistics Accelerator	DE—Hamburg	https://innovators.hamburg/places/next-logistics-accelerator/	The object of the company is the acquisition, holding, and management of company holdings in the logistics sector in its own name and on its own account
Ocean Data Alliance	USA—New York	https://www.oceandataalliance.com/	Ocean measurement technology
Ocean Exchange	USA—Fort Lauderdale	https://www.oceanexchange.org/	Advance the adoption of solutions in the field of sustainability
Open Seas Technology Innovation Hub	USA—Norfolk	https://www.odu.edu/iie/openseas	A globally focused center that investigates "wicked" and "intractable" problems in the maritime and coastal arenas
Ocean Solutions Accelerator	USA—San Francisco	https://www.soalliance.org/ocean-solutions-accelerator/	Propelling startups with scalable solutions that address the targets of UN SDG 14
Optima X	Greece	https://www.optima-x.org/	MaritimeTech hub that generates new concepts and corporate venture buildings and supports startups or scale-ups to bring their ideas to relevant markets
Pier71	Singapore	https://www.mpa.gov.sg/maritime-singapore/innovation-and-r-d/pier71	Industry-wide acceleration program for the port and maritime industry
Plug and Play	USA—Silicon Valley	https://www.plugandplaytechcenter.com	Supply chain solutions
Port of Antwerp/Plug and Play	BE- Antwerp	https://www.plugandplaytechcenter.com/antwerp/	Aims to shape productive collaborations with startups and develop Antwerp as a sustainable global hub for innovation activities
Port XL	NL—Rotterdam	https://portxl.org/	PortXL is an ecosystem of start-ups, scale-ups, corporate partners, and mentors

Table 9 (continued)

Marine accelerator	Location	Website	Type
PSA Unboxed	Singapore	https://unboxed.globalpsa.com/	Improve efficiencies and explore new spaces in port operations and supply chain adjacencies through the application of novel technology and innovative solutions
Quake Capital	USA—New York City	https://www.quakecapital.com/	Quake Capital invests in early-stage companies and takes a founder-friendly approach
Qualcomm Ventures	USA—San Diego	http://www.qualcommventures.com/	As the *venture* capital arm of *Qualcomm*, we help connect entrepreneurs to the resources, relationships, and deep industry expertise they need to succeed
Quesnay	USA—New York	https://www.quesnays.com/	Customized acceleration and ideation programs
RaaLabs Wilhelmsen	NO—Oslo	https://www.raalabs.com/	Enable maritime companies to harness data, drive digitalization, and adopt technology to take a leap into the future
Rainmaking Trade and Transport	UK—London	https://tti.rainmaking.io/	Open innovation platform matches enterprises and startups to solve real-world challenges within trade and transport
Razors Edge Ventures	USA—Virginia	https://www.razorsvc.com/	Investing at the intersection of national security and commercial enterprise
Reef Knot Investments	Singapore	https://reefknotinvestments.com/	Global VC powering high growth technology-centric start-ups to disrupt and shape the supply chain and logistics industry of tomorrow
Refashion Ventures	USA—New York	https://www.refashiond.com/	Bring innovation to the Global Supply Chain

Table 9 (continued)

Marine accelerator	Location	Website	Type
Rotterdam Startup Accelerator Antler	NL—Amsterdam	https://www.antler.co/	Experienced entrepreneurs come together at Antler to build and grow their companies
Schematic Ventures	USA—San Francisco	https://www.schematicventures.com/	Early-stage venture capital fund. The fund is focused on investments in technology companies within supply chains
Schmidt Marine Technology Partners and Ocean Innovation Hub	USA—San Francisco	https://www.schmidtmarine.org/	We fund *technologies* that solve problems limiting *ocean* research and conservation work
Sea Ahead	USA—Boston	https://sea-ahead.com/	*SeaAhead* is a bluetech startup platform, founded in Boston. We help build companies, run an incubator, facilitate investments, and catalyzing bluetech
Shipping Insight – US Connecticut	USA—Connecticut	https://www.shippinginsight.com/	*SHIPPINGInsight* is the premier technology forum and networking event for the maritime industry
SOSV	USA—New Jersey	https://sosv.com/	VC and investment management firm that provides seed, venture, and growth stage funding to startup companies in the technology sector
Startup Wharf	UK—London	https://www.startupwharf.com/startups/	The Global, Independent, Virtual Hub of *Startup*-driven Maritime Innovation and Transfomation
Summit Partners	USA—Boston	https://www.summitpartners.com/	Global alternative investment firm that invests in growth equity, fixed income, and public equity opportunities in technology

Table 9 (continued)

Marine accelerator	Location	Website	Type
Techstars	USA—Colorado	https://www.techstars.com/	A global investment business that provides access to capital, one-on-one mentorship, a worldwide network, for early-stage entrepreneurs
TecPier	DE—Hamburg	https://tecpier.vc/	Early-stage venture capital firm focused on maritime, logistics, and supply chain startups
The Captains Table	Hong Kong	http://www.ypsnhk.com/captain.html	We are a unique pitch challenge focused on innovation in the maritime and logistics industry
The Dock	Israel	https://www.thedockinnovation.com/	A vertical VC firm investing in and providing industry expertise to startups developing technologies for Maritime, Supply Chain
The Signal Group	Athens, London, Singapore	https://www.thesignalgroup.com/	We focus on early-stage technology start-ups and entrepreneurs in the shipping, logistics, and commodities space
Transnational Diversified Group	Philippines/Japan	https://www.tdgworld.com/HomePage.aspx	Logistics, ship management, tourism, and information technology services
Umass Dartmouth Center for Innovation and Entrepreneurship	USA—Dartmouth	https://www.umassd.edu/innovate/	Prototype development and biotechnology and biopharmaceutical develpment
Unknown BV	NL—The Hague	https://unknowngroup.com/	Portfolio of companies committed to make physical work safer and healthier; soft and hard technology oriented
Wavecrest Growth Partners	USA—Boston	https://www.wavecrestgrowth.com/	Invests only in high-growth, capital-efficient B2B software, data and technology-enabled service companies
Y Combinator		https://www.ycombinator.com/	Funding early stage technology startups

Table 9 (continued)

Marine accelerator	Location	Website	Type
Yara MarineX (YMX)	SE—Gothenburg NO—Oslo	https://yaramarinex.com/	Startups in early phase that have already proven product-market-fit and have a sustainability or green focus applicable within the Maritime industry. Backed by Yara Marine
Zebox	US—National Landing VA	https://www.ze-box.io/en/	Transport, logistics, and mobilities industry 4.0 AI, Blockchain, Virtual and Augmented Reality, IoT, and Robotics. Initiated by CMA-CGM
Tech Barcelona	ES—Barcelona	https://techbarcelona.com/en/pier-01/	Barcelona as a model of the international digital and technological ecosystem
Hamburg Innovation Port	DE—Hamburg	https://www.hamburg-innovation-port.com/	Financed by HC Hagemann; home to TUHH, research and tech companies
Hamburg Innovation Dock	DE—Hamburg	https://www.hamburginnovationdock.de/	Logistics innovations space; part of Digital Hub Logistics Hamburg
RDM Rotterdam	NL—Rotterdam	https://www.rdmrotterdam.nl/	Energy, human capital, digitalization, manufacturing
1000 Ocean Startups	Web only—based on UN Ocean Conference	https://www.1000oceanstartups.org/	Supporting startups for ocean impact; incubator of incubators. Ocean Impact Navigator KPI website

Appendix 2. 2021 Countries' total valuation of unicorns

The USA dominates total valuations and counts by a wide margin. Figure 12a shows that China is next largest in 2021, and they make a lot of Hard class investment. Figure 12b shows total valuations by country 2018–2020. In other countries, Soft class investments dominate. India and the UK are also larger investors, followed by Canada, Germany, Singapore, and Israel. Except for India, these are developed economies. Successful new ventures seem to be valued highest there, making them preferred ground for accelerators and incubators.

China is the big leader and, unlike most countries, invests more in the Hard class. Germany and Sweden also have a preponderance of Hard class investments. India, UK, Canada, Israel, and Singapore are also leaders, but have more Soft class investments. Among smaller countries, Czech Republic, Indonesia, Thailand, and UAE have predominantly Hard class investments. Norway, Turkey, and Malaysia are of note because they feature almost all Mixed investments.

In prior years 2018, 2019, and 2020, we see fewer countries represented.

China still dwarfs others and features large proportions of Hard class investments. India emerges as a leader in 2019. In 2020, the UK adds more Hard investments.

The valuations in countries by class show that Soft class dominates, and that investment in unicorns is distinctly a feature of developed countries. India is a curious case, since much of the country is underdeveloped, yet in recent years, there seems to be entrepreneurial capital available. It is probably because of the affinity of India's educated class with Western countries' systems, especially English-speaking.

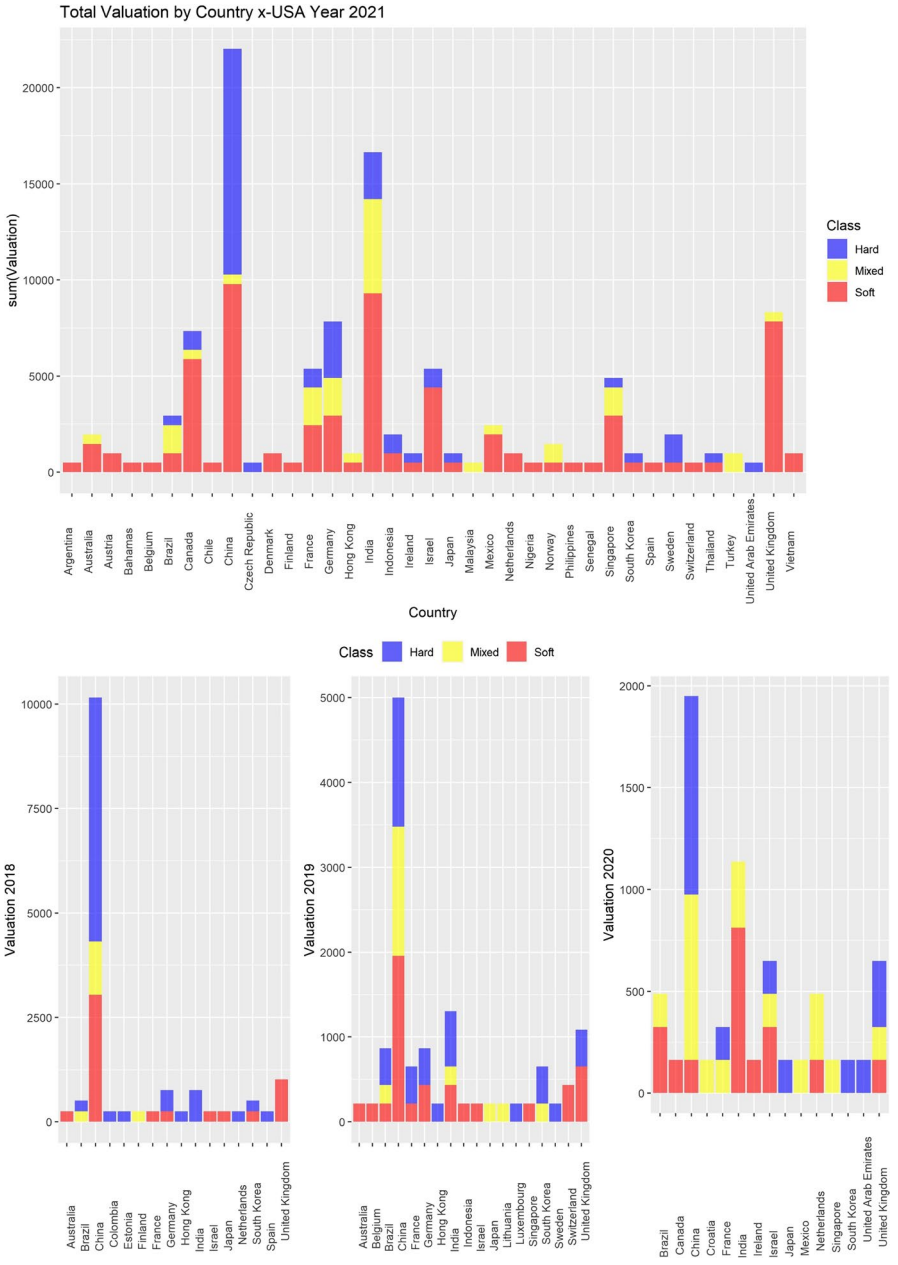


Fig. 12 **a** Total valuations of unicorns by country, 2021, USA omitted. **b** Total valuations of unicorns by country, 2018-2020, USA omitted. Source: author calculations from CBI (2022)

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