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In 1985, famous management thinker Peter Drucker famously declared “Innovate or die.” If businesses weren’t able to meaningfully separate themselves from their competitors, he argued, they would simply fail. This incentive has only gained power in the last three decades. From the advent of the Internet to the onset of global warming, innovation across all industries is no longer just a competitive advantage, but a means of survival. Innovation strategy is one of the key things students learn at business school – but what does innovation look like, and where do you start? In this blog, we’ll take you through the four main types of innovation and how you can explore these on different business programs around the world. How do we define innovation? Innovation is such a buzzword that it can sometimes sound less like a real business concept than a magic spell for business success. But put simply, innovation is just problem-solving. It’s identifying a problem that either has no current solution, an inadequate solution, or a solution that’s only available to a premium segment of the customer base and finding new solutions that problem. Often, it changes the way that things are done in that industry. It can even transform the industry completely. Is all innovation technological innovation? Not all innovation is technological innovation, though it might seem like it at times. Many companies innovate using their existing resources and you don't need to invent a a revolutionary technology to be considered an innovator. Much innovation comes from organizational innovation and creating new business models to challenge established companies and make headway in competitive markets. Many innovative companies also pursue process innovation using existing technologies, or establish themselves as early adopters of new technologies that streamline their business. So, if you're not a master programmer, fear not. There are many opportunities to pursue innovation without having to make rapid advances in technology. Many business programs offer courses on innovation, or even dedicated innovation tracks. But to know which program is right for you, you first need to think about what kind of innovation you are most interested in. The four types of innovation Because innovation is a process of problem solving, it makes sense that it does not always look the same. There are as many ways of solving a problem as there are problems in business, but innovation tends to fall into four different categories. These were outlined by business expert Greg Satell in his book, Mapping Innovation as sustaining innovation, breakthrough innovation, disruptive innovation, and basic research. They are differentiated from each other chiefly by how well the problems they attempt to find new solutions for are defined, and how well the domain in which these problems exist is defined. Here's what each of these types of innovation looks like in business and where you can study them at business school. 1. Sustaining, or incremental innovation “Sustaining innovation” initially seems like an oxymoron. If innovation is about creating something new and better than what currently exists, then sustaining the status quo seems like the opposite. But this isn’t the case. Sustaining innovation occurs when both the problem and the domain it exists in are well defined. It refers to when a company constantly makes small improvements on its products to sell them at higher prices to its best customers in order to sustain its competitive advantage and position as a market leader in an existing market. One highly visible example of sustaining innovation is the smartphone market, in which providers regularly release better versions of the same product to compete with one another and generate sales. If you’re aiming for a career in product management, a knowledge of how to manage sustaining and incremental innovation will be highly desirable to employers. One of the places to study this is at the Massachusetts Institute of Technology (MIT) Sloan School of Management. The school’s two-year, full-time MBA program offers three tracks, one of which is the Enterprise Management Track. Students solve real business problems provided by outside organizations from day one, with core courses including marketing innovation and competitive strategy. The program also offers a multi-disciplinary approach which studies show is highly conducive to innovative thinking and all types of innovation, not just sustaining innovations. One meta-analysis examining almost 18 million scientific papers found that breakthroughs frequently occurred when the research was rooted in a traditional field with limited insight from another area of expertise. Carnegie Mellon’s Tepper School of Business is also one to watch for sustaining innovation in product management careers. The New Product Management module on the full-time MBA aims to help students Evaluate and value new product projects Identifying opportunities for process innovation Design and implement a study to optimize the product Create a tailored launch marketing plan Design thinking is also an invaluable skill for product management and sustaining innovation. An example of this at business school is the design thinking and innovation MBA concentration offered at the University of Michigan’s Stephen M Ross School of Business. What's the difference between sustaining innovation and incremental innovation? Sustaining innovation is easily confused with incremental innovation, as both are processes of continuous improvement within existing markets. However there are some key differences. While sustaining innovation focuses its innovation efforts on sustaining or increasing a company's market share to keep a competitive advantage, incremental innovation is more of a maintenance process to ensure that businesses do not get left behind. It refers to when a company consistently improves its existing products and adds new features in order to keep their existing solutions up to date, for instance with new technology. An example of incremental innovation might be when smartphone providers release updates to their operating systems. Unlike new hardware, these updates are to keep customers who own their existing products happy rather than drive new sales or establish themselves as a market leader. 2. Breakthrough innovation We’ve spoken about how the current smartphone market is an example of sustained innovation. Well, the first smartphone was an example of breakthrough innovation. When Apple released the first iPhone they essentially created a totally new product that has now become ubiquitous. Breakthrough innovation is a kind of radical innovation that occurs when the problem you are trying to solve is well-defined, but the domain it exists in is still only operating at part of its potential. You see breakthrough innovation happen when a new product is introduced to the market and creates a new demand that didn’t exist before. It doesn’t happen every day, but when it happens, it is often in highly supported environments such as larger businesses like Apple. Business schools are a good place to learn about radical innovation because, due to their highly specialized research expertise, many business school professors consult on radical innovation efforts. For example, Professor David K.C. Tse, Chair Professor of International Marketing and Director of the Contemporary Marketing Centre at HKU Business School has consulted on breakthrough innovations in MRI technology, and the HKU MBA has digital innovation at the core of its curriculum. You might also use MBA entrepreneurship training to pursue intrapreneurship opportunities within larger businesses. Intrapreneurship refers to applying entrepreneurial concepts to new product development within an existing organization. One example of this in action is the story of Lishini Karunatillaka who used MBA entrepreneurship training at Aston Business School to gather the skills needed to become an intrapreneur and pursue innovation in the clothing industry. 3. Disruptive innovation Disruptive innovation occurs when a new product offering transforms the market it enters into. This occurs when the market or customer base is well-defined or understood, but the customers' problems have not been fully explored. There are two main types of disruptive innovation: Low-end disruption, when a company uses a low-cost business model to enter at the bottom of an existing market. New-market disruption, in which a company creates and claims a new segment in an existing market by catering to an underserved customer base. Usually, these two types of disruptive innovation occur as part of the same process. The Ford Model T is a good example: it wasn’t designed to compete with the expensive cars owned by the wealthy elite, but to target a new segment of lower-income customers. It began as a low-end disruption targeting a new market and totally disrupted the automobile industry. Chat With Students What's the connection between disruptive innovation and business model innovation? Learning how to spot opportunities for disruptive innovation is easier said than done. In hindsight, it’s easy to see the customer bases that were not being served until disruptive innovations brought new products to them. But in practice, identifying these segments, developing a viable product, and building a new business model that can take it successfully to market, all requires considerable skill. Perhaps the most obvious place to start learning these skills is with Harvard Business School online. Harvard includes a famous course on disruptive innovation as part of its online business certificate, taught by legendary professor Clayton Christensen, the professor who pioneered the term. For aspiring startup leaders, prioritizing programs with strong links to startup communities that can help you hone your business model is important. Many of these programs offer workshops on creating business plans with a particular focus on business model innovation. Examples of schools with built-in startup communities include The MBA at Columbia Business School, where students can access networking, funding, and mentorship from successful entrepreneurs at the Eugene Lang Entrepreneurship Center. IE University’s startup lab in Madrid, Spain, which gives students access to year-round workshops for students to develop their business plan The National University of Singapore’s Startup Runway which supports early stage and growth stage founders with everything from legal advice to networking events For existing business leaders, executive programs that focus specifically on innovation are a good investment. The Executive MBA for Entrepreneurship & Innovation at the Wharton School offers core courses in Entrepreneurship through acquisition A project-based in which students create one or more real businesses Writing a comprehensive business plan and implementation plan New product development Venture capital and the finance of innovation 4. Basic research Of course, almost every great innovation requires deep knowledge in a specialized area, and this is where research innovation comes in. Basic research refers to the discovery of a new phenomenon that enables new problem solving techniques. Larger companies include research in their innovation strategies by hosting research centres, labs, or accelerators. One example is Experian’s DataLabs project, which aims to innovate new data sources for use in financial services, telecommunications, and healthcare. However, smaller companies can also access highly specialized research through local universities and, of course, business schools. If you want to pursue innovation in a highly specialized area, selecting your business school based on its research faculty and research centers as well as the teaching available to you as a student is a great way to open these connections and be the first to hear of new discoveries. The top-ranking schools for faculty research according to the Financial Times are Harvard Business School The Wharton School The University of Chicago Booth School of Business Perhaps you’re earlier in your career and considering getting stuck into this research yourself. In this case, you might study a specialized master’s to see if the business research life is for you. One example can be found at EDHEC Business School, which offers a combined Master in Management and Masters of Science in Innovation and Data. Innovation starts at business school Now you know: What innovation refers to What the four main types of innovation are Examples of these types of innovation in practice Where you can go to find out more about them But identifying the types of innovation you’re interested in is just the beginning. Exploring these concepts and, importantly, putting them into practice in a supportive environment like business school can give you the launchpad to create a truly innovative business. Register for the GMAT Now! Register Photo by Diz Play on UnsplashYou’ve probably already seen the word “innovation” elsewhere today. What used to be a rare competitive advantage has now become an essential competency that businesses try to build. While chasing innovation is, in an unexaggerated way, depicted almost as a hype, people usually scratch their heads around what innovation really means and confuse innovation with invention.Although the two terms have been used interchangeably in many places, innovation is intrinsically different from invention. An invention is the occurrence of an unprecedented idea. It’s usually scientific or technological. In contrast, Innovation is the first implementation of an idea which focuses on betterness and improvement. Innovation usually adds value to something that already exists, hence it is not just about science or technology. In order to truly turn a great invention into a world-changing innovation, other factors must be taken into account, such as customer focus, marketing, and strategy.One of the greatest examples of innovation is the music ecosystem Apple created with iPod and iTunes. Serial entrepreneur Dr Michael Szycher explains it well in the Szycher’s Practical Handbook of Entrepreneurship and Innovation:“What made the iPod and the music ecosystem innovative wasn’t that it was the first …. What made Apple innovative was that it combined all of these elements — design, ergonomics and ease of use — in a single device, and then tied it directly into a platform that effortlessly kept that device updated with music…Apple invented nothing. Its innovation was creating an easy-to-use ecosystem that unified music discovery, delivery and device. And, in the process, they revolutionised the music industry.”Photo by Christine Sandu on UnsplashNeither inventing nor innovating is easy. However, for businesses, the process of innovation can be particularly complicated and involve cross-functional collaboration and efforts. So how might businesses innovate?Famous Innovation FrameworksGiven the value that innovation can bring to businesses is so significant, there are well-established innovation frameworks that companies can learn from. Here, we will discuss two of them and hopefully, they can inspire some thoughts in you.Desirability, feasibility and viabilityThe first framework is about seeing innovation as the intersection of desirability, feasibility and viability. Originating from IDEO as a practice to prototype new businesses, this framework focuses on the sweet spot of where innovation can arise.Desirability: What’s the unique value proposition? Do people want this product or service? Does it make sense for them?Viability: Can we build a sustainable business? What has to be true for this business to work? What are the costs? How will you pay for it?Feasibility: Does this work? Is it functionally possible in the foreseeable future? Photo by Chaitanya Tvs on UnsplashDisruptive InnovationThe second framework is the theory of Disruptive Innovation defined by the late leading business thinker Clayton Christensen. In his book, The Innovator’s Dilemma, Clayton differentiates disruptive innovation with incremental innovation and states that disruptive innovation is much more challenging.“It is a process by which a product or service initially takes root in simple applications at the bottom of a market — typically by being less expensive and more accessible — and then relentlessly moves upmarket, eventually displacing established competitors.” — ChistensenInstitute.orgBoth incremental and disruptive innovation are important and need to be aligned with a company’s strategy. Achieving disruptive innovation not only requires R&D investment and out-of-the-box thinking, but also a corporate culture where experiments are encouraged and leadership is committed.Binomial’s Take on InnovationThe idea that innovation is only about improving your products and services is misleading. In fact, innovation can encompass every aspect of your business, and it’s related to customers, competition, and macro environment). Our own Innovation Framework and Innovation Journey Map approach to innovation focuses on the three forces to figure out where companies can start in their innovation process.Binomial’s Innovation FrameworkBinomial’s Innovation FrameworkA holistic view of your business is critical when it comes to innovation, that’s why our innovation framework lays out the strategic interplay of the different parties: your brand (products and services), competitors and alternatives, customers’ existing and emerging needs, and finally disruption from start-ups and other companies. Almost every independent sub-part of each circle represents an angle where a business can focus and innovate.Applicable to companies in any stage of growth, we aim for this framework to provide a comprehensive and practical guide on identifying the strengths and weaknesses of a business, together with what can be done about them.We know how complicated it can get when it comes to innovation, and after getting numerous requests for help, we started Ampersand, an accelerator programme (for smaller companies) and innovation lab (for larger companies), to help them reap the benefits of the framework. Ultimately, we want our innovation framework to help companies combine entrepreneurial audacity and corporate excellence, so founders and leaders can strengthen fundamentals and chart sustainable growth.Photo by Jeremy Bishop on Unsplash“Smart innovators frame their ideas to stress the ways in which a new concept is compatible with the existing market landscape, and their company’s place in that marketplace.”At the end of the day, no matter what kind of innovation a company is striving to achieve, it has to be aligned with its mission and vision, as well as its long-term strategies. Business leaders need to be aware that innovation is not a fad and start to think about how they can stay ahead of the curve when disruption is happening with increased frequency. At Binomial, we help companies identify opportunities for growth, adapt to disruptions, and align their innovations with long-term strategies. Ready to unlock the full potential of innovation for your business? Get in touch with us today to start your journey. Practical implementation of improvements For other uses, see Innovation (disambiguation) and Innovators (disambiguation). Thomas Edison with phonograph in the late 1870s. Edison was one of the most prolific inventors in history, holding 1,093 U.S. patents in his name. Innovation is the practical implementation of ideas that result in the introduction of new goods or services or improvement in offering goods or services.[1] ISO TC 279 in the standard ISO 56000:2020 defines innovation as "a new or changed entity, realizing or redistributing value".[2] Others have different definitions; a common element in the definitions is a focus on newness, improvement, and spread of ideas or technologies. Innovation often takes place through the development of more-effective products, processes, services, technologies, art works[3] or business models that innovators make available to markets, governments and society. Innovation is related to, but not the same as, invention:[4] innovation is more apt to involve the practical implementation of an invention (i.e. new / improved ability) to make a meaningful impact in a market or society,[5] and not all innovations require a new invention.[6] Technical innovation often manifests itself via the engineering process when the problem being solved is of a technical or scientific nature. The opposite of innovation is exnovation. Surveys of the literature on innovation have found a variety of definitions. In 2009, Baregheh et al. found around 60 definitions in different scientific papers, while a 2014 survey found over 40.[7] Based on their survey, Baragheh et al. attempted to formulate a multidisciplinary definition and arrived at the following:"Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace"[8] In a study of how the software industry considers innovation, the following definition given by Crossan and Apaydin was considered to be the most complete. Crossan and Apaydin built on the definition given in the Organisation for Economic Co-operation and Development (OECD) Oslo Manual:[7] Innovation is production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and the establishment of new management systems. It is both a process and an outcome. American sociologist Everett Rogers, defined it as follows:"An idea, practice, or object that is perceived as new by an individual or other unit of adoption"[9] According to Alan Altshuler and Robert D. Behn, innovation includes original invention and creative use. These writers define innovation as generation, admission and realization of new ideas, products, services and processes.[10] Two main dimensions of innovation are degree of novelty (i.e. whether an innovation is new to the firm, new to the market, new to the industry, or new to the world) and kind of innovation (i.e. whether it is process or product-service system innovation).[7] Organizational researchers have also distinguished innovation separately from creativity, by providing an updated definition of these two related constructs:Workplace creativity concerns the cognitive and behavioral processes applied when attempting to generate novel ideas. Workplace innovation concerns the processes applied when attempting to implement new ideas. Specifically, innovation involves some combination of problem/opportunity identification, the introduction, adoption or modification of new ideas germane to organizational needs, the promotion of these ideas, and the practical implementation of these ideas.[11] Peter Drucker wrote: Innovation is the specific function of entrepreneurship, whether in an existing business, a public service institution, or a new venture started by a lone individual in the family kitchen. It is the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth.[12] In general, innovation is distinguished from creativity by its emphasis on the implementation of creative ideas in an economic setting. Amabile and Pratt in 2016, drawing on the literature, distinguish between creativity ("the production of novel and useful ideas by an individual or small group of individuals working together") and innovation ("the successful implementation of creative ideas within an organization").[13] In 1957 the economist Robert Solow was able to demonstrate that economic growth had two components. The first component could be attributed to growth in production including wage labour and capital. The second component was found to be productivity. Ever since, economic historians have tried to explain the process of innovation itself, rather than assuming that technological inventions and technological progress result in productivity growth.[14] The concept of innovation emerged after the Second World War, mostly thanks to the works of Joseph Schumpeter (1883–1950) who described the economic effects of innovation processes as Constructive destruction. Today, consistent neo-Schumpeterian scholars see innovation not as neutral or apolitical processes.[15][16] Rather, innovation can be seen as socially constructed processes. Therefore, its conception depends on the political and societal context in which innovation is taking place.[17] According to Shannon Walsh, "innovation today is best understood as innovation under capital" (p. 346).[18] This means that the current hegemonic purpose for innovation is capital valorisation and profit maximization, exemplified by the appropriation of knowledge (e.g., through patenting), the widespread practice of Planned obsolescence (incl. lack of repairability by design), and the Jevons paradox, that describes negative consequences of eco-efficiency as energy-reducing effects tend to trigger mechanisms leading to energy-increasing effects.[19] Several frameworks have been proposed for defining types of innovation.[20][21][22] An 1880 penny-farthing (left), and a 1886 Rover safety bicycle with gearing One framework proposed by Clayton Christensen draws a distinction between sustaining and disruptive innovations.[23] Sustaining innovation is the improvement of a product or service based on the known needs of current customers (e.g. faster microprocessors, flat screen televisions). Disruptive innovation in contrast refers to a process by which a new product or service creates a new market (e.g. transistor radio, free crowdsourced encyclopedia, etc.), eventually displacing established competitors.[24][25] According to Christensen, disruptive innovations are critical to long-term success in business.[26] Disruptive innovation is often enabled by disruptive technology. Marco Iansiti and Karim R. Lakhani define foundational technology as having the potential to create new foundations for global technology systems over the longer term. Foundational technology tends to transform business operating models as entirely new business models emerge over many years, with gradual and steady adoption of the innovation leading to waves of technological and institutional change that gain momentum more slowly.[27][additional citation(s) needed] The advent of the packet-switched communication protocol TCP/IP—originally introduced in 1972 to support a single use case for United States Department of Defense electronic communication (email), and which gained widespread adoption only in the mid-1990s with the advent of the World Wide Web—is a foundational technology.[27] Another framework was suggested by Henderson and Clark. They divide innovation into four types; Radical innovation: "establishes a new dominant design and, hence, a new set of core design concepts embodied in components that are linked together in a new architecture." (p. 11)[28] Incremental innovation: "refines and extends an established design. Improvement occurs in individual components, but the underlying core design concepts, and the links between them, remain the same." (p. 11)[28] Architectural innovation: "innovation that changes only the relationships between them [the core design concepts]" (p. 12)[28] Modular Innovation: "innovation that changes only the core design concepts of a technology" (p. 12)[28] While Henderson and Clark as well as Christensen talk about technical innovation there are other kinds of innovation as well, such as service innovation and organizational innovation. As distinct from business-centric views of innovation concentrating on generating profit for a firm, other types of innovation include: social innovation, religious innovation,[29] sustainable innovation (or green innovation),[30] and responsible innovation.[31] One type of innovation that has been the focus of recent literature is open innovation or "crowd sourcing." Open innovation refers to the use of individuals outside of an organizational context who have no expertise in a given area to solve complex problems.[32] Similar to open innovation, user innovation is when companies rely on users of their goods and services to come up with, help to develop, and even help to implement new ideas.[32] See also: Innovation economics Innovation must be understood in the historical setting in which its processes were and are taking place.[17] The first full-length discussion about innovation was published by the Greek philosopher and historian Xenophon (430–355 BCE). He viewed the concept as multifaceted and connected it to political action. The word for innovation that he uses, kainotomia, had previously occurred in two plays by Aristophanes (c. 446 – c. 386 BCE). Plato (died c. 348 BCE) discussed innovation in his Laws dialogue and was not very fond of the concept. He was skeptical to it both in culture (dancing and art) and in education (he did not believe in introducing new games and toys to the kids).[33] Aristotle (384–322 BCE) did not like organizational innovations: he believed that all possible forms of organization had been discovered.[34] Before the 4th century in Rome, the words novitas and res nova / nova res were used with either negative or positive judgment on the innovator. This concept meant "renewing" and was incorporated into the new Latin verb word innovo ("I renew" or "I restore") in the centuries that followed. The Vulgate version of the Bible (late 4th century CE) used the word in spiritual as well as political contexts. It also appeared in poetry, mainly with spiritual connotations, but was also connected to political, material and cultural aspects.[33] Machiavelli's The Prince (1513) discusses innovation in a political setting. Machiavelli portrays it as a strategy a Prince may employ in order to cope with a constantly changing world as well as the corruption within it. Here innovation is described as introducing change in government (new laws and institutions); Machiavelli's later book The Discourses (1528) characterises innovation as imitation, as a return to the original that has been corrupted by people and by time.[citation needed] Thus for Machiavelli innovation came with positive connotations. This is however an exception in the usage of the concept of innovation from the 16th century and onward. No innovator from the renaissance until the late 19th century ever thought of applying the word innovator upon themselves, it was a word used to attack enemies.[33] From the 1400s[citation needed] through the 1600s, the concept of innovation was pejorative – the term was an early-modern synonym for "rebellion", "revolt" and "heresy".[35][36][37][38][39] In the 1800s[timeframe?] people promoting capitalism saw socialism as an innovation and spent a lot of energy working against it. For instance, Goldwin Smith (1823-1910) saw the spread of social innovations as an attack on money and banks. These social innovations were socialism, communism, nationalization, cooperative associations.[33] In the 20th century, the concept of innovation did not become popular until after the Second World War of 1939–1945. This is the point in time when people started to talk about technological product innovation and tie it to the idea of economic growth and competitive advantage.[40] Joseph Schumpeter (1883–1950), who contributed greatly to the study of innovation economics, is seen as the one who made the term popular. Schumpeter argued that industries must incessantly revolutionize the economic structure from within, that is: innovate with better or more effective processes and products, as well as with market distribution (such as the transition from the craft shop to factory). He famously asserted that "creative destruction is the essential fact about capitalism".[41] In business and in economics, innovation can provide a catalyst for growth when entrepreneurs continuously search for better ways to satisfy their consumer base with improved quality, durability, service and price - searches which may come to fruition in innovation with advanced technologies and organizational strategies.[42] Schumpeter's findings coincided with rapid advances in transportation and communications in the beginning of the 20th century, which had huge impacts for the economic concepts of factor endowments and comparative advantage as new combinations of resources or production techniques constantly transform markets to satisfy consumer needs. Hence, innovative behaviour becomes relevant for economic success.[43] An early model included only three phases of innovation. According to Utterback (1971), these phases were: 1) idea generation, 2) problem solving, and 3) implementation.[44] By the time one completed phase 2, one had an invention, but until one got it to the point of having an economic impact, one did not have an innovation. Diffusion was not considered a phase of innovation. Focus at this point in time was on manufacturing. A prime example of innovation involved the boom of Silicon Valley start-ups out of the Stanford Industrial Park. In 1957, dissatisfied employees of Shockley Semiconductor, the company of Nobel laureate William Shockley, co-inventor of the transistor, left to form an independent firm, Fairchild Semiconductor. After several years, Fairchild developed into a formidable presence in the sector.[which?] Eventually, these founders left to start their own companies based on their own unique ideas, and then leading employees started their own firms. Over the next 20 years this process resulted in the momentous startup-company explosion of information-technology firms.[citation needed] Silicon Valley began as 65 new enterprises born out of Shockley's eight former employees.[45] All organizations can innovate,[46] including for example hospitals, universities, and local governments.[47] The organization requires a proper structure in order to retain competitive advantage. Organizations can also improve profits and performance by providing work groups opportunities and resources to innovate, in addition to employee's core job tasks.[48] Executives and managers have been advised to break away from traditional ways of thinking and use change to their advantage.[49] The world of work is changing with the increased use of technology and companies are becoming increasingly competitive. Companies will have to downsize or reengineer their operations to remain competitive. This will affect employment as businesses will be forced to reduce the number of people employed while accomplishing the same amount of work if not more.[50] For instance, former Mayor Martin O'Malley pushed the City of Baltimore to use CitiStat, a performance-measurement data and management system that allows city officials to maintain statistics on several areas from crime trends to the conditions of potholes. This system aided in better evaluation of policies and procedures with accountability and efficiency in terms of time and money. In its first year, CitiStat saved the city $13.2 million.[51] Even mass transit systems have innovated with hybrid bus fleets to real-time tracking at bus stands. In addition, the growing use of mobile data terminals in vehicles, that serve as communication hubs between vehicles and a control center, automatically send data on location, passenger counts, engine performance, mileage and other information. This tool helps to deliver and manage transportation systems.[52] Still other innovative strategies include hospitals digitizing medical information in electronic medical records. For example, the U.S. Department of Housing and Urban Development's HOPE VI initiatives turned severely distressed public housing in urban areas into revitalized, mixed-income environments; the Harlem Children's Zone used a community-based approach to educate local area children; and the Environmental Protection Agency's brownfield grants facilitates turning over brownfields for environmental protection, green spaces, community and commercial development. Further information: Demand articulation Innovation may occur due to effort from a range of different agents, by chance, or as a result of a major system failure. According to Peter F. Drucker, the general sources of innovations are changes in industry structure, in market structure, in local and global demographics, in human perception, in the amount of available scientific knowledge, etc.[12] Original model of three phases of the process of Technological Change In the simplest linear model of innovation the traditionally recognized source is manufacturer innovation. This is where a person or business innovates in order to sell the innovation. Another source of innovation is end-user innovation. This is where a person or company develops an innovation for their own (personal or in-house) use because existing products do not meet their needs. MIT economist Eric von Hippel identified end-user innovation as the most important source in his classic book on the subject, "The Sources of Innovation".[53] The robotics engineer Joseph F. Engelberger asserts that innovations require only three things: a recognized need competent people with relevant technology financial support[54] The Kline chain-linked model of innovation[55] places emphasis on potential market needs as drivers of the innovation process, and describes the complex and often iterative feedback loops between marketing, design, manufacturing, and R&D. In the 21st century the Islamic State (IS) movement, while decrying religious innovations, has innovated in military tactics, recruitment, ideology and geopolitical activity.[56][57] Innovation by businesses is achieved in many ways, with much attention now given to formal research and development (R&D) for "breakthrough innovations". R&D help spur on patents and other scientific innovations that leads to productive growth in such areas as industry, medicine, engineering, and government.[58] Yet, innovations can be developed by less formal on-the-job modifications of practice, through exchange and combination of professional experience and by many other routes. Investigation of relationship between the concepts of innovation and technology transfer revealed overlap.[59] The more radical and revolutionary innovations tend to emerge from R&D, while more incremental innovations may emerge from practice – but there are many exceptions to each of these trends. Information technology and changing business processes and management style can produce a work climate favorable to innovation.[60] For example, the software tool company Atlassian conducts quarterly "ShipIt Days" in which employees may work on anything related to the company's products.[61] Google employees work on self-directed projects for 20% of their time (known as Innovation Time Off). Both companies cite these bottom-up processes as major sources for new products and features. An important innovation factor includes customers buying products or using services. As a result, organizations may incorporate users in focus groups (user centered approach), work closely with so-called lead users (lead user approach), or users might adapt their products themselves. The lead user method focuses on idea generation based on leading users to develop breakthrough innovations. U-STIR, a project to innovate Europe's surface transportation system, employs such workshops.[62] Regarding this user innovation, a great deal of innovation is done by those actually implementing and using technologies and products as part of their normal activities. Sometimes user-innovators may become entrepreneurs, selling their product, they may choose to trade their innovation in exchange for other innovations, or they may be adopted by their suppliers. Nowadays, they may also choose to freely reveal their innovations, using methods like open source. In such networks of innovation the users or communities of users can further develop technologies and reinvent their social meaning.[63][64] One technique for innovating a solution to an identified problem is to actually attempt an experiment with many possible solutions.[65] This technique was famously used by Thomas Edison's laboratory to find a version of the incandescent light bulb economically viable for home use, which involved searching through thousands of possible filament designs before settling on carbonized bamboo. This technique is sometimes used in pharmaceutical drug discovery. Thousands of chemical compounds are subjected to high-throughput screening to see if they have any activity against a target molecule which has been identified as biologically significant to a disease. Promising compounds can then be studied; modified to improve efficacy and reduce side effects, evaluated for cost of manufacture; and if successful turned into treatments. The related technique of A/B testing is often used to help optimize the design of web sites and mobile apps. This is used by major sites such as amazon.com, Facebook, Google, and Netflix.[66] Procter & Gamble uses computer-simulated products and online user panels to conduct larger numbers of experiments to guide the design, packaging, and shelf placement of consumer products.[67] Capital One uses this technique to drive credit card marketing offers.[66] Scholars have argued that the main purpose for innovation today is profit maximization and capital valorisation.[68][17] Consequently, programs of organizational innovation are typically tightly linked to organizational goals and growth objectives, to the business plan, and to market competitive positioning. Davila et al. (2006) note, "Companies cannot grow through cost reduction and reengineering alone... Innovation is the key element in providing aggressive top-line growth, and for increasing bottom-line results".[69] One survey across a large number of manufacturing and services organizations found that systematic programs of organizational innovation are most frequently driven by: improved quality, creation of new markets, extension of the product range, reduced labor costs, improved production processes, reduced materials cost, reduced environmental damage, replacement of products/services, reduced energy consumption, and conformance to regulations.[69] Different goals are appropriate for different products, processes, and services. According to Andrea Vaona and Mario Pianta, some example goals of innovation could stem from two different types of technological strategies: technological competitiveness and active price competitiveness. Technological competitiveness may have a tendency to be pursued by smaller firms and can be characterized as "efforts for market-oriented innovation, such as a strategy of market expansion and patenting activity."[70] On the other hand, active price competitiveness is geared toward process innovations that lead to efficiency and flexibility, which tend to be pursued by large, established firms as they seek to expand their market foothold.[70] Whether innovation goals are successfully achieved or otherwise depends greatly on the environment prevailing in the organization.[71] Failure of organizational innovation programs has been widely researched and the causes vary considerably. Some causes are external to the organization and outside its influence of control. Others are internal and ultimately within the control of the organization. Internal causes of failure can be divided into causes associated with the cultural infrastructure and causes associated with the innovation process itself. David O'Sullivan wrote that causes of failure within the innovation process in most organizations can be distilled into five types: poor goal definition, poor alignment of actions to goals, poor participation in teams, poor monitoring of results, and poor communication and access to information.[72] Innovation is generally framed as an inherently positive force, delivering growth and prosperity for all, and is often deemed as both inevitable and unstoppable.[17] In this sense, future innovations are often hailed as solutions to current problems, such as climate change. This business-as-usual approach would mean continued and increased globalization as well as quick innovation cycles which supposedly will maximize the competitiveness of processes, in the end leading to Eco-economic decoupling or Green growth. Yet, it is unclear whether innovative solutions will be capable of solving the climate crisis: According to Mario Giampietro and Silvio Funtowicz (2020), this positive framing of innovation "demonstrates [a] lack of understanding of the biophysical roots of the economic process and the seriousness of the sustainability crisis".[73] This is due to the fact that innovation can be understood in its specific historic and cultural context: The prevailing hegemonic view on innovation, as emphasized by Ben Robra et al. (2023), aligns closely with capitalist mode of production, shown by the mantra of 'innovate or die.'[17] From this viewpoint, innovation is primarily driven by the imperative of capital accumulation, serving the sole purpose of increasing returns, neglecting societal needs such as a clean environment or social equality and in general the biophysical limits of our planet.[74][75] Main article: Diffusion of innovations Diffusion of innovation research was first started in 1903 by seminal researcher Gabriel Tarde, who first plotted the S-shaped diffusion curve. Tarde defined the innovation-decision process as a series of steps that include:[76] knowledge forming an attitude a decision to adopt or reject implementation and use confirmation of the decision Once innovation occurs, innovations may be spread from the innovator to other individuals and groups. This process has been proposed that the lifecycle of innovations can be described using the 's-curve' or diffusion curve. The s-curve maps growth of revenue or productivity against time. In the early stage of a particular innovation, growth is relatively slow as the new product establishes itself. At some point, customers begin to demand and the product growth increases more rapidly. New incremental innovations or changes to the product allow growth to continue. Towards the end of its lifecycle, growth slows and may even begin to decline. In the later stages, no amount of new investment in that product will yield a normal rate of return. Innovation adoption[77] of several common household items in the U.S.[78] (more charts) The s-curve derives from an assumption that new products are likely to have "product life" – i.e., a start-up phase, a rapid increase in revenue and eventual decline. In fact, the great majority of innovations never get off the bottom of the curve, and never produce normal returns. Innovative companies will typically be working on new innovations that will eventually replace older ones. Successive s-curves will come along to replace older ones and continue to drive growth upwards. In the figure above the first curve shows a current technology. The second shows an emerging technology that currently yields lower growth but will eventually overtake current technology and lead to even greater levels of growth. The length of life will depend on many factors.[79] Measuring innovation is inherently difficult as it implies commensurability so that comparisons can be made in quantitative terms. Innovation, however, is by definition novelty. Comparisons are thus often meaningless across products or service.[80] Nevertheless, Edison et al.[81] in their review of literature on innovation management found 232 innovation metrics. They categorized these measures along five dimensions; i.e. inputs to the innovation process, output from the innovation process, effect of the innovation output, measures to access the activities in an innovation process and availability of factors that facilitate such a process.[81] There are two different types of measures for innovation: the organizational level and the political level. The measure of innovation at the organizational level relates to individuals, team-level assessments, and private companies from the smallest to the largest company. Measure of innovation for organizations can be conducted by surveys, workshops, consultants, or internal benchmarking. There is today no established general way to measure organizational innovation. Corporate measurements are generally structured around balanced scorecards which cover several aspects of innovation such as business measures related to finances, innovation process efficiency, employees' contribution and motivation, as well benefits for customers. Measured values will vary widely between businesses, covering for example new product revenue, spending in R&D, time to market, customer and employee perception & satisfaction, number of patents, additional sales resulting from past innovations.[82] For the political level, measures of innovation are more focused on a country or region competitive advantage through innovation. In this context, organizational capabilities can be evaluated through various evaluation frameworks, such as those of the European Foundation for Quality Management. The OECD Oslo Manual (1992) suggests standard guidelines on measuring technological product and process innovation. Some people consider the Oslo Manual complementary to the Frascati Manual from 1963. The new Oslo Manual from 2018 takes a wider perspective to innovation, and includes marketing and organizational innovation. These standards are used for example in the European Community Innovation Surveys.[83] Other ways of measuring innovation have traditionally been expenditure, for example, investment in R&D (Research and Development) as percentage of GNP (Gross National Product). Whether this is a good measurement of innovation has been widely discussed and the Oslo Manual has incorporated some of the critique against earlier methods of measuring. The traditional methods of measuring still inform many policy decisions. The EU Lisbon Strategy has set as a goal that their average expenditure on R&D should be 3% of GDP.[84] Many scholars claim that there is a great bias towards the "science and technology mode" (S&T-mode or STI-mode), while the "learning by doing, using and interacting mode" (DUI-mode) is ignored and measurements and research about it rarely done. For example, an institution may be high tech with the latest equipment, but lacks crucial doing, using and interacting tasks important for innovation.[85] A common industry view (unsupported by empirical evidence) is that comparative cost-effectiveness research is a form of price control which reduces returns to industry, and thus limits R&D expenditure, stifles future innovation and compromises new products access to markets.[86] Some academics claim cost-effectiveness research is a valuable value-based measure of innovation which accords "truly significant" therapeutic advances (i.e. providing "health gain") higher prices than free market mechanisms.[87] Such value-based pricing has been viewed as a means of indicating to industry the type of innovation that should be rewarded from the public purse.[88] An Australian academic developed the case that national comparative cost-effectiveness analysis systems should be viewed as measuring "health innovation" as an evidence-based policy concept for valuing innovation distinct from valuing through competitive markets, a method which requires strong anti-trust laws to be effective, on the basis that both methods of assessing pharmaceutical innovations are mentioned in annex 2C.1 of the Australia-United States Free Trade Agreement.[89][90][91] Several indices attempt to measure innovation and rank entities based on these measures, such as: Bloomberg Innovation Index "Bogota Manual"[92] similar to the Oslo Manual, is focused on Latin America and the Caribbean countries.[citation needed] "Creative Class" developed by Richard Florida[citation needed] EIU Innovation Ranking[93] Global Competitiveness Report Global Innovation Index (GII), by INSEAD[94] Information Technology and Innovation Foundation (ITIF) Index Innovation 360 – From the World Bank. Aggregates innovation indicators (and more) from a number of different public sources Innovation Capacity Index (ICI) published by a large number of international professors working in a collaborative fashion. The top scorers of ICI 2009–2010 were: 1. Sweden 82.2; 2. Finland 77.8; and 3. United States 77.5[95] Innovation Index, developed by the Indiana Business Research Center, to measure innovation capacity at the county or regional level in the United States[96] Innovation Union Scoreboard, developed by the European Union innovationsindikator for Germany, developed by the Federation of German Industries (Bundesverband der Deutschen Industrie) in 2005[97] INSEAD Innovation Efficacy Index[98] International Innovation Index, produced jointly by The Boston Consulting Group, the National Association of Manufacturers (NAM) and its nonpartisan research affiliate The Manufacturing Institute, is a worldwide index measuring the level of innovation in a country; NAM describes it as the "largest and most comprehensive global index of its kind"[citation needed][99] Management Innovation Index – Model for Managing Intangibility of Organizational Creativity: Management Innovation Index[100] NYCEDC Innovation Index, by the New York City Economic Development Corporation, tracks New York City's "transformation into a center for high-tech innovation. It measures innovation in the City's growing science and technology industries and is designed to capture the effect of innovation on the City's economy"[101] OECD Oslo Manual is focused on North America, Europe, and other rich economies State Technology and Science Index, developed by the Milken Institute, is a U.S.-wide benchmark to measure the science and technology capabilities that furnish high paying jobs based around key components[102] World Competitiveness Scoreboard[103] Common areas of focus include: high-tech companies, manufacturing, patents, post secondary education, research and development, and research personnel. The left ranking of the top 10 countries below is based on the 2020 Bloomberg Innovation Index.[104] However, studies may vary widely; for example the Global Innovation Index 2016 ranks Switzerland as number one wherein countries like South Korea, Japan, and China do not even make the top ten.[105] Bloomberg Innovation Index 2021[106] Rank Country/Territory Index 1 South Korea 90.49 2 Singapore 87.76 3 Switzerland 87.60 4 Germany 86.45 5 Sweden 86.39 6 Denmark 86.12 7 Israel 85.50 8 Finland 84.86 9 Netherlands 84.29 10 Austria 83.93 Global Innovation Index 2020[107] Rank Country/Territory Index 1 Switzerland 66.08 2 Sweden 62.47 3 United States 60.56 4 United Kingdom 59.78 5 Netherlands 58.76 6 Denmark 57.53 7 Finland 57.02 8 Singapore 56.61 9 Germany 56.55 10 South Korea 56.11 Innovation Indicator 2020[108] Rank Country/Territory Index 1 Switzerland 74 2 Singapore 70 3 Belgium 60 4 Germany 54 5 Sweden 54 6 Denmark 52 7 Ireland 52 8 United States 52 9 Austria 50 10 Finland 50 In 2005 Jonathan Huebner, a physicist working at the Pentagon's Naval Air Warfare Center, argued on the basis of both U.S. patents and world technological breakthroughs, per capita, that the rate of human technological innovation peaked in 1873 and has been slowing ever since.[109][110] In his article, he asked "Will the level of technology reach a maximum and then decline as in the Dark Ages?"[109] In later comments to New Scientist magazine, Huebner clarified that while he believed that we will reach a rate of innovation in 2024 equivalent to that of the Dark Ages, he was not predicting the reoccurrence of the Dark Ages themselves.[111] John Smart criticized the claim and asserted that technological singularity researcher Ray Kurzweil and others showed a "clear trend of acceleration, not deceleration" when it came to innovations.[112] The foundation replied to Huebner the journal his article was published in, citing Second Life and eHarmony as proof of accelerating innovation; to which Huebner replied.[113] However, Huebner's findings were confirmed in 2010 with U.S. Patent Office data.[114] and in a 2012 paper.[115] The theme of innovation as a tool to disrupting patterns of poverty has gained momentum since the mid-2000s among major international development actors such as DFID,[116] Gates Foundation's use of the Grand Challenge funding model,[117] and USAID's Global Development Lab.[118] Networks have been established to support innovation in development, such as D-Lab at MIT.[119] Investment funds have been established to identify and catalyze innovations in developing countries, such as DFID's Global Innovation Fund,[120] Human Development Innovation Fund,[121] and (in partnership with USAID) the Global Development Innovation Ventures.[122] The United States has to continue to play on the same level of playing field as its competitors in federal research. This can be achieved being strategically innovative through investment in basic research and science".[123] 50 W. San Fernando Street in downtown San Jose is the site of the world's first radio broadcasting station, created in 1909 by Charles Herrold, the "Father of Broadcasting".[124] Given its effects on efficiency, quality of life, and productive growth, innovation is a key driver in improving society and economy. Consequently, policymakers have worked to develop environments that will foster innovation, from funding research and development to establishing regulations that do not inhibit innovation, funding the development of innovation clusters, and using public purchasing and standardisation to 'pull' innovation through. For instance, experts are advocating that the U.S. federal government launch a National Infrastructure Foundation, a nimble, collaborative strategic intervention organization that will house innovations programs from fragmented silos under one entity, inform federal officials on innovation performance metrics, strengthen industry-university partnerships, and support innovation economic development initiatives, especially to strengthen regional clusters. Because clusters are the geographic incubators of innovative products and processes, a cluster development grant program would also be targeted for implementation. By focusing on innovating in such areas as precision manufacturing, information technology, and clean energy, other areas of national concern would be tackled including government debt, carbon footprint, and oil dependence.[58] The U.S. Economic Development Administration understand this reality in their continued Regional Innovation Clusters initiative.[125] The United States also has to integrate her supply-chain and improve her applies research capability and downstream process innovation.[126] Many countries recognize the importance of innovation including Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT);[127] Germany's Federal Ministry of Education and Research;[128] and the Ministry of Science and Technology in the People's Republic of China. Russia's innovation programme is the Medvedev modernisation programme which aims to create a diversified economy based on high technology and innovation. The Government of Western Australia has established a number of innovation incentives for government departments. Landgate was the first Western Australian government agency to establish its Innovation Program.[129] Some regions have taken a proactive role in supporting innovation. Many regional governments are setting up innovation agencies to strengthen regional capabilities.[130] Business incubators were first introduced in 1959 and subsequently nurtured by governments around the world. Such "incubators", located close to knowledge clusters (mostly research-based) like universities or other government excellence centres – aim primarily to channel generated knowledge to applied innovation outcomes in order to stimulate regional or national economic growth.[131] In 2009, the municipality of Medellin, Colombia created Ruta N to transform the city into a knowledge city.[132] Innovation in the prevailing hegemonic view today mostly refers to 'innovation under capital',[18] due to the prevailing capitalist nature of the global economy. In contrast, Robra et al. (2023) propose a counter-hegemonic view on innovation.[17] This alternative lens revises the centrality of capital accumulation as the primary goal of innovation. Instead of being solely driven by profit motives, a counter-hegemonic understanding sees innovation as a means to create user-value, with a focus on satisfying societal needs. This view on innovation is underpinned by open access to knowledge, adaptability, repairability, and maintenance of products as well as Eco-sufficiency, defining progress not by efficiency but by staying within planetary boundaries, thereby challenging the hegemonic belief in limitless growth. This perspective is exemplified by commons-based peer production (CBPP), offering an alternative vision of innovation that prioritizes conviviality over relentless competition. In essence, this counter-hegemonic view describes a more socially and ecologically conscious approach to innovation, striving for a balance between technological progress and human wellbeing. Hegemonic innovation vs. counter-hegemonic innovation (taken from Robra et al., 2023)[17] Hegemonic view Counter-hegemonic view Purpose Capital valorisation and profit-making/maximizing Use-value creation and focus on societal needs Underpinning common senses Fencing off and appropriation of knowledge Open access to knowledge Planned obsolescence (incl. lack of repairability by design) Adaptability, repairability, and maintenance Eco-Efficiency Eco-Sufficiency Look up innovation in Wiktionary, the free dictionary. Communities of innovation Creative problem solving Diffusion (anthropology) Ecoinnovation Hype cycle Induced innovation Information revolution Innovation leadership Innovation system International Association of Innovation Professionals ISO 56000 Knowledge economy Obsolescence Open Innovation Open Innovations (Forum and Technology Show) Outcome-Driven Innovation Participatory design Product innovation Pro-innovation bias Sustainable Development Goals (Agenda 9) Technology Life Cycle Technological change Technological innovation system Theories of technology Timeline of historic inventions Toolkits for User Innovation UNDP Innovation Facility User Innovation Virtual product development

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It was an unusually complex problem, so the firm set up a team of crack microchip designers, and they started putting their heads together.