Script

China's National Innovation Systems

Class 1: What is Innovation:

Three definitions of innovation

The first man we should discuss is Joseph Schumpeter, an Austrian genius who placed the entrepreneur/innovator at the centre of his economic theory. In Schumpeter's Innovation Theory of Profit, he posits that the main function of an entrepreneur is to introduce innovations and the profit in the form of reward is given for his performance. According to Schumpeter, innovation refers to any new policy that an entrepreneur undertakes to reduce the overall cost of production or increase the demand for his products. To Schumpeter, a capitalist society consists of many entrepreneur/innovators, who each seek to earn profits from their innovations. The function of innovation is therefore to reduce the overall cost of production or to increase the demand for products, because by reducing costs and increasing demand, entrepreneurs can increase the margin on their products or capture a greater market share. Either way, they will earn more money. In the second category, increasing demand, innovation can consist of introducing a new product or a new quality of goods, open new markets, find new raw materials, introduce a new variety of design…In identifying these novel ways of producing, entrepreneurs engage in what Schumpeter calls creative destruction.

The second renowned scholar to discuss innovation is Peter Drucker. Peter Drucker is another Austrian economist, who has come to revolutionize the field of innovation and management. Drucker grew up in a very affluent and intellectually awake household, where famous economists met for lunch to discuss some of the most modern theories of the day. These included Friedrich Hayek, Joseph Schumpeter and Ludwig von Mises, the clique that would come to dominate what became known as the Austrian School of economics. In America, Drucker taught at the New York University, where he was Professor of Management from 1950 to 1971. As a management professor, he was particularly interested in the function of innovation as a driver of wealth, which you can see from this second definition.

Third, the OECD is a forum and its members are countries which describe themselves as committed to democracy and the market economy, providing a platform to compare policy experiences, seek answers to common problems, identify good practices and coordinate domestic and international policies of its members. The OECD also conducts a huge amount of research on a variety of subjects, including innovation. From the Oslo Manual, the definition of innovation is: "An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)".

8 Fields of Innovation

We distinguish between 8 fields of innovation and 4 types of innovation. The first field where innovation can occur is probably the one most of us think of intuitively. Either a new product

is developed or the performance of an existing product is improved. This kind of innovation is very common in the business world. An example that came to my mind were improvements in the automobile, but honestly, you could have any category of product here: computers, lawn mowers, cell phones. All the innovation in these products can be counted as product innovation.

The second field is technology innovation. New technologies can also be the basis for many other innovations. The best explanation for the difference between product and technological innovation is that technology is more inventive than product development. A technology is used to engineer a new functional subsystem for a product, not the product itself. Product innovation meanwhile is the commercialization of the invention. The first example that springs to most our minds is the internet.

The third field is business model innovation. Many of the most successful companies in the world managed to innovate their business model. Using different channels, technologies and new markets can lead to new possible business models which can create, deliver and capture customer value. Netflix is a very good example of a company that innovated their business model. They used to be a company that lent out DVDs, but then decided to switch to online streaming. In doing so, they completely changed their business model.

Fourth, organizational innovation is different from business model innovation, in that organizational innovation tries to change the way the business manages and shares resources, while business model innovation restructures the entire purpose, the vision and mission of the company. This way it's possible to use resources and assets in a completely new way. Example: McDonalds. When it comes to developing new ideas, McDonalds itself says that it is important for the company that everybody is involved as far as possible: partners who supply the raw material, employees from various areas and hierarchical levels, customers. As a method of organizational innovation, McDonalds has created its own test kitchens and so-called "noodle teams" in which employees at all levels of the hierarchy develop new ideas and try them out. The hierarchies are flat. So organizational innovation can involve targeting hierarchies, making them flatter or more vertical.

Fifth, innovation in the processes can improve the efficiency or effectiveness of existing methods. So what you are doing is trying to innovate how a product is produced or delivered or how the customer interacts with the product. One of the most famous and groundbreaking examples of process innovation is Henry Ford's invention of the world's first moving assembly line. This process change not only simplified vehicle assembly but shortened the time necessary to produce a single vehicle from 12 hours to 90 minutes. Or the invention of the container for container shipping, which revolutionized the logistics industry.

Sixth, channel innovation seeks to capture new methods to hold the attention of customers. This can be done either through the use of innovative marketing/sales concepts or the use of new channels for customer acquisition/sales. The best example that really took off during the pandemic was click and collect. Some stores allowed you to purchase the product online and then come and collect the product at a certain time slot.

Seventh, the intention of network innovation is to connect different groups and stakeholders in order to create extra value. This type of innovation is very common due to the use of ICT

services. Example: Zoom, which has been used not only for online teaching, but also for holding conferences and connecting suppliers.

Finally, there are innovations that seek to improve customer engagement. Example: social media.

What is interesting from the OECD's publications on innovation, specifically the OSLO manual, is that the definition of different types of innovation have changed over the years. Check out this comparison of the Oslo Manual in 2005 and the Oslo Manual in 2018. Focus specifically on product and process innovation, the two highlighted fields for the 2018 manual (slide 29).

4 Types of Innovation

The model plots impact on the market on the Y-Axis and the newness of a technology on the x axis. According to this simple diagram, there are four different types of innovation: architectural, radical, incremental and disruptive innovation.

When a technology is already well established, so is not particularly new, but an innovation in the technology has a huge impact on the market, then we speak of architectural innovation. Architectural innovation is a redesigned method to move products/services into a new market, still based on existing knowledge of core technology. *Canon* is the main competitor of Xerox in photocopiers. Canon can win over Xerox, because of its physical transformation in photocopies machine. What Xerox offered is a big giant copying machine that requires particular space in large-sized businesses. Whereas Canon redesigned huge photocopiers into desktop photocopiers that still contain existing compact concepts of functions.

With radical innovation you have a completely new product, which has a massive impact on the market. Radical innovation either applies a new technology or combines new with existing technologies, which target new markets to build new products. Mostly, companies use radical innovation to create short-term competitive advantages and then apply incremental innovation to sustain potential gains. *Gillette* is a good example that involves both innovations. Gillette launched its radical innovation as a disposable blade that can be replaced in the razor. Then Gillette sustains its profitable business by introduced various versions of razor blade; pack of 3 blades or 5 blades with new razor model.

With disruptive innovation, you have a completely new technology that is introduced to an already existing market. The difference between architectural innovations and disruptive innovation is that architectural (also called sustaining) innovations try and keep existing customers and to serve their ever-increasing demands, whereas disruptive innovations try and attract a completely new customer group. The disruptive innovation model shows that when the disruptive innovators enter the market, they are only able to target low-end customers (low end footholds), but over time they are able to target more and more mainstream customers. The incumbents in the market flee from this disruptive innovator and start targeting high-end customers over time. What rarely happens is that a disruptor completely destroys the incumbent's product.

Finally, incremental innovation can also be termed continuous innovation. It builds on existing knowledge of a technology to continuously improve on an existing product. So existing

product/technology in an already existing market. The brand's line extensions such as Cherry Coke, Coke with Lime and more recently Coca-Cola Life have enabled a 130-year-old brand to stay relevant, tap into emerging trends and bring something new to its customers over the years.

Difference Invention and Innovation

An invention is a completely new idea. The Cambridge Dictionary defines invention as "something that has never been made before, or the process of creating something that has never been made before". So, by definition, an invention has to be something entirely new. To invent something is to discover a new thing. To innovate, meanwhile, again according to the Cambridge Dictionary, means "to use a new idea or method". To innovate is to introduce something new to the market, to manipulate existing inventions and turn them into a product or process that is of use in the real world.

Of course, inventions also have to be proven to work. You can't just go around calling yourself an inventor, just because you have thought of a way to make a time machine. You have to be able to show that you can make your idea a success. And that is where innovation comes in. Innovators might come up with something that is not new at all, but rather operate within the realm of what already exists. Innovators use processes or platforms that have already been invented to create a commercially successful product or process that will satisfy a market need. Besides differences in novelty (inventions create a completely new idea whereas innovation takes an idea and does something new with it), commercial application is a key difference between invention and innovation. A product or process is inventive if it has never been done before – whether it is innovative depends on whether users will get a real value out of the product.

If we think about invention and innovation in a real-life context, we can observe a pattern. Great innovations were not necessarily made by those who first came up with the idea. Instead, they are credited to the innovator who managed to turn the idea into a viable product. Take for example the telegraph, one of the great innovations of the nineteenth century. The first crude telegraph was invented in Bavaria in 1809, but Samuel Morse, who also created Morse Code, was the first person to build a commercially successful telegraph communication system. Morse's telegraph was affordable, efficient, and could reach further than similar efforts made by Sir William Cooke and Charles Wheatstone at the same time in London. Who cared that it wasn't his idea to begin with? Morse certainly didn't – he started the Magnetic Telegraph Company and launched the first commercial telegraph line in the US. There's a valuable lesson to be learnt here. An original invention won't get you very far if it's not innovative enough. If an invention lacks real-life value for the user, it will be overtaken by an innovation that manages to satisfy a need.

Value of Innovation

For the economy, innovation fosters growth, it drives prosperity, but can also be a way for humans to remain autarch, so less dependent on other countries. For companies, innovation can raise productivity and efficiency. It can help improve a product or service's quality and in so doing enhance the company's standing in international markets. For individuals, we benefit from innovation, because we get to enjoy the added value from new products and services.

In so many ways, innovation improves our living standards, which is why countries are so intent on pursuing indigenous innovation.

Class 2: China's National Innovation System

Definitions

"…a set of distinctive institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such, it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies"

"… a network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies"

"…the elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge […] and are either located within or rooted inside the borders of a nation state"

"… a set of institutions whose interactions determine the innovative performance […] of national firms"

Institutions

According to Douglas, institutions are understood as "legitimized social groupings" which could consist of "a family, a game or a ceremony". They are made up of "regulative, normative and cultural-cognitive elements that together with associated activities and resources provide stability and meaning to social life". These three elements, so regulative, normative and cultural-cognitive elements, are present in any institution and together influence the behaviour of actors within an institutional setting. The central thesis is that institutions lay down the rules of the game that govern societal interactions. Over time, institutions develop their own system logic and dynamisms that are geared towards self-perpetuation. The system logic determines the forms of communication and the behavioural boundaries for the institution's internal members and affected outsiders. Institutions are useful in that they facilitate transactions, interactions and communication between members of society by decreasing complexity.

In general, we distinguish between two types of institutions: formal and informal institutions. The distinction between what are formal and informal institutions isn't always easy to grasp. Formal institutions are those that are enforced by a local authority, usually these institutions are written down, for instance in the form of laws, contracts or the constitution of a country. Informal institutions meanwhile are usually unwritten rules that a society agrees on in their form of social interaction. This can include rules that you may have in your family about where each of you sit, when you have dinner, who gets to sit down on a bus, but also more serious issues like customs and traditions. But take religion as a case in point, is this a formal or

informal institution? So formal and informal institutions can be complementary, competing or overlapping, depending on the case you are discussing.

Nations

Most would use the terms nation, state and nation-state interchangeably, but in fact there are clear differences. States are defined by sovereignty over territory and a group of people, what most of us would call countries. China is undoubtedly a country. Nations generate identity and loyalty. They are groups who share common histories, myths, culture, economy and rights. Ethnic groups also have a common ancestry and solidarity within the group, but oftentimes they do not engage in politics or nationalism. A nation in the common sense may therefore span a state's boundaries or only be confined to a certain area within the state. States have devised instruments to generate a sense of national identity for the state. National anthems, the flag, national holidays… Finally, a nation-state would be a sovereign territory with one group of individuals who share a common history. Today, a true nation-state in the academic sense of the word does not exist. Nearly every state/country in the world contains multiple national groups.

National innovation systems model

Now, from these clarifications we can surmise that a national innovation system describes a set of institutions that promote the generation and diffusion of knowledge and innovation within a country's borders. From this simple definition, the OECD has developed a comprehensive model that shows the actors and linkages that contribute to innovation within a country's borders. You can see that firms, research bodies, the science system and other supporting institutions all play a huge role in generating, diffusing and using knowledge. The OECD stresses that these innovation systems, with similar actors, also exist at the global, regional or local level. The conditions that these actors face, with respect to for example factor markets, product markets, education systems, communication infrastructure and regulatory settings, strongly shape a country's innovation capacity. As the OECD states: „The structure of countries' national innovation systems helps explain international differences in innovation performance, with different weights and relative focus of public and private sectors in funding and performing R&D, different objectives and instruments of government support, different roles of government ministries, and different scientific, technological and industrial specializations all contributing to different institutional arrangements and outcomes". This means that one-size-fits-all approaches to designing a country's innovation system based on blueprints from other nations will unlikely prove successful. Instead we need to analyze countries' innovation systems on a case by case basis.

Evolution of China's National Innovation System

Prior to reform and opening up, China's science and innovation system was centrally planned. Most of the new technology that entered the country did so via other communist states, in particular the Soviet Union and the GDR. The key players in China's national innovation system at the time were the Chinese Academy of Sciences, research academies affiliated with line ministries, provincial governments and their R&D institutions, universities and R&D institutes connected to the army. The problem before the reforms was that there were very little incentives for R&D in China's national innovation system. People weren't being rewarded for

coming up with useful ideas and so no one bothered to think outside the box. The central government under Deng Xiaoping felt that this needed to change and with the gradual implementation of markets, inventors and innovators finally had an outlet to profit from creative thinking. Another reason for reforms to China's national innovation system was outside pressure and the perception that China was falling behind Western developed nations. And so, policies were drawn up to stimulate innovation in China

In all, we can distinguish between four phases of Science and Technology policy. First, from a 1975 Outline Report on Science and Technology to 1978, when a Science Conference was held to stimulate S&T as a productive force. Remember, in 1975, Mao was still alive, but Deng was brought back to the centre and tasked with rectifying China's economic, S&T and education systems. Consequently, Deng and his followers drafted three important policy documents on first economic modernization, second industrialization and third development of S&T. These were submitted in an Outline Report, which was accepted, but at the time still faced significant head-wind from anti-liberal forces (particularly around the Party veteran Chen Yun). After Mao's death and the arrest of the Gang of Four, Deng was able to maneuver himself to the centre of Party operations. Deng saw S&T as a productive force. The problem he faced was ideological, up until then, innovation was seen as originating from class struggle. So what Deng, rather cleverly did, was equate intellectuals with the working class, so that the work of intellectuals was interpreted as critical and conforming with China's guiding ideology: Marxism.

The second phase, from 1979 to 1994 can be divided into a trial phase (up until 1984) and an implementation phase. In March 1985 the Central Commission issued the 'Decision on Reforming the Science and Technology System', which laid down the guiding principles for China's S&T. This also triggered the start of S&T reform in China. The approach adopted was a push and pull approach. The push factor was a reduction of funding for public research institutes. Pull meanwhile constituted a further development of the technology market. In this phase, we see an emphasis on market incentives over public innovation efforts. In 1986, the power of public research institutes was further downgraded, by structuring their efforts according to 1) technology development, 2) basic research and 3) public interest. This division also brought market forces into the S&T sector. Administratively, 1993 also brought about the establishment of the State Council Leading Small Group of S&T; an important driver for innovation in China during the 1990s.

The third phase encompasses the decade from 1995 to 2005. This phase begins with the 14th Congress of the Central Committee of the CCP, which established the term 'socialist market economy'. China's economy had been growing rapidly since the first phase, but there were still severe problems that arose during the 90s. For innovation, the most critical included China's inefficient industrial structure, poor technology levels, low labour productivity and low quality of economic growth. Consequently, in 1995: the decision was made to make S&T a primary productive force. China shifted the country's development model to a reliance on S&T, but also sought to improve the quality and skills of its labour force. Initially, the focus was on driving innovation via the market, but in 1999 the State Council decided it would promote technological innovation and the development and industrialization of high-technology also in the public sector. Zhu Rongji, China's premier at the time, was the driving force in a campaign to revitalize the nation through S&T. As a consequence, there was a rapid growth in spending on R&D and programmes to foster talent: such as the World Class University

Programme, the National Science Fund for Distinguished Young Scholars or the State High-Technology R&D Programme. An effort was also made to integrate private and public companies in joint-programmes to stimulate innovation, especially in basic research.

Finally, the fourth phase spans 14 years from 2006 to 2020. 2006 is a significant year for China's National Innovation System, because of the Medium to Long Term Strategic Plan for Development of Science and Technology, which covered the years from 2006 to 2020. The document lays down China's goal of stimulating indigenous innovation in order to make China an innovation-driven nation by 2020. The key objectives therein include: strong improvements in the country's indigenous innovation capabilities, a solid improvement in the capability of S&T to promote economic and social development and to safeguard national security, significant increases in the overall strength of basic science and frontier technology research, S&T results with significant global impact and finally becoming an innovation-driven country → so a world superpower in innovation by the middle of the 21st century.

To achieve these ambitious targets, China issued a series of complementary policies to raise the scale of R&D investment and to make effective use of public funding. A key characteristic of China's national innovation system, in contrast to innovation systems elsewhere, is the scale and reach of central funding to stimulate innovation. China's National Innovation System, in particular during this fourth period, has become more centralized and directed. At the same time, the policy process has become more collaborative, meaning companies that have proven successful in producing innovation in the past are consulted in policy design much more than they were in the past. The problem of course is that companies that proved successful in the past, may not be innovative again in the future, so there is a danger that policy design becomes captured by incumbents with vested interests in remaining strong in their respective industries.

The National innovation-driven Development Strategy Outline from 2016 places innovation-driven development as a top priority for national development. To become an innovation-driven economy, China follows a three-step strategy: First, By 2020 China wishes to enter the group of innovation-driven countries. Specifically, this means being able to form innovation-oriented economic patterns, to spend more than 2.5 percent of GDP on R&D, to create a collaborative innovation system, increase independent innovation capabilities and finally that a large number of industries enter high-end sections of global value chains.

Regional Innovation Systems in China

Deloitte identifies five regional innovation systems that contribute in different ways to furthering China's national innovation system. Deloitte established these five regions by examining innovation ecosystems based on three indicators. First, innovation institutions reflect the number off innovative entities in a city and the strengths of the city in carrying out scientific and technological research and development and business innovation. This includes innovation companies, unicorn companies and scientific research institutes. Second, innovation resources reflect whether the various elements of a city can adequately support innovation activities in institutions. And third, innovation environment reflects a city's ability to attract and retain outstanding innovation resources and create a sound external environment for aggregating innovation institutions.

By allocating scores to each of these categories, Deloitte graded these different cities into three bands, where Beijing, Shanghai, Shenzhen, Hangzhou and Guangzhou rank as the top five innovation ecosystems in China. Band 2 then included cities such as Nanjing, Chengdu, Wuhan, Suzhou, Tianjin and Chongqing and band three less prosperous cities such as Hefei and Guiyang right at the bottom. In terms of innovation institutions, Beijing, Shanghai and Shenzhen ranked highest. These three cities also owned the highest number of new technology enterprises and were home to 60% of the top 100 internet companies in China. In terms of unicorn companies, there were 162 unicorn companies in Beijing, Shanghai, Shenzhen and Hangzhou, accounting for 80% of the total number of unicorns in China. In terms of scientific research institutes, Beijing is at a huge advantage, as it is home to some of the country's best universities: think Qinghua, Renmin, Beida or my alma mater Beiwai for foreign languages.

In terms of innovation resources, Beijing, Shanghai and Shenzhen were among the top three, followed by Hangzhou. These four cities host over 55% of AI talents in China and attract the largest amount of incoming investment in innovation. Beijing and Shanghai also have the most makerspaces registered with the state, accounting for nearly 20% of the total. This also contributes to Beijing's positive score in terms of innovation environment, joining Shenzhen, Guangzhou and Shanghai among the top four. Shenzhen performed best in terms of innovation atmosphere, not surprising to anyone who has been there. Guangzhou's main advantage is a very active government, which launches a range of policies to stimulate innovation, more than any other city in China. If you are looking for a job in innovation though, best go to Beijing, where they pay the highest salary and provide other bonuses (subsidized rental) to talents working in innovation.

Class 3: China's Innovation Policies

Definition Industrial Policy and Innovation Policy

Industrial Policy is…
"…any type of intervention or government policy that attempts to improve the business environment or alter the structure of economic activity"

"…the set of government actions affecting companies in different productive sectors in a country"

"…coordinated government action aimed at directing production resources to domestic producers in certain industries to help them become more competitive

Innovation Policy …
„A government intervention including measures, programs, incentives, and other instruments aimed at supporting the creation and diffusion of innovations"

„…requires a constant policy learning process"

„…Is the interface between research and technological development policy and industrial policy and aims to create a conducive framework for bringing ideas to market“

From these definitions, you see that there seems to be significant discord with respect to what set of policies can be categorized as industrial policy. In industrial policy theory, literature generally distinguishes between functional/horizontal and vertical/selective industrial policies that differ in their degree of selectivity and intrusiveness in market operations. While vertical/selective industrial policies are treated synonymously, some authors distinguish between functional and horizontal policies in that the former seek to change the overall business environment, while the latter trigger transformation in nascent and newly emerging industries. Selective/vertical policies do as the name suggests: they select industries and, in some cases, even individual companies and technologies for preferential treatment. Consequently, they are far more intrusive and controversial than either functional or horizontal industrial policies. Within vertical categorization, further distinctions can be made in terms of comparative advantage conforming vs. comparative advantage defying, as well as conceptional vs ad-hoc industrial policies. Green industrial policy design is a relatively new field of research that requires further treatment to reduce definitional ambiguities and clarify instruments.

Class 4: China's Intellectual Property Rights System

Definition

The example of a recipe is actually a really good place to start in developing our definition of intellectual property. There is actually quite a lot of discussion around this, as one New York Times Article shows. The article argues that a recipe is a factual list of ingredients and steps, not a creative expression. For the article, and in fact for many definitions of intellectual property, intellectual property is intimately connected with creative expression. What you also see again and again is the importance of the mind in creating intellectual property. This intellectual property is an intangible asset, so an asset you cannot touch, but that enjoy equal protection to tangible assets in law.

The definition that we will be working with is from the World Intellectual Property Organisation or WIPO, the global forum for intellectual property services, policy, information and cooperation:

Intellectual property…
Refers to the creations of the mind: inventions, literary and artistic works; and symbols, names and images used in commerce. IP is protected by law, for example patents, copyright and trademarks, which enable people to earn recognition or financial benefit from what they invent or create

WIPO provide a policy forum to shape balanced international IP rules, so they offer member states to participate in discussion on policy changes. Second, they provide global services to protect IP across borders. And in case of disputes, they offer arbitration services. They also provide the technical infrastructure to connect IP systems and share knowledge, so a sort of networking function. Then they also offer training programmes to help raise awareness for IP

and IP infringement. They also allow individuals and companies to file patents and have developed a database to reference IP information. China has been a member of WIPO since 1980 and what you can do on the WIPO website is check out the number of patents that Chinese companies have filed with WIPO, the number of times China has complained about IP infringements, how often China has been accused of IP infringement and much more, which we will get to later on in class.

Intellectual Property Types

Intellectual property can be divided into two different categories: industrial property and copyright. Industrial property includes tools such as patents, industrial designs, trademarks, geographical indicators and trade secrets. These tools are reserved for ideas and inventions used for industrial purposes. Copyrights then cover literary works, films, music, artistic works, architectural design. Rights that are awarded to performers, artists, producers and broadcasters for their work.

- Patents

A patent grants exclusive rights to an invention, but just because you own a patent, doesn‘t mean you can stop someone from developing on the basis of the technology. The patent grants you protection from direct imitation, but doesn‘t stop others from continuing inventing on the basis of your technology. Protecting an innovation from imitation, but not stifling further innovation is the central dilemma why designing an equitable intellectual property rights system is so difficult for countries. The ultimate goal is to incentivize innovation, but innovators will only innovate, if they are guaranteed that any innovation is protected from imitation. Otherwise, latecomers will simply wait for others to innovate and then make money on the back of their hard work. Countries need to design an intellectual property system that protects innovations from imitation, but doesn‘t stifle further progress on the technology.

Distinguishing whether something is a new invention that deserves protection or an imitation of an existing technology is not always so easy. Have a look at the evolution of the pressure coffee maker, which was initially innovated by James H. Kasof in 1865. But as you can see, based on Kasof‘s invention, others were able to add new alterations to the technology and patent them each time. To do so, innovators have undertaken a series of steps. First, you have to consider whether an innovation is commercially viable, so is it even worth starting the process of patent application. Second, you have to do a patent search to make sure that no one else has already come up with your formula, process or innovation. The best way to go about doing a patent search is to employ someone called a patent satellite, who works for the country’s patent office and knows if there is already a patent for this new technology out there. Third, after you have searched for patents, you have to apply for the patent. You need a patent lawyer for this, in order for it to be watertight. The official text can only be written by a patent lawyer. You only patent things that are in the text, the pictures are only illustrative, in order that you are able to know what they are actually talking about. In your application, you have to prove three requirements: the technology has to be novel, the technology has to prove a certain degree of innovation and it has to be commercially viable. The patent office evaluates the three requirements. Novelty and commercial viability are usually easy to evaluate, but how would you go about evaluating whether a technology is innovative enough to merit protection?

The answer is rather mundane: The civil servant at the patent office decides, and he/she has an interest to not grant the patent, because it causes him/her more work. Combinations of technologies that are already known are very rarely granted. Once you hand in a patent, the year of priority starts. Within this year, you can register this technology in other countries. When this year is up, then the patent has to remain in one country. Often ideas are created around the same time, because the inputs are the same for all developers. They may go to the same conferences and come up with the same ideas. Within this year, you can make a PCT (Patent Cooperation Treaty), which allows you to apply for patent protection in other countries you want the technology patented within 30 months.

- Industrial Design

Industrial designs protect the ornamental or aesthetic aspects of a product. Innovators can either protect 3D features, so the shape of an article or 2D features. An industrial design is different from a patent, which aims to protect an improvement in functionality. If the innovation for which you are trying to obtain protection is rooted in improved functionality rather than an original visual appearance, you should consider filing a patent application if you believe that it meets the requirements for patentability (novelty, commercial viability and degree of innovativeness)

The example that have brought along is a sports shoe, such as this one from Li-Ning. An industrial design could protect an original shape and configuration of shoes or a pattern of a tablecloth. In contrast, a change in the functionality of an article or in the materials used to manufacture an article are not aspects which are eligible for industrial design protection. For greater clarity, if the same shoes featured a new shock-absorption mechanism, the functionality of this aspect of their design wouldn't be protectable by an industrial design, but may, if novel and inventive, be protectable by a patent. As such, different aspects of a single article (e.g., a shoe) may be protected by a combination of patents, industrial designs, trademarks (which protect the Nike swoosh thereon, for example), and even copyright (should they feature, for example, original art).

- Trademarks

Trademarks are unique brand signs, designs or expressions. They are intimately connected to brands. The term trademark refers to a recognizable insignia, phrase, word, or symbol that denotes a specific product and legally differentiates it from all other products of its kind. A trademark exclusively identifies a product as belonging to a specific company and recognizes the company's ownership of the brand. You will see trademarks frequently connected to company names in the form of the little encircled R (registered trademark).

- Geographical Indications

According to WIPO: „A geographical indication (GI) is a sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin. In order to function as a GI, a sign must identify a product as originating in a given place. The reason why regions may want to protect a product‘s geographical origin is that the product‘s quality and the region‘s reputation are intimately linked. In order for customers to be able to trust that a product is actually from the region, WIPO allows regions to file applications to protect the product‘s origin. Sichuan pepper is protected as a geographical indicator, for example.

- Trade Secrets

Finally, for industrial property, you can also protect your product by keeping the product‘s formula, practices to produce the product or its design a secret. There are many different kinds of trade secrets, including how you distribute your product, your consumer profiles, advertising strategies, you list of suppliers and customers. The information you want to keep secret should have a commercial value to you and your company. Naturally, as with any secret, not too many people should now the secret, otherwise it’s not secret anymore. Finally, and probably most importantly, the holder of the secret should take reasonable steps to keep the secret, for example by having others who know the secret sign confidentiality agreements. An example is Laoganma. The exact ingredients and mixture are kept a trade secret, otherwise you‘d have immediate imitators for this delicious recipe.

- Copyright

For the second category of intellectual property protection there is only one tool, which is synonymous with the category name, namely copyrights. Copyrights are granted to creators for literary and artistic works, so novels, poems, computer programmes, codes, films etc. Reproduction, so copying or printing the works without the author or creator’s permission is prohibited. You can tell if a work of art, literature or film is copyright protected by the little encircled C. A famous case from last year was the Ed Sheeran vs. Marvin Gaye lawsuit. Ed Sheeran was being sued by the estate of Marvin Gaye for stealing chords from Marvin Gaye‘s song ‚Let‘s Get It On‘ for Ed Sheeran‘s song ‚Thinking Out Loud‘. The courts decided it was not a copyright infringement, that the two songs were sufficiently different in the notes, lyrics and rhythm for it not to be a copyright infringement.

China’s Intellectual Property Regime

China‘s intellectual property protection regime doesn‘t stretch back very far, in fact, it was only in the early 1980s that China really started designing laws to protect intellectual property in the country. China joined the World Intellectual Property Organisation in 1980, which triggered a series of domestic regulation on a variety of tools deployed to protect intellectual property. The Trademark Law in 1982 was followed by the Patent Law in 1984 and then later the Copyright Law in 1990. Joining WIPO meant that China agreed to a series of conventions the international community had designed over the course of the 20th century to protect IP, for instance the Berne Convention for the Protection of Literary and Artistic Works, the Paris Convention for the Protection of Industrial Property and the Madrid Agreement for the International Registration of Trademarks. In 2001, China joined the World Trade Organisation, which meant the country would become subject to the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). TRIPS is an international legal agreement between members of the WTO that establishes minimum standards for the regulation of different forms of intellectual property. Essentially, TRIPS guarantees that members of the WTO protect intellectual property from other members within the nation‘s borders. The TRIPS agreement introduced intellectual property law into the multilateral trading system for the first time and remains the most comprehensive multilateral agreement on intellectual property to date. Specifically, TRIPS requires WTO members to provide copyright, covering copyright holders, as well as holders of related rights, namely performers, sound recording producers and broadcasting organizations. Geographical indications, patents, trademarks and other industrial property is also to be protected. TRIPS also specifies enforcement procedures, remedies, and dispute resolution procedures.

Like most countries in the world China allocates responsibility for administering intellectual property protection to a series of ministries, who each have the power and legal capacity to enforce laws concerning patents, trademarks, copyrights and geographical indicators. Should you wish to register a patent in China, you should turn to the China National Intellectual Property Administration (or Guojia zhishi chanquenju SIPO). The patent office was founded in 1980 as the Patent Office of the People's Republic of China, so the same year that China joined WIPO. In its own words it is responsible for "patent work and comprehensively coordinating foreign related affairs in the field of intellectual property". Consequently, it is also responsible for issuing and responding to complaints for patent infringement.

Patents in China

China distinguishes between different three different types of patents, namely invention patents, utility model patents and design patents. From the *The General Provisions of the Civil Law of the People's Republic of China*, whose definition of IP we encountered earlier, we know that Intellectual property rights are the exclusive rights enjoyed by the right holders according to law on the following subject matters: works, inventions, utility models or designs. The Patent Law, issued in 1984, we know that inventions mean "new technical solutions proposed for a product, a process or the improvement thereof". Utility models describe „new technical solutions proposed for the shape and structure of a product, or the combination thereof, which are fit for practical use". With design, the law covers „new designs of the shape, patter of the combination thereof or the combination of the color with shape and pattern, which are rich in an aesthetic appeal and are fit for industrial application".

The law also states, that patent applicants must prove that the technology is novel, commercially viable (not only financially, but also in terms of industrial applicability, we must be able to use it). In line with TRIPS, the law excludes scientific discoveries, methods for mental activities, methods for the diagnosis and treatment of disease, animal and plant varieties and a catch-all for other undesirable inventions. These cannot be patented according to the law. Besides novelty and commercial applicability and similar to WIPO, the law also stipulates that applicants must prove inventiveness. To be considered inventive an invention must have, in the eyes of a notional addressee, prominent substantive features that mark a notable progress in the state of the art, or in the alternative, that the addressee cannot obtain from existing technology all the necessary technical features of the invention. A notional addressee is defined as an ordinary technician skilled in the field of invention, who will assess an invention and decide whether it deserves to be protected by a patent, based on novelty, inventiveness and commercial viability.

Trademarks in China

Should you wish to register a trademark, you should contact the China Trademark Office, which is a subdivision of the National Intellectual Property Administration. The Trademark Mark Office offer trademark, patent and copyright services. They provide customers with an online trademark registration system, where all you need is the business registration certificate and a passport to file a trademark application (and money to pay them). They also help foreign companies find trademarks.

Geographical Indications in China

The Chinese government has made the General Administration of Quality, Inspection and Quarantine (AQSIQ) responsible for geographical indicators. They haven't been active for very long. Only in March 2021 did China and the EU enter into China's first bilateral comprehensive and high-level agreement on the protection of geographical indications. In the China-EU Agreement on Geographical Indications, China and the EU decided on batches of 100 Chinese and 100 European products that should be protected under the agreement. The aim is to better protect and market these products to meet the needs of consumers on both sides. On the Chinese side, protected products include Fuzhou Jasmine Tea, Baoshan Arabica Coffee, Cangshan Garlic, Anyue Lemon… Long list of mainly agricultural products ranging from Chilli to Crayfish. The European list is divided by country.

Copyright in China

For literary works, films, music, art etc., you should turn to the State Administration of the press, publication, radio, film and television or their sub-departments, the National Copyright Administration of China. The Copyright Protection Centre is in charge of collecting and sorting copyright applications. To do so, it has created a digital copyright identifier system, which plays a significant role in the core infrastructure of national internet copyright public services. The Copyright Protection Centre also evaluates and appraises copyright registrations, for various goods: such as software, films, sketches, maps, music and dance…

Difference China/EU Intellectual Property Systems

The main difference is that in the EU, you may be able to enforce IPR without registration, but only under certain conditions. To receive protection without registering, you will have to prove earlier use in a European market, but no guarantees are provided. In China, if you have not formally registered your IP in China, then you cannot enforce them in China. This is particularly true for industrial property. Although copyright does not need to be registered in China, registration is available and advisable as Chinese courts require registration of copyright or notarized proof of copyright in order to accept a case. The second difference between China and the EU is that your IPR is only protected from the date of registration in China, whereas in the EU you receive conditional protection from the day you file your application. In China, your IPR is unprotected during the period between application and registration. You can only start enforcement procedures once formal registration is published. In terms of similarities, IPR is territorial for both China and the EU.

What does this mean? It means that IPR registered in China is only protected in the territory of China. IPR registered in China is not protected in Europe and vice versa. Taiwan, Macao and Hong Kong all have separate IPR systems, so if you want your intellectual property protected there, you will have to file a separate application! Another similarity is that patents and trademarks can be extended internationally. Both the EU and China have signed the Patent Cooperation Treaty and the Madrid System treaty, both administered by WIPO. As signatories, it makes it easier for both EU and Chinese nationals to have their domestically registered patents extended to other countries within WIPO.

IPR Protection Globally

China is way ahead of everyone else in applying for patents. One reason is that patent registrations are a quantitative performance evaluation criterion for many companies and universities. To receive a positive evaluation, Chinese scientists and companies register patents like crazy, even if the change to the technology is minimal. In the graph, you see patent applications at the top 10 WIPO offices in the world, divided according to resident and non-resident patent applicants. First of all, look at the Y-axis WIPO had to break down the Chinese bar to make it fit on the graph, China had approximately 1 million 400 thousand applications in 2020, the US just under 300.000. Mad numbers. What is also interesting, is that there are hardly any non-resident applications in China, compared to resident applications at least.

The Property Rights Alliance also publish an annual report on how countries fare each year in terms of property rights protection. Some of the indicators they examine are the legal and political environment, so aspects such as judicial independence, rule of law, political stability and control of corruption that all influence to a country's IPR system. They also measure the perception of physical property protection, access to loans, the registering process, patent protection, trademark protection, copyright protection and other metrics that are ranked between 0 and 10 and finally contribute to creating an overall score for the company. This allows them to then rank countries. Overall, China ranks 47th out of 129 countries, so in the mid-range with an average score of 5.6. So pretty bog average. Compared to previous years though, the trend for 2022 is pointing downwards, particularly for physical property rights. The Intellectual Property Rights Sub index did not change and remained at 6.2. Individually, intellectual property protection scored 5.8, patent protection 7.2, copyright protection 3.4 (which is disastrous) and trademark protection 8.6. So, room for improvement in copyright, but solid scores in patent and trademark protection. Geographical indications are not assessed.

Shanzhai

If you translate the term literally, it means something like mountain camp. During the Song dynasty, it came to describe a group of bandits who would invade the corrupt authorities in their mountain camps. These bandits were sort of a Chinese version of Robin Hood, their actions, though illegal, were perceived as justified. In the modern world, Shanzhai describes counterfeit goods, that are regarded as rebelling against the established commercial market. Some shanzhai products are created with the intent of deceiving buyers, others are created with features not included in the authentic originals.

Class 5: Entrepreneurship in China

Definition

Entrepreneurship is a French compound word that combines the French preposition 'between' (entre) with the verb 'to take' (prendre). If we take the word literally therefore, you can think of an entrepreneur as someone who stands between buyers and sellers and takes on the risk of starting a new venture.

Entrepreneurship is defined as the the process by which individuals pursue opportunities without regard to resources they currently control. Entrepreneurship is **the art of turning an idea into a business**. In essence, an entrepreneur's behavior finds him or her trying to identify opportunities and putting useful ideas into practice.

Difference Entrepreneurship/Innovation

To conceptualize the difference between an innovator and an entrepreneur, we can think of how a business is created. Usually, businesses are based on innovation, they offer a solution to a problem. Innovators create a new solution to a problem, whereas entrepreneurs can either build a business around a new OR an already existing solution. Most businesses are based on an innovation and built by an entrepreneur. Innovators create new products, services, or ways of doing things, while entrepreneurs turn those ideas into viable business concepts. As such, entrepreneurs need resources to build their business, specifically money and people. Innovators don't necessarily need money and people to produce an innovation, only when they decide to commercialize their innovation do they become entrepreneurs, who then of course require money and people. So, if you believe you have developed a better way of providing a service to a client, then you're innovating. If you also have business know-how, don't mind taking a few risks and can formulate a business plan around that idea, you're an entrepreneur as well.

Often, however, innovators don't like taking the risks necessary for success and find a business partner to help them bring their ideas to the marketplace. Entrepreneurs have specific skillsets that some innovators lack and so are better suited to commercialize an innovation. But innovation isn't the only way to start a business.

Creating a Business

In broader theory, we distinguish between two ways of creating a business: vertical vs. horizontal progress. Besides creating something entirely new that the world has never seen, you could also take something that works somewhere else and apply it to a new industry or location. Peter Thiel, who you may know as the first outside investor in a small company called Facebook, defines horizontal progress as „taking something that works in one geography and introducing it in a new one, while he defines vertical progress as technical innovation where there is no existing completion. You can think of horizontal progress as being about creating a better mousetrap, while vertical progress is about finding a better way to catch mice. Can anyone think of examples of vertical and horizontal progress?

Vertical: Google, Amazon, eBay, and Facebook were essentially businesses that made vertical progress and captured large margins to dominate their market.

Horizontal: Red Bull

Aspects of Being an Entrepreneur

First, being an entrepreneur involves a creation process, which means entrepreneurs need to be creative. They need to be able to think outside of the box, see solutions that others don't immediately see. They also need to be able to recognize opportunities in the market and

identify the right timing and strategy to pounce. Second, being an entrepreneur requires devotion of time and effort. Entrepreneurs dedicate a huge amount of time and passion to bringing a product they believe in to market. They must therefore be willing to sacrifice a lot of their private time, because setting up a business is all-consuming. You need to have a supportive family, who are willing to accept that you will be spending a lot of time in the office. Above, all, entrepreneurs need to be hard-working, they must have the right morale make the business succeed. Third, entrepreneurs must be able to see the potential rewards once a business is created. One aspect is believing in the product, but also having a vision of where they want to take the product. They must fully believe in this vision, so entrepreneurs need to be optimists and opportunists, because if they don't believe in the idea, then who will. Finally, being an entrepreneur requires the assumption of necessary risks. Entrepreneurs need to be able to embrace risk; a risk averse entrepreneur will not get very far. We can see this aspect from the definition of entrepreneurship, which places risk at the centre of entrepreneurship.

Entrepreneurship in China

From 1949 and the 1980s there can hardly be much discussion of entrepreneurship in China. During the Mao era, for instance, private entrepreneurship was virtually eradicated and was a political taboo. Entrepreneurship was "shunned" in the country as late as the 1980s and "the entrepreneur" as an occupation was often considered for individuals that were not able to find other jobs (e.g., those with criminal records).

This changed slightly, but not radically, during the 1980s, when tentative steps were taken to open up the economy to the entrepreneurial class. With the economy in very poor shape, the new premier, Deng Xiaoping, launched China's Four Modernizations in 1978. We discussed the four modernizations before, can anyone remember in what fields Deng wished to see China improve? Correct, agriculture, industry, defense and S&T. Among the reforms Deng introduced was the household-responsibility system, which paved the way for individual farmers to become businessmen that could sell their products on the market. Small businesses started emerging initially in rural areas, the getihu, which later extended into the urban centers. Managers of TVEs, the small getihu, were different from authentic entrepreneurs though, because most were contractors and did not own the enterprises themselves. But still, they did display several entrepreneurial traits. First, by collaborating with local government officials, managers and officials strove for institutional change that would foster regional growth. Local governments in a way became entrepreneurs or rather angel investors who stimulated entrepreneurial activity. We can therefore speak of local government entrepreneurship and TVE entrepreneurship as the dominant forms of entrepreneurship during the 1980s.

The period from 1992 to 2000 is characterized by a rise in entrepreneurial activity predominantly in the private sector, as SOEs relative importance decreased. Deng's ‚Tour to the South' was a catalyst for entrepreneurship, especially in the South of China, where private enterprises had settled in designated zones that protected private initiative. At the national level though, while the market did gain in relevance, State policies still emphasized economic regulation and command and control as well as the mainstay status of the public sector. But public SOEs remained sluggish in their entrepreneurial spirit, they just didn't have the incentives that private companies have to innovate or think outside of the box. So, while private companies didn't enjoy the same rights as SOEs, their status still improved during this

period. The 15th Party Congress Meeting finally recognized the legal status of private enterprises as one of parity with the public sector in 1997 and a 1999 constitutional amendment acknowledged that non-public enterprises are an important part of a socialist market economy. Also, in 1999, Jiang Zemin invited private entrepreneurs to enter the Party; a huge step considering entrepreneurs were considered criminal only 20 years earlier.

The year 2000 marks the beginning of the third stage of China‘s entrepreneurship development. Especially since China‘s entry to the WTO in 2001, the country has issued a series of encouraging policies to incentivize entrepreneurship and private investment. In 2002, the government announced that it would „eliminate all restrictive and discriminatory regulations that are not friendly towards investment and private economic development in taxes, land use, business start-ups and imports and exports. The Small-and medium sized-enterprises promotion law, issued in the same year, marked the start of a new era for SME development. The development and expansion of the internet naturally offered a platform for these SMEs and innovators to expand. The ‘Millennial’ Chinese entrepreneurs combined ‘opportunism with pragmatism’. They often profited from overseas education; a new feature among Chinese entrepreneurs. The number of entrepreneurs grew throughout the 2000s. Leaders from Xiaomi, JD.com and Qihoo 360 are all prime examples of China’s internet entrepreneurs that arose during this period. Apart from the internet and mobile technology sectors, many entrepreneurs started appearing in other industries: energy, healthcare, financial services, consumer, retail among others, where businesses were increasingly intertwined with the rapid growth of science and technology.

During the Xi era, we see an initial period of support, followed by a radical tech crackdown starting in 2021. Observers were initially buoyant, when in 2014 Premier Li Keqiang issued the Mass Entrepreneurship and Innovation Policy, which promised government support for innovation and entrepreneurship to boost employment, promote technological innovation and stimulate industrial growth. The policy was part of China‘s drive to shift its economic development towards a path characterized by slower, but high-quality growth. As part of the Mass Entrepreneurship and Innovation Policy, the government would innovate its institutional mechanisms to create a better environment for fair competition, deepen business system reforms, strengthen intellectual property protection and establish a mechanism for the training and hiring of talented professionals. Financial support would also be available at all levels of government; a move recent literature has tried to capture in the debate over the Chinese venture capital state. In the process, banks were encouraged to cooperate with other financial institutions to offer special support to start-up firms. The government also promised that it would support the development of Internet finance companies and crowd funded projects.

China’s Entrepreneurship Ecosystem

For despite the disruptions experienced over the last couple of years, China is still a vibrant place for people to set up their business. The Fortune Global 500 is now more Chinese than American. In 2022, 145 Chinese companies featured on the list of the world‘s largest companies by revenue, but the top ranked companies were still American. Top 10: Walmart, followed by Amazon and then three Chinese Companies: State Grid, China National Petroleum and Sinopec. China State Construction Engineering, at number 9, is the final Chinese company in the top 10. (slide 18)

The Global Entrepreneurship Monitor conducted an annual assessment of conditions for entrepreneurship in different countries around the world, until covid hit, so 2020 is the last year we have an assessment for China. The spider diagram shows how experts from China rated the country according to different factors required for successful entrepreneurship. The blue line shows the experts‘ ratings, the orange line the ratings from the Global Entrepreneurship Monitor, which consistently rates issues worse than experts in the country. However, the lines largely mirror each other, there is no factor in which the GEM comes to a contrary assessment than the experts. Ratings are from 1 to 10. (slide 19)

China seems to offer the physical infrastructure required for entrepreneurship, but does not provide a great deal of education on entrepreneurship in schools. Finally, internal market dynamics and government policies are also assessed positively, while entry regulations still seem to be a problem.

In terms of location, the four main locations for Chinese entrepreneurship, measured by the number of start-ups are Beijing with 1593 starts, Shanghai with 893 start-ups, Shenzhen with 514 start-ups and Hangzhou with 407 startups. Then there is a big gap, where we find Chengdu with 129 start-ups, Wuhan with 90 start-ups and Xiamen with 89 start-ups. All numbers are for 2021. So, in terms of quantity of start-ups, Shanghai outranks Beijing. In terms of quality though, Beijing outperforms Shanghai, at least according to StartUpBlink, who rate cities according a number of indicators, including the presence of strategic branches and R&D centers, branches of multinational enterprises, private sector investment, number of employees in startups and many more indicators.

The Pitch

A pitch is a roughly 20-minute-long presentation of what your business is trying to do. The pitch is the foundation of a business plan. A presentation is created quicker than a text document, it can be tested and adjusted quicker. In creating a pitch, entrepreneurs with a business idea should try and stick to the 10/20/30 rule: meaning they need to create 10 Slides, shouldn’t exceed the 20 minutes and should use at least 30-point font for their slides.

Chinese business lives off of personal relationships, or guanxi. This also means, that for entrepreneurs it is critical that they build a powerful network, preferably with connections to angel investors or venture capitalists with money. According to Damien Zhang, vice president of CDH Capital, entrepreneurs should not hesitate and should reach out to investors and build personal bonds. What is particularly is attending informal meetings and dinners, where you really get a chance to talk to investors on a friendlier basis. Entrepreneurs should be proactive and interact with investors, even if they do not fit investors‘ mandates. Angel investors aren‘t just useful for money, they usually also have a huge amount of experience and advice that entrepreneurs can profit from, even if the investor decides not to invest. What is also important during a pitch is that entrepreneurs do not exaggerate numbers. Investors in China will conduct a thorough investigation of the business‘s figures, to see if they add up, so there is no point embellishing numbers or capabilities. Investors will always do their research before taking any decision and investors may choose to pass on the company once they realize that the pitch was not true. So, honesty is super important. In the same vein, you should be realistic and open about the competition that you are likely going to face for your product. Every

Chinese investor does a very thorough cross-checking and if you understate your competition or there is something amiss with your numbers, investors will go past you. So yeah, these are all points you should pay attention to when preparing a pitch in China.

Class 6: Universities in China's National Innovation System

Value of Universities

Benjamin Disraeli, the former British prime minister once said, „a university should be a place of light, of liberty and learning". What he meant, is that a university should be a safe space to exchange ideas, sometimes radical and controversial ideas. For it is when bright individuals feel enabled and comfortable to push the boundaries of their imagination that extraordinary new ideas emerge. The definition of innovation, innovation starts with an idea, followed up by courage to pursue ideas. That is the ideal at least, of course there are many more factors involved in producing innovation, such as money and demand, which can hamper innovation in both firms and universities. While some, like Benjamin Disraeli, place great hope in the concentrated and liberalized brain power in universities, others are more skeptical over universities abilities to produce talent and innovation. Anton Chekhov remarked that "universities bring out all abilities, including incapability". Derek Bok, a former president of Harvard, one of the most prestigious universities in the world, said that „universities are institutions run by amateurs to train professionals".

Naturally the focus for many, such as Nelson Mandela and Aristotle, focus on education as the main take-away from university. Dr. Martin Luther King Jr. teaches us that education does not necessarily mean the accumulation of knowledge alone, but rather that the function of education is to think intensively and critically. Others, such as the 19th century American journalist George Horace Lorimer, point out that for students the aim of attending university should be to eliminate the need to attend university, that you should become self-educating men and women. Apologies for the lack of gendering, it seems Mr. Lorimer still requires a little more time at university to expand his intelligent observation to the other half of the world's population. Robert Oppenheimer is equally cynic and sexist, but wise. He states that no one should leave universities with a feeling that you know everything. Finally, besides knowledge dissemination and personal edification, we should not underestimate the social function of universities, as nicely summarized by David Wood. We grow from our encounters at university, from the exchanges and intensive discussions with friends and lecturers.

Universities and Innovation

The proper role of the university in a national innovation system, or more broadly, in a knowledge economy is an extremely controversial topic. We defined a ‚national innovation system' as "…a set of distinctive institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such, it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies"? A knowledge economy is defined as "a system of consumption and production that is based on intellectual capital. In particular it refers to the ability to capitalize on scientific discoveries and applied research". So, while national

innovation systems focus on institutions, in essence the actors and policies that produce innovation, the knowledge economy investigates the mechanisms in between institutions, the intellectual flows that are traded between institutions.

Studies on national innovation systems would focus on the rules that enable the production and safeguard the value of intellectual property, whereas studies on the knowledge economy investigate how science and academic scholarship can be commercialized. The terms will overlap to a certain extent, but for our purposes, think of the two concepts as different angles that you can use to investigate a topic of research. Take universities. From the standpoint of national innovation system research, you could investigate how countries design policies that foster innovation in universities. From the standpoint of the knowledge economy, you could investigate how ideas generated in universities can be brought to market, so the linkages between academia and business.

Theoretical Justification for Universities

While there is a consensus on the role of the university in disseminating knowledge through teaching, there are disagreements regarding its role in generating knowledge, and even less agreement on its linkage to the industry and the commercial market. Theoretically, Nelson and Arrow laid the foundation for the division of labour between industrial and academic research. For firms, they found that investments in R&D are guided by the hope that there will be a significant return on their investment. This seems obvious, profit-maximizing firms will only invest in innovative activities, if there is hope that their innovations will make them a lot of money. This is why they need intellectual property protection, so as to ensure that once they produce a new technology, that they have the opportunity to recoup those investments and make a profit, preferably exclusively, without other copy-cat and latecomers reaping the rewards without having taken on the investments in R&D. For as Nelson and Arrow argue, creating knowledge is expensive, but once it is produced, the knowledge will not diminish or degrade as a result of other firms using the knowledge. This is a problem for the firm, because if adoption and dissemination of knowledge is cheap, there are fewer barriers for other companies to marketize the innovation, meaning it becomes harder for the original inventor to recoup investments. Society meanwhile doesn‘t care. For society as whole, it would be optimal for the new knowledge to be available at the cheapest cost. And usually competition drives down prices, so for society, the extra competition an innovator faces is a good thing. We don‘t care whether they get back their money for investing in innovation, all we care about is what price we pay for the product. As a result, the social returns to R&D investment far exceed the private return earned by the individual firm, which would lead to under investment in basic research. And so, the market fails, because innovation is a public good, which once produced allows other firms to reap profits or users to deploy the knowledge for free. Consequently, firms are disincentivized to invest in basic research that is demanded by the market. When the market fails we need state intervention, in this case in the form of public funding for basic research carried out by government laboratories, think tanks, incubators and universities.

Triple Helix Model

Merton argues that academic research has its own motivations, that are centered on the efficient creation of knowledge and on the advance of scientific frontiers. In essence, he

argues that academics innovate, because they have an internal drive to produce progress, that they relish the quest to discover and publish new knowledge. Merton‘s insights are supported by Dasgupta and David (1994), who are that industrial research focuses on profit and intellectual property, while academic research is a quest for fundamental discovery.

Yet industrial and academic research isn‘t as separated as Merton (1973) or Dasgupta and David (1994) suggest. Industry funding of university research is an important component of academic research and industrial innovation, especially as federal funding for universities continues to decline and companies cut back on basic, intramural research. When the state cuts budgets, universities are forced to look elsewhere for funds. While such support to university research takes many forms from contracted research to individual consulting, university-industry cooperative research centers are seen as an effective means to promote the linkages between industry and university. For academia, funding is necessary, but there are both optimistic and pessimistic views on allowing industry to guide research. Some are worried, others not, about the consequences of universities’ external orientation and changed funding base for academic roles and performance. The “pessimistic view” is based on a possible decrease in long-term research or changed research agendas, tensions between the culture of open science and increased commodification and commercialization, and increased pressures on the researchers and the traditional teaching and basic research tasks they carry out. On the other hand, it has been argued that the convergence between academic and corporate research can imply increased flexibility and autonomy for researchers and a more practical approach to research at universities. The literature of National Innovation Systems is full of examples of how important it is to link university research to industrial needs, but in a symbiotic (and not parasitic) fashion.

An important model to conceptualize the relationship between the government, industry and academia is the triple helix model by Henry Etzkowitz and Loet Leydesdorff. What the model does is investigate interactions between universities, industries and governments to show how intermediary institutions have developed that facilitate interactions. Technology transfer offices and science parks, but also incubators and think tanks are examples of institutions that work at the intersection of the three elements. The model begins with the assumption that the three actors each serve an ‚initial role‘ to society: universities engage in basic research (more on basic research in just a moment), industries produce goods and governments regulate markets. As interactions with the other actors increase, each component evolves to adopt some of the characteristics of the other institution, which then gives rise to hybrid institutions, such as think tanks.

Because universities basic role is to provide education and conduct basic research (more on the different types of research in just a moment), interactions between universities and industry initially revolves around universities providing the research that industry builds upon to produce commercial goods. Another interaction is when university staff or students join industry or vice versa, which fosters knowledge exchange between the two elements. Then there is informal interaction, for instance at conferences or creating co-op programs, such as our case study seminar, that aim to integrate industry approaches into students‘ curricula.

The strength of interactions between government and universities depends on government policy and its general relationship to higher education. When higher education is largely public, the government has a higher influence on universities and the research conducted, just

because it provides the funding. This is the case in Germany for instance. For countries, where universities rely more on private investments, you will see less government interference. Another example of state involvement in higher education is the establishment of new universities.

Etzkowitz and Leydesdorff initially argued that the strength of the interactions between governments, industry and university depends on which component is the driving force in the framework. In a statist model, a strong state is driving interactions between the three components in a top-down implementation. In a laissez-faire model, in which the industry and market forces are the leading forces, the ties are weaker and each institution tends to remain very independent. However, the distinction between the two models is not always clear cut, as the government can choose to adopt a strong or a weak stance depending on the context and the industry. In a knowledge-based society, where innovation is increasingly based on scientific knowledge, the role of universities as creators of knowledge is more valued. As a result, university, industry and government are more equal, and that no particular element is necessarily the driving force of the triple helix model of innovation.

Innovation vs. Research and Development (R&D)

Innovation seems to focus on producing new or improving products and processes, while research and development doesn‘t necessarily focus on the application of generated knowledge, rather it seeks to increase the stock of knowledge itself. Research and development (R&D) includes activities that companies undertake to innovate and introduce new products and services. It is often the first stage in the development process. Many people use innovation and R&D interchangeably, but technically they are complimentary to one another.

Take the example of the Apple iPhone: Steve Jobs and Apple innovated the cellular phone industry when they introduced the smartest of smart phones—the iPhone. Fast forward to over ten years later, where they now spend millions and millions of dollars each year to research and develop this innovative product and improve its functionality and use. It started with innovation, and turned into rigorous research and development to improve on their innovative idea.

Innovation usually occurs on a much larger and more sweeping scale. It often isn’t incremental…it is huge. Innovation and R&D both play a tremendous role in the success of any product or company. You absolutely need both R&D AND innovation to survive and succeed.

Yet R&D and innovation also share commonalities, especially in terms of function. First, both innovation and R&D should produce something novel, i.e. the aim of both innovation and R&D is to uncover new knowledge. Second, both require creativity to succeed, they are based on original ideas, not just some routine change. Third, both involve a great deal of uncertainty, they involve costs, time and the outcome cannot be predetermined. Fourth, ideally the process is planned and recorded, meaning that whoever is engaged in innovation or R&D is doing so in a systematic fashion. Finally, the new knowledge generated needs to be transferrable/reproducible. In other words, the new knowledge needs to be codified so that it can be transferred to and used in different contexts.

Types of R&D

First, basic research is „experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view." Again, the idea of the noble researcher should come to mind that conducts research just for the sake of producing knowledge, without an afterthought to how that knowledge could be applied. This is why basic research is also called pure or fundamental research, because it is mostly driven by curiosity. But basic research is super important, because it involves whacky ideas, out of the box thinking, which can often be very expensive and extremely risky. However, when it works, it can fuel technological innovations that can be applied in practice. Examples: a study searching for the causative factors of cancer, a study on the growth process of oak trees, a study on the origin of cryptocurrency, a study on Ming emperors' favorite underwear… Anything, where application or commercialization are not the primary objective.

Second, applied research is an original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective." Applied research is a type of examination looking to find practical solutions for existing problems. These can include challenges in the workplace, education and society. This research type uses empirical methodologies, such as experiments, to collect further data in an area of study. Findings are applicable and usually implemented upon completion of a study. Applied research focuses on answering one specific question for a client or sponsor. There are three types of applied research:

Action research: Action research helps businesses find practical solutions to problems by guiding them.
Evaluation research: In evaluation research, researchers analyze existing information to help clients make an informed decision.
Research and development: Research and development focus on creating new products or services to meet a target market's needs.

Research and development is a type of applied research. Examples: a study on how to improve literacy in teenagers, a study on how German companies can market their products in China, a study on how to design industrial policies…

Finally, experimental development is "systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes." With experimental development you acquire, combine and shape existing scientific, technological, business or other knowledge and skills in a new way. Experimental development may comprise prototyping, demonstrating, piloting, testing and validating new or improved products, processes or services. The primary aim is to make further technical improvements on products to make them commercially viable.

China's Higher Education System

China's current higher education system was largely shaped by the history of the last 50 years. During this period, two opposing forces have played an important role in the formation of the

current system, the centralized Soviet education model and the informal Chinese education model. The working of these two forces generated the current two overlapping systems: the regular higher education system and adult higher education system. Both systems were administered by central ministries and provincial or municipal governments. Only in recent years have private higher education institutions begun to emerge. The regular higher education system was set up to respond to the state's need of industrialization, whereas the adult higher education system was to meet the education need of the generation whose higher education opportunities were delayed by wars before 1949 or by the cultural revolution, as well as those who failed in the national higher education entrance examination.

There were two major structural changes in China's regular higher education system in the latter half of the 20th century. The first major structural change took place from 1949 to 1955. Private universities, 65 in total, were either merged into public universities or transformed into public universities soon after the founding of the People's Republic of China. Also, 227 Chinese universities were consolidated into 181 universities following the Soviet centralized model. To match the centralized economic planning system, Chinese universities were recombined into new categories based on their disciplines, such as comprehensive universities, normal universities, polytechnic universities, medical universities, and so on. You can still see the remnants of this structural reforms in the names of many Chinese universities today. Geographic distribution was also considered to make sure that each major region in China would have different types of universities represented. As you can see from the figure on the following slide (change to following slide), the administration of these universities also followed a hierarchical model with the Ministry of Education in charge of comprehensive, normal, and polytechnic universities. Other universities were administrated by the corresponding government Ministries and local governments.

The second structure change was carried out in a broad context of reform and opening up in the education sector, which started in 1985 when the Central government issued the ‚Decision of the Central Committee of the Communist Party of China on the Reform of the Educational Structure'; a major policy decree detailing the reform measures that the government was going to take. This reform, along with other changes since the end of Culture Revolution, has been characterized as "3Ds" and "3Cs."

3Ds and 3Cs

The 3Ds refer to decentralization, depoliticization, and diversities. As part of the legacy from the Russian model, the central government had a very tight control of the university system. Neither the local government nor the universities had much incentive to initiate any change. In the 1985 reform, the central government relinquished power to the provincial and municipal governments so that better coordination among different local universities could be achieved. Universities were also given more autonomy in their day to day management. Depoliticization mostly took place in terms of the curriculum. During the Cultural Revolution, universities were seen as institutions for ideological indoctrination and many courses were designed to fit the political need. Soon after the end of the Cultural Revolution, the prerogative of setting up curriculum was returned to academics in the universities. Diversities mainly refers to opening up opportunities for new providers of higher education services. For instance, many private universities have been set up since the reform began in 1985. Diversity also means different channels for financing higher education. The proportion of government

funding in the operating budget of the universities has been in decline, so many universities have found ways to compensate the shortfalls by charging tuition fees, raising fees for special groups of students, commercializing R&D outcomes, fundraising from private sources and so on.

Three "Cs" refer to commercialization, competition, and cooperation. The commercialization of Chinese higher education is discussed mostly in terms of charging tuition fees and interacting with the market by providing R&D services. Competition for students, for faculty members, for research funding, for donations, and so on has become increasingly heated, particularly among the top research universities. At the same time, cooperation amongst Chinese universities and local government and industry has also become very strong. Many municipal governments have signed agreements with universities to become partners in promoting local economic and social development.

Universities in China's National Innovation System

With the 3Ds and 3Cs, universities' role in China's overall national innovation system started to change. As we discussed in previous lectures, China's national innovation system began to take shape in the 1950s and was heavily influenced by the Soviet Union. The Soviet Union's centralized management and planning meant that the government played a major role in almost all aspects surrounding research work. The government was the 1) only financial supporter for research work; 2) was a leader in activities like project planning and execution, 3), was in charge of direct supervision over research institutes, 4) coordinated the deployment of research resources and 5) was the pivot for knowledge flows among different research entities. It was also the government that dictated what would be on the curriculum, so what was taught in universities, which at the time was even more ideological than today. Under such a model, R&D work was undertaken by an independent research network which was composed of the Chinese Academy of Science and a number of research institutes directly under the supervision of central government, different ministries, or local governments, with projects and funds being directly deployed by the government. Universities were mainly set up to train S&T talents for the government, the emphasis was clearly on teaching and education; so, producing talent for industry, not conducting research themselves.

Since the 1985 reforms, China's National Innovation System has entered into a new era. Universities have since been recognized as centers for both teaching AND scientific research, as well as an integral part of the Chinese national innovation system. The diversification of China's national innovation system has generated much needed vitality. Government-affiliated research institutes are no longer the only players in the nation's research system; now research institutes, such as the Chinese Academy of Sciences are joined by public and private universities, industrial research labs, think tanks and incubators in the question to produce innovation. After more than two decades of reform, the position of China's universities in the country's national innovation system has been substantially promoted to a high level.

R&D Intensity in China

The diversification in players, as well as the more prominent role of universities in China national innovation system has also led to a greater focus on R&D as a share of China's GDP.

From this World Bank graph, you can see that R&D intensity, which measures how much of a country‘s GDP is spent on R&D, has been increasing steadily in China from 1991 onwards. In 2020, the last year we have records for, China‘s R&D intensity stood at 2.4 percent. This is still rather low, compared to other major economies. Countries with largest share of their GDP on R&D: South Korea (4.64%), followed by Japan (3,2%), Germany (3,19%) and the US (3.13%). Translated into absolute numbers, China spent 525 billion US$ on R&D in 2019, beaten only by the US, who spent 668 billion US$. Germany comes in at a credible fourth with 148 billion$ spent on R&D.

China’s Leading Universities

In September 2021, there were 3012 colleges and universities in China, with over 40 million students enrolled. Not surprisingly, the majority of Chinese universities are along the coast, with Jiangsu leading the way as the province with the highest concentration of universities by number. But what of quality institutions? In October 2015, the State Council published the 'Overall Plan for Promoting the Construction of World First Class Universities and First-Class Disciplines' (Overall Plan for Double First-Class Universities), aiming to comprehensively develop elite Chinese universities into world-class institutions through building and strengthening their disciplines and faculties, and eventually developing the universities included in this plan into 'world-first-class' universities by 2050. The Double First-Class University Plan represents a whole new way of ranking universities in China, replacing previous projects such as ‚Project 211‘. Project 211, initiated in 1995, sought to raise the research standards at universities, essentially by picking 100 universities that would excel in the 21st century (hence the name: 21 for 21st century 1 for 100). By 2008, China had some 116 institutions designated as 211 projects. These universities received extra funding, because they had managed to meet scientific, technical and human resources targets and were consequently able to offer advanced degree programmes. But by 2014, universities stated that funding from Project 211 had ceased, probably in preparation the Double First-Class University Plan in 2015.

As of 2022, 110 Double First-Class universities from among the Chinese mainland universities were shortlisted in the world's top 1,000 by the Academic Ranking of World Universities, including 61 Top 500 universities, 38 Top 300 universities, 26 Top 200 universities and 8 Top 100 universities. Also known as the Shanghai Ranking, the league table was originally compiled and issued by Shanghai Jiaotong University in 2003, making it the first global university ranking with multifarious indicators. Among the indicators are the number of alumni that receive Nobel and Fields prizes, staff that have received Nobel and Fields medals, number of cited researchers, papers published in Nature and Science, citation indexes and per capita academic performance. The ranking has been criticized for relying too much on award factors, thus undermining the quality of instruction and humanities. The Shanghai Ranking has however also been praised for being unbiased towards Chinese institutions.

Top 5:

1. Harvard
2. Stanford
3. Massachusetts Institute of Technology
4. University of Cambridge
5. University of Berkeley

The best Chinese university is, unsurprisingly, Qinghua University at number 26, followed by Peking University at 34, Zhejiang University at 36, Shanghai Jiaotong University at 54, University of Science and Technology of China at 62, Fudan University at 67, Sun Yat-sen University at 79, the Huazhong University of S&T at 96 and the University of Hong Kong at 96 below the top 100 in the world. Unsurprisingly, most of these universities also form an alliance of top-class universities in China that seek to become China‘s answer to America‘s Ivy League: the C9 League.

C9 League

The C9 League is an alliance of nine universities in China, initiated by the Chinese government to promote the development and reputation of higher education in China in 2009. Collectively, universities in the C9 League account for 3% of the country's researchers, but receive 10% of national research expenditures. So similarly, to the US, there exists inequality in the distribution of funds to universities, based on their ranks in, among others, the Shanghai Ranking. The C9 produce 20% of the nation‘s academic publications and 30% of total citations.

The C9 League schools enjoy access to special resources, and have arrangements amongst each other for sharing resources. Besides producing a greater number of publications, they also have a higher fraction of elite academics who have been awarded one of China's top academic honors, the Thousand Talents Plan for Professorship and the Changjiang Professorship. While the former honors programme specializes in attracting talent in S&T from abroad, especially from among overseas Chinese communities, the latter represents the highest academic award issued to an individual in higher education by the Ministry of Education. Again, the award is disproportionally awarded to individuals affiliated with the C9 League, creating a self-reinforcing cycle of both academics and students wishing to attend C9 universities. Higher student numbers and quality staff in turn, lead to the C9 League receiving more funding from both national and local governments in order to build new research centers, improve facilities, hold international conferences, attract world-renowned faculty and visiting scholars, and help Chinese faculty attend conferences abroad.

Class 7: Pavitt Taxonomy

Definition

The origin of the word taxonomy dates back to the 18th century. Originally, it was used as a synonym for the word ’category‘ to classify minerals and animals. The etymology of taxonomy goes back to the Greek words for arrangement (táxon) and nomos (law). Nomos you will find in many words, such as economics, meaning the law to run an agricultural estate, essentially a household. While taxonomies were initially used predominantly in the natural sciences, think of Charles Darwin and his evolutionary taxonomy, over the 20th century taxonomies have also crept into social sciences, such as our own. Taxonomies are meant to classify phenomena with the aim of maximizing the differences among groups. The aim is to reduce complexity, by examining a population and distinguishing similar elements from dissimilar elements within a population under study.

In industrial economics, taxonomies have proven extremely useful to subdivide productive activities into classes. For example, grouping similar firms according to their size, their organization or their main products. But many other classifications have been attempted for other purposes, such as the distinction between producers of durable and non-durable goods. What other taxonomies can you think of in the realm of economics (stock market indices, the Global 500, taxonomies for standards, varieties of capitalism…)

Pavitt Taxonomy

Pavitt's taxonomy has a different purpose, namely to classify firms based on their technological competence. Keith Pavitt, was an English professor of Science and Technology Policy at the University of Sussex. In a distinguished career that included stays at Harvard, Princeton and the OECD, his most prolific work was on pioneering new methods to measure innovation and technological change. He focused on using patents as an indicator of technological competence in firms, which also served him to develop his famous taxonomy. Together with his colleague Joe Townsend, he gathered a comprehensive database of innovations introduced in the UK since the end of the war. He presents the database in the text we read for today's class. It serves as the foundation for the methodology used to develop the Pavitt Taxonomy.

To establish the database, Pavitt and Townsend questioned experts (either via interviews or surveys, not specified) to encounter significant innovations in British manufacturing output since the second world war. Importantly, the experts had to be knowledgeable about, but not working for the innovating firms. What is super confusing, or at least it was to me, is that the innovations are sampled from three and four digit product groups.

What Pavitt is referring to is the Industry Classification System, which classifies businesses for the purpose of collecting statistics. Digits simply represent a hierarchy within a sector. Two-digit products are products from the overall sector. Products from subsectors within that two-digit sector are classified with 3 digits. Products from industry groups within the sector's subsector are then 4-digit products. So what Pavitt is saying when he says the sample of innovations covers three- and four-digit product groups, is that the innovations he collected were primarily sourced from industry groups and actors on the subsector level. Meaning that his sample mainly covers large companies. He himself states that most of the companies he talked to were in mechanical engineering and metals, as well as textiles. He concedes that there was a slight under-representation of firms in chemicals and electronics, and a considerable under-representation of firms in aerospace. What he doesn't address at all is the service sector, where innovation can also occur, but that was not considered to construct his database.

So, what did Keith Pavitt do with this database? Put simply, he looked through the experts' responses and tried to categorize innovations according to the source of the technological change (so the sectors, subsectors and firms), the use of the innovations and the size of the principal actors. To determine the source of the knowledge, Pavitt asked experts to identify the type of institution that provided the most important knowledge inputs to a particular innovation. This allowed Pavitt to determine firms' relative importance in providing knowledge.

For the use case, Pavitt defines innovations that are used in the same sector as where they were produced as process innovations. Those innovations that are used in different sectors than where the innovation was produced, he defines as product innovation. Distinguishing between process and product innovation shows how knowledge flows from on sector to another.

For the size of the firms, he looks at their total world employment and employment in the UK. Checking firm sizes allows Pavitt to compare the size of distribution of innovating firms amongst sectors to see whether the size of the firm correlates with innovative output.
Then he also checks for a firm‘s principal activity, to see whether firms produce innovations outside their principal sector of activity. So, whether a shipbuilder‘s innovation is used in a different sector.

5 Scenarios

From the information on the source of innovation, the use of an innovation and the primary activity of the principle actors, Pavitt develops five possible scenarios:

1. Sectors of production, use and principal activity are all the same.
2. Sectors of production and principal activity are the same, but the innovation is used in a different sector
3. Sectors of principal activity and use are the same, but different sector of production
4. Sectors of production and use are the same, but different principal activity.
5. Sectors of production, use and principal activity are all different

For Category 1, where the sectors of production, use and principal activity are all the same, the example he provides is when a steel making company produces a process innovation for itself. Pretty logical so far.

For Category two, where the sectors of production and principal activity are the same, but the innovation is used in a different sector, the example he provides is a firm making textile machines (their principal activity is making machines) designs a new textile machine (production sector the same) for use in the textile industry (use not in machine factories, but in textile industry)

For Category 3, where principal activity and use of innovation are the same, but the production sector is different, the example he provides is a shipbuilding firm (principal activity is shipbuilding), develops a special machine (production sector not connected to shipbuilding), but for use in building ships.

For Category 4,where the sectors of production and use are the same, but principal firm activity is different, the example he provides is a company engaged principally in general chemicals develops a process innovation (remember, a process innovation is an innovation used in the same sector according to Pavitt) in textiles (so production and use are the same, but innovation is produced by a company not principally engaged in textiles).

For Category Five, sectors of production, use and principal activity are all different. The example he provides is a firm engaged in electronics develops an innovation in instrumentation (different production sector) for use in making cars.

What the five possible combinations show us is that knowledge can flow, it is easily transmitted and can be reproduced, but is only applicable for a very specific use-case. The assumption Pavitt makes is that firms will not be able to identify and evaluate ALL innovations on the market, but that they are constrained in their search by an existing range of knowledge and skills. From this assumption, he concludes that knowledge transfer and innovation is specific to firms. What they can do in the future is conditioned upon their knowledge today.

This realization means that different principal activities in firms generate different technological trajectories. Pavitt groups these different trajectories into three categories, which form his taxonomy: first, supplier dominated, second, production intensive and third science based. For the second trajectory, production intensive firms, Pavitt distinguishes between scale intensive and specialized suppliers, so in total we have four categories that make up the taxonomy: supplier dominated firms, scale intensive firms, specialized suppliers and science-based firms.

4 Technological Trajectories

This realization means that different principal activities in firms generate different technological trajectories. Pavitt groups these different trajectories into three categories, which form his taxonomy: first, supplier dominated, second, production intensive and third science based. For the second trajectory, production intensive firms, Pavitt distinguishes between scale intensive and specialized suppliers, so in total we have four categories that make up the taxonomy: supplier dominated firms, scale intensive firms, specialized suppliers and science-based firms. Pavitt intended the taxonomy to describe the behaviour of innovating firms, to predict their actions and to suggest a framework for policy makers. The taxonomy also shows you which group of companies provides other groups with innovation. For instance, supplier dominated firms get most of their technology from scale intensive firms and science-based firms (for example transport equipment, power tools etc.). Science based firms in turn also transfer technology to both types of production intensive firms, but at times will also benefit from machinery from specialized suppliers. And it‘s not just innovation that flows between these different groups, also knowledge and information, as well as skills can be traced from one group to another. So pretty powerful, if used correctly.

Supplier dominated firms are active in traditional industries, such as clothing and furniture. These are firms that innovate by acquiring machinery and equipment. Usually, in these sectors smaller firms are prevalent and technological change is introduced rather than generated internally. Innovations are introduced through inputs and machinery provided by suppliers from other industries. This is why these types of firms are called supplier dominated firms, because they rely on suppliers as a source of innovation. Consequently, firms in this group do not carry out much R&D or other innovative activities. The goal of these companies for innovation is to cut costs and to provide greater flexibility.

Within the production intensive group of firms, we have specialized suppliers and scale intensive firms. Specialized suppliers of capital goods and equipment live on the symbiosis with their customers. Specialized suppliers include the sectors producing machinery and equipment, their products are new processes for other industries. R&D is present, but an important innovative input comes from tacit knowledge and design skills embodied in the

labour force. The goal for these companies for innovation is mainly improved product design. The average firm size is still small and innovation is carried out in close relation to customers.

The second subcategory of production intensive firms are what Pavitt calls scale intensive firms. Scale Intensive firms are located in industries where scale economies are relevant (automotive and basic metals for example). Their production processes are characterized by rigidity, so technological change is usually incremental. Important process innovation coexists with new product development. The goal for this type of company in terms of innovation is incremental improvements in cost and reliability.

Finally, science-based firms can be found in sectors where innovation is based on advances in science and R&D. Prominent examples are the pharmaceutical or electronics industries, where in-house research laboratories are important. These firms are characterized by intensive product innovation and a high propensity to patent.

China's Regional Innovation System II

So far, we have viewed China's innovation system from a national perspective. In doing so, we followed a systems approach to innovation, where a large group of actors interact with one another. In systemic approaches to innovation, innovation is considered an evolutionary, non-linear approach. This stands in stark contrast to the linear or Schumpeterian view of firms innovating in isolation; an approach we will encounter in greater detail next week. The literature on national innovation systems argues that states can design institutions that enable intensive communication and cooperation between stakeholders to create an environment conducive to technological change. So far, we have viewed the state's possibilities at the national level in China, let's now get a bit more granular and examine how innovation works at the regional level in China.

The literature on regional innovation systems argues that because regions differ in terms of their patterns of industrialization, culture and other elements we have already established as critical for innovation systems, we need to dissect national systems and concentrate on smaller geographical units and their distinct innovation infrastructure. In doing so, we can examine the four resource types inherent in regions, namely territorial resources, relational resources, intangible resources and institutional resources. The need to treat regions separately is especially important in China, a large country with considerable regional disparities. Regions in China compete amongst each other to achieve individual career advancement and economic prosperity. As such, they will erect barriers that guard against knowledge spillovers, which as we know play a crucial role in innovation processes.

Research on Regional Innovation in China

Research on regional innovation systems in China in the past has focused on uncovering reasons for success stories of regional innovation, such as Shenzhen. By identifying key actors, institutions, infrastructure and their interactions within a well-performing cluster or region, RIS scholars have attempted to explain why innovation may become concentrated in certain regions. Accordingly, regional public policy has been crafted based on such analyses, leading to focuses on high-tech or knowledge-based industries, increasing research excellence, attracting globally competitive firms, and stimulating university- based spin-offs.

In general, four different approaches to regional innovation system research can be identified:. First, the triple helix approach analyses interactions between universities, industry and government, whose calibration the model argues is key to crafting a regional innovation system. The second approach generally used is called the structural approach, which identifies key structural elements in regional innovation systems (such as education, regional R&D investments, existing technological base and technological output, such as patents). The advantage of the structural approach is that it is visible, straightforward and can produce useful implications for policy-makers. The disadvantage is that it is impossible to identify ALL the elements in an innovation system. The third approach is called the functional approach, which is a more pragmatic approach, whose main aim is to reduce complexity. The approach simplifies the number of elements to limit the number of specific functions in a system. The downside is that simplification makes it hard to compare functions in different systems and within a system at different periods. Finally, the fourth approach, called the effectiveness approach to research links system inputs to their corresponding performance outputs to evaluate a system‘s efficiency and effectiveness. Quick recap, what was the difference between efficiency and effectiveness? Very good, efficiency is defined as the ability to accomplish something with the least amount of wasted time, money, and effort or competency in performance. Effectiveness is defined as the degree to which something is successful in producing a desired result; success. So, the focus of the effectiveness approach is on optimizing inputs and improving innovation systems‘ performance.

As you can imagine, a lot of research is undertaken to deconstruct China‘s national innovation system and focus more closely on regional innovation. Li (2009) for example asks Why are there growing disparities in innovation output between provinces when the comparative resources dedicated towards innovative activities have remained roughly the same? Using an effectiveness approach, Li finds that the answer lies in the efficiency with which innovation is undertaken. Remember in our treatment of the history of China‘s national innovation system, we learned that gradually R&D is shifting from government run institutes, such as universities and research laboratories to firms? Remember that far back? No, well it is and the consequence that Li finds for regional innovation is that the shift leads to greater disparity between provinces, because some provincial governments are able to provide more industrial policy tools that encourage innovation in firms than others. Li finds that government support is a significant determinant for innovation efficiency. Exploring the regional differences in government support for innovation is therefore an important strand of regional innovation research in China.

Another important strand is trying to link intellectual property rights protection, FDI and the country‘s WTO entry to differences in regional innovation. For instance, after China joined the WTO, it was forced to develop a more stringent intellectual property system. You would think this would benefit innovation across the country and to a certain extent it did. As we saw a couple of weeks ago, patent registrations in China shot up, but not everywhere in China. WTO entry and IPR protection do not therefore serve as sufficient explanations for patenting activities across provinces. Research into regional innovation systems has been able to uncover that additional regional differences and stimuli contribute to the upsurge in patent applications. For instance, application fee reimbursements or bonuses for patent registration, which differ across regions, also help explain regional differences in innovation.

Measuring China's Regional Innovation Systems

The measurement criteria we are going to use to judge provinces is patent applications, which you can see here on the map. As you can see, there are three big clusters found in the coastal area, namely Beijing (in particular Zhongguancun district), the Shanghai/Yangtze River Delta (including Suzhou and Hangzhou) and the Shenzhen Pearl River Delta, including Guangzhou. In addition, you have some other regional clusters in-land, such as Chengdu, Chongqing, Xi'an and Wuhan, but these are relatively small compared to the three coastal clusters.

But judging a regional innovation system on patent applications alone seems a little unjust. As we saw a couple of weeks ago, the number of patents doesn't necessarily convey a good measure of innovative capability. After all, many patents in China are registered for the sake of registering, because researchers receive monetary rewards for registering. The quality of the innovation, represented by the patent is not revealed. We can also evaluate regions based on the mobility and number of high-tech talents. Particularly, for the establishment and growth of high-tech ventures, how to secure talented people is important. Once personnel have gathered in a location, they will interact and as we know, interaction, exchange, communication produce innovation. They will come up with new ideas and maybe establish new businesses themselves.

The figure on this slide (23) shows the number of inventors moving into an area, so the number of those moving in minus those moving out. Red shaded areas indicate provinces where the number of researchers increased (so inflow of talent exceeded outflow), while blue areas done provinces where researchers decreased. In general, researchers tended to move from the provinces (cities) where the patenting activities are concentrated, such as Beijing, Shanghai, and Guangdong. Some inland provinces in the south, such as Sichuan, also gained inventors. In contrast, outflows of inventors dominated inflows in northeastern provinces such as Liaoning, Jilin, and Heilongjiang.

Class 8: Creative Destruction

Difference Creative Destruction and Disruptive Innovation

Essentially, the difference is in the impact a novel technology has on an industry. Joseph Schumpeter defines creative destruction as "the process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one". He obviously liked the word 'incessantly', but he uses the term deliberately to emphasize something. What do you think Schumpeter wants to stress with the term 'incessantly'? Right, that creative destruction is continuous, that it will always exist, that we as humans are relentless and brutal in our drive for progress. Importantly, creative destruction also brings increases in productivity. Schumpeter believed that for us to progress as a species, we needed to destroy long-standing arrangements, question existing assumptions and innovate new methods of production in order to free up resources and energy.

Clayton Christensen, the brain behind disruptive innovation defines disruptive innovation as "a product or service that takes root initially in simple applications at the bottom of the market

and then relentlessly moves up the market, eventually displacing established competitors". Disruptive innovation is more specific in terms of where the disruption occurs and what progress the disruption will take. Christensen specifically states that the product or service that will eventually cause disruption occurs at the bottom end of the market. Schumpeter does not make this kind of distinction, to him creative disruption can occur in any sector of the economy, upstream or downstream, in services, public office and private manufacturing. Also, the focus of creative destruction is on technologies and products, not necessarily on jobs and firms. The destruction of jobs and firms, due to the rise of a new wave of reinvention, out of an alternate technology core, that is disruptive innovation. You can think of disruptive innovation as a radical type of creative destruction.

Exogenous and Endogenous Growth

Creative destruction theory treats economics as an organic and dynamic process, which stands in contrast to the static mathematical models of the time. For static models, such as those advocated by Alfred Marshall for example, the end goal of market economics is to reach an equilibrium stable condition. Schumpeter realized that markets are messy, that human beings are chaotic and that we like to rationalize decisions we made on a whim or accidents that led to breakthrough innovation by chance. Schumpeter did not see reality reflected in the standard exogenous growth theories on technological progress that dominated economics at the time. Endogenous and exogenous growth theories stress the role of technological progress in achieving sustained economic growth, the difference lies in where the theories see technological growth originating from. For exogenous growth theories, technological progress originates outside the economic system. The underlying assumption is that economic prosperity is determined by external, independent factors outside the economy, rather than internal, interdependent factors. Endogenous growth theories, which include Schumpeter's creative destruction, meanwhile believe that an economy's long-term growth is a by-product of activities, including innovation, within the economic system. In essence, Schumpeter placed innovation at the heart of economic growth. He believed, that as long as an economy was innovative, growth would follow.

For a model to be considered endogenous or Schumpeterian, it has to fulfil the following three criteria:

1) Growth is generated by innovation
2) Innovations result from entrepreneurial investments that are motivated by the prospects of monopoly rents
3) New innovations replace old technologies: growth involves creative destruction

The definition of entrepreneurship by Barringer and Ireland, stresses that entrepreneurship is the art of turning an idea into a business. In essence, an entrepreneur's behavior finds him or her trying to identify opportunities and putting useful ideas into practice. And to convert an idea into a business, they need to invest resources (time, money, materials…) and collectively this can be understood as entrepreneurial investment. The investments of an entrepreneur essentially. Entrepreneurs, people who take on the risk between buyers and sellers, they invest for the purpose of achieving monopoly rents. Monopoly rents are rents that can be extracted, because a firm enjoys a monopoly position. A monopolist is able to control price by restricting or loosening the supply of products the monopolist produces without fear of

attracting competitors. For Schumpeter, innovation arises because entrepreneurs strive to attain this privileged position.

Creative Destruction and Monopoly

To Schumpeter, creative destruction is intimately linked to monopolies. How? Schumpeter realized that in a dynamic economy, risky decisions are made, which may not turn out to be good for the firm making them. Good decisions are often not known in advance. When we make a bad decision, we tend to want to forget that decision immediately. When a decision turns out to be a good one, then boy do we like to milk how it was US that made the decision. Schumpeter admitted that providing good incentives can increase the likelihood of managers making good decisions. Incentives motivate managers to at least try to make good decisions, but even companies that provide incentives sometimes fail. Schumpeter saw failure as a natural part of market economies. To Schumpeter, bankruptcies lead to 'industrial mutation', an incessant revolution from within. Creative destruction can therefore be thought of in Darwinian terms, as a metaphor for evolution or as a selection device, in which progress occurs, because the 'least fit' are destroyed. Schumpeter believed that this destruction would naturally lead to monopoly structures in which the strongest and most innovative firms survived.

And thinking in Darwinian terms, and is implied by the word 'destruction', Schumpeterian innovation always creates both winners and losers. But Schumpeter also deployed creative destruction to investigate a wide range of phenomena in economics: how recessions serve to destroy older, inefficient technologies; how innovations create entrepreneurial waves leading to business and product life cycles or how the development of functioning financial markets can foster innovation. Schumpeter's insights created a tidal wave of research on the origins of creativity and the fate of companies and technologies. In other words, you can use creative destruction in your research not just to analyse why companies failed, but also why certain technologies were supplanted by others. Some argue that creative destruction is a precondition for economic development, because it ensures that the fittest, most innovative companies make the most profit and therefore survive.

Innovation in Chinese SOEs: Past

When economic reforms began in 1978, SOEs dominated the industrial landscape, producing 76 percent of China's industrial output and employing 59 percent of non-agricultural workers. By 1994, their share in industrial output had plummeted to 43 percent and non-agricultural employment was down to 41 percent, despite the government implementing a series of measures to prop up the public sector. Over the course of the 1990s, over half of China's SOEs were losing money and state industrial output growth had slowed to zero. Any yet, SOEs continued to enjoy advantages other companies did not benefit from, such as access to state subsidies, tax concessions, cheap utilities and land. In essence, optimal external conditions to innovate.

So why didn't they? Simple: the hand of the state was so overbearing that it stifled innovation during the 1990s, 2000s and some would argue into the 2010s. For at the same time that SOEs were struggling, township and village enterprises emerged, who were incredibly productive in producing innovations. These TVEs were often quasi state-run entities themselves, benefitting

substantially from local government patronage. So why did they innovate and formal SOEs did not? According to Lardy, TVEs were far more entrepreneurial in the Schumpeterian sense in that they paid a price for capital and inputs much close to market-clearing levels, they paid wages based on profitability and they sold output on the market, rather than the state-run commercial network. In short, TVEs were subject to market forces and were consequently obliged to think outside the box, to compete, to produce innovation. In addition, they faced much clearer and consistent objectives than SOEs and were not forced to carry the burden of paying for housing, medical care, schooling and other expenses associated with the danwei system. And even as TVEs merged to become private entities or when entrepreneurs were formally welcomed into the socialist market economy, soft-budget constraints didn't produce the type of impulse necessary for SOEs to innovate.

Fast forward to 2017, an IMF report still highlights similar deficiencies in SOEs as during the 1990s. SOEs are more likely to do nothing and maintain the existing advantages. Managers in SOEs lack professional management skills, because they are often appointed by the government. They are politicians, not entrepreneurs, so the accusation goes. SOEs are burdened by policies, which restricts their autonomy and flexibility, both needed to be creative. That these deficiencies in SOEs are being reproduced much closer to our times implies that prior reforms did not bear fruit. But this is only partly true, there have been reforms that have made SOEs in China more efficient than they were in the 1990s. The establishment of TVEs in 1984 can be seen as a first step in the right direction. Quasi-state run TVEs were already far more innovative than the formal state sector. Another important reform of the state sectors was the split shares reform in 2005, which allowed SOEs to sell previously non-tradable shares on stock exchanges. Effectively, the reform was a tool to privatize SOEs, so the government realized that to make SOEs more effective, they would have to be subjected to similar forces as private companies. The split shares reform was the first in a series of reforms that would eventually culminate in mixed-ownership reforms proposed by the Xi administration.

Mixed-ownership reform

The mixed-ownership reform was launched after the 3rd Plenary Session of the 18th CPC Central Committee in November 2013 as part of the 'Decision on Several Major Issues Concerning Comprehensively Deepening Reform'. The goal of 'The Decision' was to develop a more diversified ownership economy, so to have public ownership diluted by private investments in SOEs. In July 2014 and on the behest of SASAC, pilot projects were established for central SOEs to initiate mixed ownership. Reform efforts accelerated from 2015 onwards, when the 1 + N Files called on SOEs to introduce capital from private sources in competitive industries. The files set the goal of improving the efficiency of capital allocation and operation in SOEs and perfecting the modern enterprise system. Later that same year, the State Council issued a legislation that clarified what was meant by a modern enterprise system. For the State Council, a modern enterprise system would see SOEs accelerating technological innovation, management innovation and business model innovation, focusing on R&D innovation through the introduction of non-state capital. The Guidance on Deepening the Reform of SOEs places SOEs at the heart of China's innovation landscape, promoting independent innovation. China should cultivate a large number of SOEs with innovative capabilities even in international comparison. Additionally, the influence of administrative appointment in SOEs should be weakened, by building up a corporate governance mechanism with clear property rights and

proper incentives. On the back of the State Council's 2015 edict, Employee Stock Ownership Plans were piloted in SOEs, so shares were issued to employees as an incentive to work productively. We are now in the fourth round of ESOP reforms, meaning mixed ownership of SOEs is gathering pace.

And have these latest rounds of reforms resulted in an increase in innovative activities in SOEs? From afar that is obviously hard to assess. We have already had a look at the Fortune Global 500 list in previous classes and established that 95 of the 143 Chinese companies on the list were SOEs. But that doesn't necessarily give us a good measure of their innovativeness. The problem is of course that it is hard to gain access to SOEs, so qualitative studies based on interviews are cumbersome. Fang et al. (2017) find that the number of patent applications by SOEs since privatization drives have increased. Zhang et al (2020) show that mixed ownership reform has seen SOEs invest more in R&D, but did not have a significant impact on patent numbers.

Creative Destruction in China

Scott Kennedy, Indiana University professor who some of you may know for his work on lobbying in China, argues that China is really good at creation, but not so hot on destruction. The numbers show that in 2013 11.3 million new companies were registered in China, with 95 percent of them private enterprises. Scott Kennedy says, that the dismantling of the planned economy over the past two decades has led to a tremendous boom in the creation of new private-sector firms. Perhaps less encouraging for fans of Schumpeter is China's record on the exiting side. While in the last few years not more than 8 percent of China's existing firms have been shuttered annually, the rate in the U.K. has been around 10 percent, and in the U.S. over 13 percent. "Today American and European companies are five times more likely to die in their first year as Chinese companies," writes Kennedy.

Worrying, too, is the fact that companies shuttered in China usually are private, not the state-owned enterprises (SOEs) that often are the worst performers. For example, more than three-fifths of all Chinese companies that closed from 2008 to 2012 were in sectors of manufacturing dominated largely by private companies: wholesale and retail trade and shipping and storage. "By contrast, the sectors that suffered the fewest deaths during this period had a higher proportion of SOEs: mining, electric power, finance and education," writes Kennedy. But data from the Poulsen Institute suggests that SOEs are in trouble, despite (or maybe because of) mixed ownership reforms. Since the Corona virus broke out in 2019, the number of SOEs defaulting on debt has increased rapidly.

And yet, they are not exiting industries, the number of SOEs across industries has barely changed, efficiency has not improved and more than 70 percent of dividends paid were reinvested back into SOEs, not used for social spending, such as on R&D. Reforms have failed because SOEs lack incentives to exit commercial industries. If SOEs were to exit, the argument goes that they could make space for more competitive private companies. SOEs would still retain a role in critical industries, such as security and energy, but would leave industries more suitable to private initiative to the private sector. Comparing the first two quarters in 2020, SOE revenue barely grew, while private companies' revenue grew 6%, as they benefited from China's export recovery.

SOEs continue to underperform private firms in almost all sectors. One reason SOEs perform worse, is that they are forced to expand investment to stabilize the economy, even when their books don‘t look too healthy. In short, they must perform political duties on top of their business interests. Another reason for the low exit rate for SOEs is that they are really important employers for local governments. The Chinese government therefore designs policies to protect these low-productivity employers, to avoid corporate failures wherever possible. The banking sector is instructed to provide SOEs with preferential access to credit. What we saw from our class on entrepreneurship, setting up a company in China is relatively straightforward, China‘s bigger problem in terms of creative destruction is the exit of companies, especially inefficient SOEs.

Class 9: Disruptive Innovation

Low-End Footholds and New Market Footholds

Clayton Christensen emphasized that disruptive innovations, whether as products or services, can come in two forms. Disruptive innovators either target low end customers by offering a basic product at lower costs that the current option on the market or by creating an entirely new market.

In targeting low-end customers by providing an existing product at a cheaper price, disruptors take advantage of incumbents tendency of always striving to provide their existing customers with improved products and services. In doing so, incumbents focus their attention on satisfying existing customers, the most demanding customers and their desires. But by constantly innovating and improving their products, incumbents' offering will often overshoot the performance requirements for many conventional customers. Some customers may be satisfied with a basic, low performance, low cost version of the product, they will not demand the fancy additions installed in incumbents' improved version of the products. Disruptors take advantage by providing low-end customers with a 'good enough solution'.

The second option for disruption, the one you evaluated as more difficult to bring about, is when disruptors create a new market where none existed before. This form of disruptive innovation is more akin to Schumpeter's idea of creative disruption, where an innovation provides a totally new solution that hadn't existed before or finds a way to turn non-consumers into consumers. This last point distinguishes disruptive innovation from creative disruption. To Christensen, a disruptive innovation is not a breakthrough innovation, but rather transforms an existing product in a way that makes it more accessible to a new market of customers. As in the low-end footholds example this can be done via the price, so by making a previously expensive product more affordable AND/OR disruptors come up with a new business model or variation of a product that attracts new customers.

The Innovator's Dilemma

As such, disruptive innovations are the opposite of sustaining innovations, which try to keep hold of existing customers by catering to their rising demands. Sustaining innovations seek to improve existing products and processes. Sustaining innovations don‘t necessarily create new

markets, but rather build on a certain level of innovation, there has already been R&D conducted that the incumbents build on to improve their products. In a way you could compare sustaining innovation to incremental innovation, because sustaining innovation occurs in response to customer demand or technological improvements. Disruptive innovations meanwhile try to target a whole new consumer group by reinventing a technology, business model or simply inventing something new altogether. The innovators dilemma is the choice a company faces when it has to choose between holding onto an existing market by doing the same thing but better (sustaining innovation) or capturing new markets by embracing new technologies and adopting new, but potentially risky business models (disruptive innovation).

Disruptive Innovation Model

As most good authors, Christensen also developed a model of disruptive innovation. The disruptive innovation model shows that at the time the disruptive innovators enter the market, they tend to target low end customers. Over time, once they have established themselves in the market, they are able to target more and more mainstream customers and maybe at a later point in time even high-end consumers. The initial incumbents in the market flee from disruptive innovators and start targeting high end customers. What rarely happens is that a disruptor completely destroys the incumbents' product or service. In fact, most disruptive innovations fail, which is why they are so risky.

Unicorns and Start-ups

In theory, the term ‚unicorn' refers to a privately held start-up company with a value over 1 billion$. What does start-up mean though? If you look up the definition of a start-up you can find examples that range from ‚a fledgling business enterprise' to ‚a company or project undertaken by an entrepreneur to seek, develop and validate a scalable economic model'. In the broadest sense, a new company is a start-up. How long a new company carries that label though depends less on time, although there are definitions that a start-up is no older than 3 – 5 years, but more on whether you have achieved a certain level in the following metrics: product-market fit, scale, profitability and standardisation.

Startups begin with the assumption that their product or service will be attractive to a large group of people. When a startup has created a product or service that people buy, proving the 'attractiveness', then it will have validated its business model and achieved product-market fit. In other words, when a product or service has gone beyond alpha or beta versions (for software for example) and prototypes (for hardware) and are actually being bought by people, then the company could consider abandoning the start-up label.

If we look at the more comprehensive definition of a startup, a startup cannot just be any 'fledgling' business enterprise, it has to be focused on growth and scale. Scale is typically measured in terms of revenue, number of employees and valuation, but can also include age i.e. categorizing companies that are more than 5 years old as no longer startups. In terms of revenue, number of employees and valuation, there is a set of metrics popularized by Techcrunch's Alex Wilhelm called the 50-100-500 rule. This means that you can no longer be called a startup if you achieved or surpassed any of the following:

- $50 million (around €41.9 million) revenue run rate (forward 12 months)
- 100 or more employees
- Worth more than $500 million (around €419 million), on paper or otherwise

In the strictest sense of the word startup, a unicorn, worth 1 billion USD, could no longer be considered a startup. Yet these metrics can still vary depending on who is looking. Some VCs would still consider lower revenue figures, employee count or higher valuation.

Unicorns Characteristics

What characterizes unicorns, besides their worth and ownership structure is their rarity and innovativeness. In order to become a unicorn, companies must have an innovative idea, a clear vision for growth and a solid business plan. They must also be convincing, in the sense that they have to persuade venture capitalists to invest. Unicorn founders then have different options to capitalize on their entrepreneurship. If they want to retain control over the company, then they will remain private. But remaining private limits the potential for growth, since they must find ways of providing funders with a return on their investment. The second option available to them is going public. Companies get access to the capital they need to grow with an initial public offering, an IPO. But going public has the downside that the process dilutes ownership, meaning the original entrepreneurs may lose control over their baby unicorn. Finally, founders can also appeal to a buyer. With only one sole investor, the buyer, it will be easier for company owners and executives to achieve their goals quicker.

Unicorns Worldwide

As of 2022, there were over 1.147 unicorn companies in the world. Astonishingly, 62 percent or 711 companies joined the list of unicorns in 2021 and 2022 alone. The term was first coined in 2013 by the American economist Aileen Lee of Palo Alto Cowboy ventures. Up until 2013, there were only 10 companies globally that had managed to reach the 1 billion US$ evaluation. Now, less than ten years later there are 1.147!

Number of unicorns by country: In first place is the United States with 615 unicorns. So just over 50% of all unicorns are registered in the US. China is second on the list with 174 unicorns in 2022. Then comes India (65), the UK (43) and surprisingly Germany at fifth (29).

21 percent of the world‘s unicorns, or 242 companies, are engaged in Fintech. In second place is software and internet services at 19 percent and 217 companies, in third e-commerce with 10 percent and 115 unicorns, fourth is health with 7.5 percent and 87 unicorns and finally in fifth is AI with 7.4 percent and 85 unicorns. In general, though, the diversity of industries in which you can find unicorns is far more varied than the geographical distribution of unicorns.

Bytedance, TikTok‘s parent company, is the world’s most valuable unicorn, followed by Elon Musk‘s pet project Space-X. In third is another Chinese company, the fast fashion e-commerce giant SHEIN. Thereafter you will find Stripe and Klarna of Fintech.

Unicorns in China

Bytedance is first in terms of value in China as well in 2021, but then, instead of SHEIN, we see Xiaohongshu in second. What is particularly interesting if we look at the list of the top Chinese unicorn companies for 2021, then you will see that SHEIN only appears in fourth position, behind Bytedance, Xiaohongshu and Yuanfudao. The top then is then completed by DJI Innovations, SenseTime, Bitmain Technologies, ZongMu Technology, Weilong and Heytea.

For the world, most unicorns are founded by an all-male team or a solo male founder. If we combine the two figures, then over 85 percent of unicorns have no female involvement during the foundation stage. 10 percent are mixed gender teams and only 1.8 percent are founded by a solo female. In China, the figures are slightly better, but still not flattering. What is interesting is that there are more solo male founders than all-male teams, so Chinese entrepreneurs that manage to establish a unicorn tend to go at it alone. Together, male founders, whether in teams or solo account for 82 percent of unicorn foundings. Mixed gender teams account for 10 percent and 2.5 percent of unicorns are established by a single female, so better than the global average.

Chinese Venture Capital

Investments via venture capital took a massive hit during the COVID pandemic. Leading up to 2019, when the first cases of the pandemic were first registered in Wuhan, venture capital investments were at an all-time high in China. Approximately 96 billion US$ were invested in 2018 alone, though the trend was already declining from the second quarter of 2018 onwards. The first three quarters have pretty similar numbers of deals that were struck, around the 600 mark, but then in Q4, the number of deals and the amount invested drop precipitously! This led several newspapers to declare a freezing of the venture capital market from 2019 onwards.

Others however saw cause for optimism, as China‘s Venture Capital Market bounced back from January 2020. But the upturn in 2020 was followed by a downturn in investments in 2021 and 2022. In 2022, only 73 billion dollars were invested in venture capital, down 42 percent from 2021 and the least since 2019. Fewer than 10 unicorns emerged from January to early October 2022, compared with 44 in all of 2021. Of course, the pandemic restrictions posed within China are one reason for the doldrums in China‘s VC market, but the trade ware with the US also poses a massive deal breaker for investors. The investments that were undertaken are however mainly in industries related to pandemic recovery, such as in biotech and pharma, which was the industry with the most investment in 2020, followed by semiconductors, medical devices, food and beverage and education.

Class 10: Diffusion Theory

False Positives and False Negatives

The aim of diffusion theory is to predict which technologies will be adopted and which technologies will end up in the dustbin of history, never to be adopted. The problem at the heart of the theory is that oftentimes inventions succeed that we would never have expected to succeed. Alternatively, several innovations that we would have expected to fail succeed.

Take Segway as an example. When it was first brought to market, the Segway was predicted by some to revolutionize the way we get from A to B. 20 years later it has still not managed wide-spread adoption. The Segway is an example of a false positive: It was forecasted as a hit, but turned out to be a massive flop. Contrarily, we can look to innovations, for instance the popular TV show Seinfeld, which were predicted to fail, but then flourished, as customers unexpectedly adopted the show as one of the most popular American TV shows of the 1990s. Seinfeld is an example of a false negative: an innovation that was expected to fail, but ultimately flourished.

Diffusion Theory

Diffusion theory, developed by E.M. Rogers in 1962 explains how over time, an idea or product gains momentum and diffuses (or spreads) throughout a specific population or social system. The theory shows how an idea, depending on its successful diffusion, passes through the population along an S-curve segregated according to different types of adopters. Adoption means that a person does something differently than what they had been doing previously, for example they purchase or use a new product or they acquire and perform a new behaviour. The key to adoption is that the person must perceive the idea, behaviour or product as new or innovative. Only when the person considers the new technology/behaviour as novel is diffusion possible.

E.M. Rogers realized that a new idea, behaviour or product (i.e. the innovation) does not happen simultaneously in a social system. Some people adopt the innovation earlier than others, some people are more apt to adopt, they are willing to take the risk, more curious… Researchers have subsequently tested this theory and found that people who adopt an innovation early have different characteristics to people who adopt an innovation later. Rogers developed five adopter categories and even assigned percentages that represent the share of people within his investigated population who fall into each category. While the majority of the general population fall into the middle categories, it is important to realize that these shares can vary depending on the target population under investigation.

Five Adopter Categories

Innovators constitute the smallest share in Roger‘s population study. Only 2.5 percent of the general population identify with the characteristics of what Rogers calls innovators. Innovators are people who want to be the first to try an innovation. They are venturesome and interested in new ideas. These people are very willing to take risks, and are often the first to develop new ideas. For companies, very little, if anything, needs to be done to appeal to this population.

Early adopters are the second smallest group of adopters in Rogers model at 13.5 percent of the total population. Early Adopters are people who represent opinion leaders. They enjoy leadership roles, and embrace change opportunities. They are already aware of the need to change and so are very comfortable adopting new ideas. Strategies to appeal to this population include how-to manuals and information sheets on implementation. They do not need information to convince them to change.

The early majority share the highest share of the population at 34 percent. The Early Majority are people who rarely lead, but they do adopt new ideas before the average person. That said, they typically need to see evidence that the innovation works before they are willing to adopt it. Strategies to appeal to this population include success stories and evidence of the innovation's effectiveness.
The Late Majority, who also make up 34 percent of the population, are skeptical of change, and will only adopt an innovation after it has been tried by the majority. Strategies to appeal to this population include information on how many other people have tried the innovation and have adopted it successfully. If you want to consider these different categories as dwarves from Snow White, then the late majority would be Grumpy, who eventually comes on board, but only after forceful persuasion by the others.

Finally, laggards make up approximately the same share of the population as innovators and early adopters combined at 16 percent. Laggards are bound by tradition and very conservative. They are very skeptical of change and are the hardest group to bring on board. Strategies to appeal to this population include statistics, fear appeals, and pressure from people in the other adopter groups. The image of this devilishly handsome young man brings me to the next question.

4 Stages and 5 Factors of Adoption

The stages by which a person adopts an innovation, and whereby diffusion is accomplished, include awareness of the need for an innovation, decision to adopt (or reject) the innovation, initial use of the innovation to test it, and continued use of the innovation.

There are five main factors that influence adoption of an innovation, and each of these factors is at play to a different extent in the five adopter categories:

- Relative Advantage - The degree to which an innovation is seen as better than the idea, program, or product it replaces.
- Compatibility - How consistent the innovation is with the values, experiences, and needs of the potential adopters.
- Complexity - How difficult the innovation is to understand and/or use.
- Triability - The extent to which the innovation can be tested or experimented with before a commitment to adopt is made.
- Observability - The extent to which the innovation provides tangible results.

S-Curve

Based on these four stages and five factors, the final piece of the jigsaw in diffusion theory is to show the typical rate of adoption, which is captured by the famous S-curve. Most of innovations have S-shaped rate of adoption. This curve shows that only a few individuals adopt innovation in each time period (months and years). But soon the curve begins to climb as more and more individuals adopt and eventually curve begins to slow down as fewer individuals adopt innovation. On the Y axis you have performance, on the X axis time. In the early stages, companies need to invest a lot of capital in R&D to raise awareness of the innovations' relative advantages to ‚cross the chasm' from early adopters to early majority users. At later stages, when the market for the technology is close to saturation, companies would have to invest

more to avoid the innovation reaching its natural limits. What we cannot predict though is the length of the S-Curve, which differs from one technology to the next. What can also happen is that a second S-Curve disrupts the natural progress of the initial technology, as would be the case for disruptive innovations.

Diffusion of the Mobile Internet in China

One by Liu and Li sought to investigate innovation diffusion of the mobile internet in China. They asked students, blue collar workers, primary and junior managers, common office staff and entrepreneurs about their adoption of mobile internet services in the PRC. They found that the mobile internet has a rapid diffusion rate in four of the five adopter groups, from innovators to late majority adopters. Innovators primarily adopt the mobile internet to satisfy their hunger for enjoyment. For early adopters there is an additional need to access the mobile internet in terms of contextual requirements.

Specifically, they will be more willing to use the mobile internet if the technology becomes more compatible with their lifestyle and habits and the outcomes of operating the mobile internet become more visible. For the late majority, they are more likely to accept the mobile internet, if they find that the technology is easy to use. Even the laggards had started using the technology at the time of writing, though at a much slower pace. While the speed of adoption was rapid, they find significant and important differences in users' perceptions of the technology, which varied from one adopter group to another.

In terms of the five factors that influence adoption, the authors find that intrinsic motivation was the most important reason for people to use the mobile internet across all adoption groups. Relative advantage, a sort of extrinsic motivation, was not found to be a reason for driving the technology's use. They also find that industry participants should take the impacts of technological complexity and compatibility into consideration. Particular attention should be paid to the design of devices, which should be intuitive to use and easily operable.

Diffusion of the Covid Vaccine in China

A further use case where researchers applied diffusion theory was a study on the intention to receive the COVID-19 Vaccine in China. The authors, all associated with the University of Basel, found that the perceived efficacy of the vaccine, social media use for vaccine-related information, openness to experience and descriptive norm were all significant in influencing the intention to receive the COVID-vaccination. The authors found additional factors, for instance openness-to-experience, that have not yet been incorporated in diffusion theory. The factors they identify as being critical to the diffusion of vaccines are different from the factors identified for mobile internet technologies from the previous study.

Think Tanks Definition and Types

According to the Britannica dictionary, a think tank is an institute, corporation or group organized for interdisciplinary research with the objective of providing advice on a diverse range of policy issues and products through the use of specialized knowledge and the activation of networks. Many think tanks are independent from government and are set up as non-profit organizations, but their work may be conducted for governmental as well as

commercial clients. For the purpose of innovation, commercial projects include developing and testing new technologies and products.

We can differentiate between at least four types of think tanks. The first is the ideological tank, which refers to organizations that have a clearly specified political or, more broadly, ideological philosophy; they resemble "advocacy tanks," institutions founded to research and solve problems and to lobby legislators to adopt their solutions. The next type is the specialist tank, which includes institutes that have a thematic focus. The most common subjects are foreign and public policy, but think tanks also specialize in other issues, such as the environment. The third category includes institutes that work not at the national level but at either the regional level. The final category is that of "think and do" tanks, which, apart from their traditional research activities, are active at a more practical level, such as in the funding of charity projects. This type of think tank bears some similarity to nongovernmental organizations (NGO).

Think Tanks in China's National Innovation System

Think tanks are not a new addition to the Chinese National Innovation System. Until the late 1980s, however, Chinese think tanks were few in number and closely integrated with the government. They included the policy research offices of the Party and the government at various levels, academies of social sciences at the state and provincial levels, and Party schools at the level of the central government, provincial governments, and the governments of several major cities. In addition to those with a focus on domestic policy, a small group of think tanks specialized in international and regional studies. Traditionally, Chinese think tanks' tasks included collecting information, conducting policy analyses, and providing suggestions for policy planning and development.

When liberal intellectual who were affiliated with think tanks in the Central Committee lent support to the democracy movement that later culminated in the 1989 Tiananmen crackdown, many think tanks were closed, but others survived and became more institutionalized under Jiang Zemin. Most of Jiang Zemin's leadership comprised a decade-long period of more or less political tolerance, which unleashed notable social vibrancy and activism in various social sectors, including Chinese think tanks. The China Institute of Research and Development (CIRD) stood out as a shining example of a successful nongovernmental think tank.

Following in Jiang's footsteps, Hu Jintao turned the Central Party School into a prominent think tank in the late 1990s when he served as the president of the school. For over a decade now, the CPS has functioned as a leading research center for the study of China's domestic political reform and international relations. In 2006, at the "First Forum on China's Think Tanks," held in Beijing, the Chinese authorities, for the first time in the PRC's history, designated the top 10 think tanks in the country, further enhancing the status and influence of the older, more established institutions.

These "top 10" think tanks are all considered state-sponsored institutions. Some of these think tanks are gigantic government institutions with a large number of employees. For example, the Chinese Academy of Social Sciences (CASS) in 2021 consisted of 42 research institutions, 6 functional departments, 5 directly affiliated institutions, 3 directly affiliated companies, and 3,200 researchers. At least half of China's top 10 think tanks concentrate on the country's

foreign relations and international affairs. None of them is headed by an economist or a leader with a strong background in economic affairs, although some, including the Development Research Center of the State Council and the China National Committee for Pacific Economic Cooperation, are focused primarily on economic issues.
While non-government think tanks, notably the China Institute of Research and Development, enjoyed periods of tolerance under Jiang and Hu, in recent years they have become increasingly marginalized or even silenced. An example is the life story of the Unirule Institute of Economics. The Unirule Institute of Economics was among the very few truly social think tanks in China. It was created in 1993 by a group of Chinese economists who dedicated the organization to the open exchange of ideas in economic issues and policies in China. However, it came under increasing governmental pressure in recent years and was closed down in August 2019 amid the ever-stern political constraints.

The Unirule event is representative of the current think tank landscape in China. Since late 2012, little room is left for Chinese think tanks to pursue independent research. This is particularly the case for the small number of truly social think tanks in China. It is estimated that social think tanks currently account for about 5 percent of all think tanks in China. However, a close examination suggests that these social think tanks are linked with the government in one way or another. The China Center for International Economic Exchange, for example, is a self-proclaimed major and independent social think tank, but it is headed by a former vice premier and has a close affiliation with the National Development and Reform Commission of the State Council.

Think Tanks in China Today

In today‘s China, think tanks (or zhiku in Chinese) are experiencing something of a Golden Age (at least if we consider the number of think tanks founded in the last few years and the support from the Party and the Government for their development). This rapid growth was partly sparked by President Xi Jinping’s call at the plenary session of the Chinese Communist Party (CCP) in April 2013 for China to „Build a new type of think tank with Chinese characteristics“. According to Xi, think tanks should be targeted on promoting scientific and democratic decision making, promoting modernization of the country’s governing system and ability, as well as strengthening China’s soft power. Xi‘s main strategy is to strengthen the existing think tank sector based on several major traditional think tanks. In the field of social sciences, this relies on the efforts of academies of social sciences and Party schools (and schools of public administration) at various levels to pursue innovation and development. Universities are responsible for building trustworthy think tanks with strong social science databases and laboratories and soft science research bases. In the areas of high-level science and technology innovation, the plan includes major institutions such as the Chinese Academy of Sciences, the Chinese Academy of Engineering, the Chinese Science Association, and some selected state-owned and state-controlled enterprises. These institutions and enterprises are expected to support the establishment of new kinds of think tanks that merge industry with scholarship, research, and application.

Since the call from the top CCP leadership, this trend has significantly accelerated. Most notably, the official status of Chinese think tanks has for the first time been formally recognized, with the term *zhiku* (智庫, think tank) written into the official document on think tank construction in China in 2015. Compared with their counterparts in previous eras,

Chinese think tanks today are more highly regarded, and their research and ideas play an increasingly important role in China's policy making . Internationally, Chinese think tanks have also gained in visibility. According to the most recent report of a popular global think tank ranking, China has 1,413 recognized think tanks, ranking the second in the world to the US's 2.203 think tanks. Ten Chinese think tanks were ranked among the world's 174 top think tanks.

Class 11: Innovating China's Energy Transition

Defining Smart Grids

The problem with defining smart grids is that smart grids are not a single innovation, they are not one technology, but a system of technologies in the energy system that range from renewable generation methods, transmission and distribution equipment (power lines), storage, ICT and consumption. Solar panels and wind farms are definitely part of the smart grid, but so are electricity storage devices, such as massive batteries or electric vehicles (EVs). The idea is that EVs function as a storage device, so that consumers charge their vehicles when the price of electricity is low and are able to sell the electricity back to the grid when the electricity price is high. Electricity works similar to any other good: when you have a lot of it available, the price drops, when it is scarce, the price rises. On the consumption side, you also have smart home appliances, like washing machines you can programme to turn on when the electricity price is low or smart meters that allow you to monitor and manage your own electricity consumption in real time.

So why do we need a smart grid, what is the urgency now? The simple answer is that our entire electricity system needs to adapt to the requirements brought about by renewable energy, principally intermittency. Intermittency means that the sun doesn't always shine and the wind doesn't always blow. In the past, when we needed more electricity, the grid companies would simply write to generators and tell them to shovel more coal onto the fire. But with renewables, we can no longer do that, instead the weather dictates when we can produce electricity with renewables. If we want to use renewables, then we need to adapt the entire electricity system to suit the technical demands brought about by renewables. We need to make our grids far more sensitive, so that grid operators can tell in real time how much electricity is on the grid. They need better monitoring and forecasting technologies to estimate demand and supply, because once electricity is generated with renewables it needs to be either stored or consumed immediately. Because storage technologies are currently the chink in the smart grid's armour, at current levels of technological development, grid operators need much greater abilities to match supply and demand.

Grid operators need more sensors and cameras along the entire electricity supply chain to know what is going on in generation, along the lines and in our homes. But digitization also means that the system becomes more vulnerable to attacks, so you need Information and Communication technologies to not only improve the speed of transmission, but also to protect the system from hackers. Grid operators also need sensors to detect outages faster and to be able to reroute electricity along the most optimal path as fast as possible. All these technologies form part of the smart grid.

China's Energy Transition

But due to differences in geography, natural resource endowments, population density and demands on the electricity system, each country faces its own individual energy transition challenges. China's renewable energy is primarily produced far away from its major population centers. This is in line with China's centralized strategy to transition its energy system. Centralized generation means that you concentrate the generation of renewable energy in areas where you will produce the most amount of electricity. In China, this just happens to be in the West, in desert areas, where the sun shines almost all year round. For wind, China's steppes in Inner Mongolia and Xinjiang offer ideal conditions. In contrast, Germany has placed its bets on a decentralized or distributed strategy for renewable generation, where electricity is produced closer to where it is needed. Take a drive out of Würzburg one day to the surrounding villages. Walk up the vineyards and look down on the houses bellow you, you will see solar panels plastered across a large portion of the residencies.

While there are technological arguments to be made for a centralized strategy, primarily that it makes the management of the grid a lot easier, the main reason for adopting this strategy in China is political. China's entire national grid is divided between two state-owned companies, the world's largest utility provider, the State Grid Corporation of China and China Southern Grid. The former operate all but a small Southern district and operate 89 percent of the country's power lines. Germany, a country the size of a province in China, has four multi-regional grid operators and dozens of regional grid operators that consumers can choose from. In China, influence in the grid sector is far more concentrated, which means these large monopolists can steer political decisions in their favour. When it came to deciding on a strategy to transition the country's energy system towards renewables, the grid operators made sure that the transition would proceed under their terms.

China's Electricity Grid

For grid operators the most important technology to transition the energy system are electricity grids. With the current centralized strategy in place, renewables are built far away from load centers in the East and thus require extremely long transmission lines to connect generation to consumption. The technological goals at the heart of the transport of electricity are to minimize the amount of electricity that is lost and maximize the amount of electricity that is successfully transported from the point of generation to consumption. To minimize the amount of electricity lost, wire insulation is crucial, but also finding superconducting, high-density and heat resistant materials that conduct electricity more efficiently without raising costs. Silver, copper and gold are the best conductors of electricity, but due to cost reasons, we use aluminium wires or steel wires wrapped in aluminium to conduct electricity

The big problem China faces is how to get electricity from generators in the West to load centres in the East with the least amount of resistance on the wires and in a cost-effective manner. To transport electricity along the path of least resistance, the smart grid demands innovations to improve the capacity, synchronization and economics at the heart of the electricity system. The logic for deploying transmission technologies to transport electricity rests on the principle that the amount of energy lost decreases with higher voltages and volumes of electricity; a principle that in turn can bring cost advantages through scale economies and land use. Because energy loss is proportional to the square of the current,

increasing voltages, while at the same time lowering line current, can allow electricity to flow more efficiently over longer distances, in large capacities and with low transmission losses. 1000 kV Alternating Current (AC) lines, for example, can carry four to five times as much electricity as a 500 kV AC line and a ± 800 kV Direct Current (DC) line has a capacity equal to 2.1 times a ± 500 kV DC lines. Doubling the voltage more than doubles the amount of electricity that can be transported. Higher voltages, both for AC and DC, also take up less area during construction and are cheaper to operate than lower voltage alternatives. But bulk transportation also increases the risk that power outages affect more people over a wider area.

Alternating Current and Direct Current

One current type flows back and forth (AC), while the other flows in one direction (DC). One of AC's main benefits is that voltage levels can easily be adapted to specific requirements. Line maintenance is also simpler and cheaper, but because AC runs on the surface rather than through the diameter of cables, the danger of electricity dissipation is larger. To avoid losses, more insulation is required, which raises the overall price of AC lines. AC lines are also more susceptible to interferences from other devices, resulting in stability and synchronization problems. In DC transmission, voltages are more stable, and can also be generated at higher voltages, which make DC cables more suitable for high voltage transmission over longer distances. Overall, because less insulation is required, DC equipment is more efficient and cheaper than AC counterparts. But transforming voltage levels remains cumbersome, expensive and complex, which hinders use at the point of consumption. While conversion from AC to DC (or vice versa) is possible, the operation should be avoided, as a lot of power is lost in the process.

Alternating Current lines above 1000 kv and Direct Current lines above ± 800 kV can be classified as Ultra high voltage lines. So how does China deploy these two sets of lines? While UHV AC lines are predominantly used to connect China's North with load centres in the East, UHV DC transmission grids bring power from Western, Southern and Central China to cities along the coast. UHV lines also aid in integrating China's fragmented grid infrastructure. In doing so, they relieve railways from congestion caused by the huge amounts of coal shipped across the country on a daily basis. So instead of shipping coal to load centres in the East on train tracks, which was done in the past, UHV power lines allow electricity to be produced further away and transported thousands of kilometres to where it is consumed.

China's UHV Innovation

Several of the lines merit a little more attention in terms of their innovatory excellence. The first is the Sunan to Zhundong line, the world's first UHV DC line above 2000 km in length, which came into operation in 2018 and at 3324 kilometres is currently the world's longest and most powerful DC line. Second, the Yunnan to Guangzhou corridor was the first ± 800 kV DC line to operate anywhere in the world when it was opened in 2009. Finally, the Jinping to Sunan connection was the first to deploy 900 square millimetre diameter conductors capable of transporting electricity at higher altitudes, where ice and adverse weather play an impeding role.

Actors in China's Smart Grid Innovation

With state-owned grid operators forming a monopoly in the transportation of electricity in China, it should come as no surprise that the State Grid Corporation of China and to a lesser extent China Southern Grid are at the forefront of innovation in China's grid. Besides setting a significant number of technological standards, SGCC and CSG are also heavily involved in most smart grid pilot projects, thereby controlling the direction of future innovation and standard setting nationwide. In addition, the two state-owned monopolists, along with local governments, have significant say in selecting equipment manufacturers in tendering processes for UHV transmission lines. For smaller enterprises this invariably means complying with grid operators' technological demands, which on the one hand ensures unified grid codes and nationally standardised equipment, but on the other also limits outside-the-box research on unconventional, yet potentially ground-breaking smart grid innovation.

But there is recourse for smaller equipment manufacturers, as some of my interview partners revealed. During a tour of a factory in Nanjing, a floor manager described how, although tenders tend to favour state-owned competitors, his company is able to challenge in terms of technological superiority. When an UHV line is built, you need all kinds of equipment, so while State Grid will be in charge of overall construction, they need other companies, both state-owned and private, to provide material and equipment that goes into the construction of the line. And in order to find the right equipment at the lowest price, they advertise a tendering process, where companies can submit an offer. The manager at the plant in Nanjing stated that it is important smaller companies evaluate in advance which contracts can realistically be obtained. Other managers at private manufacturers complained that competition in the industry is skewed in favour of SOEs, who are more likely to obtain capital from banks, be granted concessions on land, receive tax rebates and subsidies from the state and are consequently capable of offering a lower price on the tender. Interestingly, however, their ire was directed not towards SGCC or CSG, whose contracts manufacturers rely on, but at state-owned competitors producing substitute technologies.

To stimulate innovation along the smart grid, the two monopolists use a combination of in-house R&D facilities and competition on the market to produce the technologies they need to advance UHV transmission grid construction. Many of my interview partners were quick to raise SGCC's impressive track record in innovation, but many also conceded that large companies are less likely to bring technological breakthroughs to the market. This is a critique of SOEs in general, that their size and lack of competitive incentives slow down innovation. To overcome this difficulty, SGCC creates a sort of competition, primarily among its subsidiaries, but also sometimes private companies on the open market, with rewards given to the most successful innovators. One of my interview partners, an employee at NARI, a SGCC subsidiary in Nanjing, pointed out how a large number of patents held by the mother company were actually worked on at private subsidiaries, employed to conduct research on SGCC's behalf. In some cases, when private research facilities prove especially profitable, SGCC buy out shareholders to internalise research initiatives. Such was the case with NARI, for instance, which has subsequently become one of China's largest research institutes in smart grid innovation. When objectives are set by the government, SGCC also often creates subsidiaries that compete to attain the state's targets. As a reward for impressing in this internal competition, the winner's management team are rewarded with promotions and additional

commissions, while the loosing subsidiary is either granted further opportunities to shine or dissolved entirely.

In all, you therefore have a plethora of actors involved in China's smart grid development: from state regulators and ministries, via state-owned enterprises down to private equipment manufacturers. As a network industry, the electricity sector is characterised by high fixed costs and scale economies, which combined lead markets towards monopoly structures, where new entrants have a hard time dislodging the cost advantages and market power enjoyed by incumbents. In light of these structural considerations and the resulting potential for abusive behaviour, as well as the importance of electricity for national security, it should come as no surprise that the Chinese state has a heavy hand in regulating actors in the industry.

Steering China's Energy Transition

Contrary to what you often read here in the media, the Chinese state isn't a single gigantic monolith that pulls together in one direction. SOEs squabble amongst each other and with state ministries, including the regulator in the grid industry, which formally is the National Energy Administration. The problem is that the NEA remains answerable to the National Development and Reform Commission, China's macro-economic planning agency, to the extent that the NEA's national offices are in the same building as the NDRC. Additionally, in China's hybrid administrative Party-state, corporate executives frequently outrank NEA officials, who on top of knowledge gaps and understaffing, also have to contend with pay gaps that lure talented personnel to the SOEs they are supposed to be regulating. In all, incentives and opportunities exist for enterprises to disregard regulators' supervisory function, which in the grid industry becomes manifest in the opacity surrounding operators' cost structures. Employees in institutions tasked with governing the electricity sector are often underqualified and outnumbered when faced with grid operators' human capital capabilities, lobbying activities and legal prowess. In short, the state-owned companies, both in generation and transmission have a greater say in the direction of innovation than ministerial regulators, particularly the NEA.

Other ministries critical to innovation in China's smart grid are the Ministry of Science and Technology, the Ministry of Industry and Information Technology and the Standardization Administration. But as a consequence of the number of ministries, their frequent reorganisation and SOEs' lobbying, China's governance of the electricity grid faces problems associated with fragmented authority. Examples of difficulties include a reliance on bargaining and incremental reforms, as well as unclear institutional boundaries, that combined often lead to gridlock in decision-making and legal enforcement. As a result, "no nationwide policy laying out the mechanism for promoting smart grid development exists in China today. Deficiencies in control also hinder markets from being opened to new actors capable of producing technological and business model innovation in China's smart grid. Consequently, instead of formalized institutions, grid operators are often the active agents for smart grid reforms and in particular UHV grid development in China.

China's Electricity Innovations Abroad

China is not only content on setting standards for UHV transmission at home. The company, designated one of China's national champions, is also heavily active in international standard

setting agencies and exporting the technology across the globe. For example, Chinese standards in UHV AC transmission, particularly in switchgears and insulation coordination, have been welcomed by a range of international standard setting organisations, such as the International Electrotechnical Commission. China or rather Chinese individuals have also taken on leadership roles in major bodies, such as the Global Energy Interconnection Development and Cooperation Organization, where Liu Zhenya, previously the long-serving head of State Grid and one of China's most influential energy thinkers, is at the helm.

Liu Zhenya is also the author of one of China's most influential minds in terms of policy design in the electricity sector. His book on the possibilities of global energy interconnection is also a must-read for every State Grid employee. In the book he describes how the world could leverage the natural advantages in different regions to harvest renewable energy most efficiently and then transport that energy across the globe via thousands and thousands of kilometres of UHV power lines. The idea would be to produce wind energy in the arctic and oceans, solar energy in the deserts and then transport that electricity to where it is needed on a global super grid.