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Janvee Garg and Anil Kumar Singh
An exploration of the ankle-biters and their role in business ecosystems

Lara Kämmerer, Denis Ludwig, Carla Mereu and Ari Pankiewicz
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After COVID, what's next for pharma supply chains?

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Editorial Board

Aim and Scope

The Journal of Business Chemistry (JoBC) focuses on current developments and insights at the intersection of management and chemistry, biotechnology or pharmacy.

The JoBC provides an international forum for researchers and practitioners in companies, research institutes, public authorities, consultancies or NGOs to present and discuss current challenges as well as potential solutions in an interdisciplinary manner. Thus, the JoBC aims to foster the dialog between science and business, to support management practice in the chemical and pharmaceutical industry and to indicate where further research from academia is needed. The JoBC offers high quality publications with academic standards, a fast publishing process and global reach. With this multidisciplinary and boundary-spanning approach, the JoBC intends to become the leading journal for decision makers in the chemical and pharmaceutical industry.

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Letter from the Editors

Is the globalized world reordering itself?

Two years ago, we described that the pandemic has added an additional element of chaos to an already volatile, uncertain, complex, and ambiguous world and we have asked, among other things, the questions: What about the highly globalized value chains – will we try to move the supply chains back to Europe and is it at all possible? Will we value climate protection more or less than before? The situation today still feels more like not normal than new normal, especially against the backdrop of the outbreak of the war in Ukraine. The articles in this issue take up some aspects of the questions posed two years ago and show that the world is still in a process of reordering itself.

Janvee Garg´s and Anil Kumar Singh´s "An exploration of the ankle-biters and their role in business ecosystems" article contributes to the understanding of the term "ankle-biters" which is used for start-ups that challenge incumbents in established industries. They trace the term's etymology, propose a classification and give examples from different industries, e.g. the pharmaceutical industry.

Reporting the environmental footprint of chemical products is a huge challenge for companies. However, it´s increasing expected from society and the regulatory side. Lara Kämmerer, Denis Ludwig, Carla Mereu, and Ari Pankiewicz address this topic with their article "Product footprint reporting for chemicals companies". They outline and compare two product footprint reporting frameworks: GHG Protocol's Product Standard and the EU Commission's Product Environmental Footprint.

Marcus Ehrhardt, Christine O´Brien, and Wilderich Heising ask the question "After COVID, what´s next for pharma supply chains?" in their commentary. At first, they look at the current structure of the pharmaceutical industry: A supply chain network with suppliers in all parts of the world with high dependence on certain countries. This enables cost reduction but leads also to management challenges and complexity. Another important influencing factor is the topic of sustainability, particularly climate change. As the majority of emissions in the pharma sector are scope 3 emissions, a look at the entire value chain is necessary. They close by outlining and summarizing levers to increase resilience and sustainability in pharma supply chains.

Please enjoy reading the second issue of the nineteenth volume of the Journal of Business Chemistry. We are grateful for the support of all authors and reviewers for this new issue. If you have any comments or suggestions, please do not hesitate to contact us at contact@businesschemistry.org. For more updates and insights on management issues in the chemical industry, follow us on LinkedIn: www.linkedin.com/company/jobc/.

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Research Paper

Janvee Garg*, Dr. Anil Kumar Singh**

An exploration of the ankle-biters and their role in business ecosystems

Innovative firms evolve, positions shift, and markets realign due to the dynamics of innovation. The role of innovations in reconfiguring markets and economies is well understood. The schools of thought that guided this understanding in erstwhile literature are based on ecological principles, institutionalism, and industrial economics. Whatever the side of human ecology, population ecology or industrial economics, all agree that new entrants disrupt incumbents on both a spatial, a temporal, and a magnitude basis. The Marketing Science Institute's research priorities highlight the term ankle-biters. Further research into this term in different databases revealed very few publications. This study is therefore a modest attempt to add value towards the understanding of the term, „ankle-biters," by tracing the etymology, understanding the significance, integrating it into current contexts, and adding to the body of knowledge associated with the term. In 2018, the term „ankle-biters" gained massive traction in the business world. In order for firms to evolve successfully in business, there needs to be convergence and encapsulation of fine touch points, which limit the ankle-biters' ability to destabilize the existing business model. A firm in the Technology sector can facilitate this understanding (since technology is the biggest disruptor) which faces numerous ankle-biters in different configurations. We need to devise a classification mechanism that facilitates a coherent, structural understanding of ankle-biters.

1 Introduction

This study addresses the void created by business innovations that reduce the growth pace of established businesses because they keep on hurting the ankles. Scholars (Adner, 2017; Jacobdies, Cennamo & Gewar, 2018; Iansiti & Levien, 2004; Moore, 1993) have vaguely identified the enterprises that enable new configurations by means of transformation and contribute to ecological drift. The most common focus of business literature has been towards growing and developed companies, if not, then it has been a discussion of successful industries, especially those that have an easy data collection process. Based on Nutanix as an example, it intends to dominate the world of hyper-converged infrastructure and everything software. According to Dheeraj Pandey (2018), the Nutanix CEO, every infrastructure in the next three years will be hyperconverged, and he deems the rivals to be ankle-biters.

Taking into account the views expressed, we can interpret ankle-biters as non-threatening entities that cannot put existing businesses at risk. Another equally compelling lens

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views ankle-biters as small, niche brands that impede the growth of large consumer goods companies. As a result, the notion of ankle-biters is shaped by the managerial understanding of the businesses' susceptibility to risk by new entrants.

Additionally, the pesky ankle-biters also threatened retailers, whose cumulative impact hampered growth. Even though the ankle-biter phenomenon has been growing for over a decade, it is one of the authors' top predictions for how the world of retail will change in the near future. Due to factors such as technology, social media, e-commerce, and shifting consumer preferences, ankle-biters are well suited to meet fragmented demand.

With the advent of social media, it has never been easier to build a personal brand. An individual who pursues a passion often gains a following and a level of celebrity that can be translated into product sales. Those who plan to be merchants can simply use digital communication methods to connect directly with shoppers seeking niche items not readily available in local stores. Through Google's capabilities or by participating in one or more of the third party marketplaces, these merchants are able to reach millions and millions of potential shoppers.

One of the best examples of this is Amazon's FBA (Fulfilled by Amazon) program, which allows small merchants access to a highly advanced supply chain network and an ever-expanding system of fulfillment centers. Anyone with access to inventory and an Internet connection can operate as a brand or retailer, supported by marketing, merchandising and supply chain capabilities as sophisticated as those available at some legacy companies.

The ankle-biters can range from multi-billion dollar companies with conventional retail distribution to thousands of much smaller companies using e-commerce marketplaces or shipping products from their garage. They don't even reach ankle height and their sales aren't included in any Nielsen or IRI reports. The existence of ankle-biters can only be verified by sales and traffic weakness at established retailers, which makes ankle-biters seem like an odorless and colorless gas.

This is why the ankle-biter effect is so frustrating and different from competitive challenges of the past. For example, in the 90s, if Walmart opened a 200,000-square-foot supercenter near an aging Kmart store, Kmart would know who took its share of the market. However, the same is true to a lesser degree today when it comes to rapidly expanding chains such as Dollar General and Aldi. It is easy for competitors to identify either of these as a weak point when they open nearby.

In the current ecosystem, ankle-biters will continue to exist. It will persist and intensify in the coming years and become even more of a competitive issue. However, there is a solution and it doesn't require going head-to-head with Amazon or Walmart to offer an endless aisle marketplace. It does mean that innovation has to accelerate in organizations at a rapid pace, something we often hear, but rarely see - to provide the uniqueness and personalization that makes shoppers receptive to ankle-biters.

In addition to factors like better assortment planning, leveraging new sources of insights for personalized offers, focusing relentlessly on the supply chain to more efficiently flow goods, eliminating waste, and implementing new fulfillment models such as click-and-collect or home delivery, there are a number of other things to consider. Food retailers in particular need to be more aggressive about adopting a digital-first philosophy, utilizing stores to drive traffic to their Web sites and exposing shoppers to a universe of products that physical stores cannot offer.

The ankle-biters will continue to gnaw at the market share of established retailers, moving up the leg of the vulnerable who are deluded about the relevance of their stores or the extent of digital advancements. If that makes for a disturbing visual - that's a good thing, because no retailer should be looking in the mirror several years from now and regretting not having acted sooner (Troy, 2018).

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2 Literature Review

For a business, technological innovation is often a key to survival and a source of sustained growth, but it is also expensive and difficult (Schumpeter, 1934). The concept of market-to-market competition has been a subject of intense academic inquiry ever since Schumpeter brought it to light and its equivocal creative and destructive implications. It is Christensen (2000), which describes instances in which entrepreneurs touting inferior technologies disrupt established firms with superior technologies (Danneels, 2004). The „innovator's dilemma" is the fact that well-established and well-run companies can lose customers by doing the right thing by listening to their customers - upstart firms that offer new technologies for which no customers as yet exist (Dew, 2008).

Figure 1 shows the performance trajectory of products (the red lines showing how they improve over time) and the performance trajectory of customer demand (the blue lines showing the willingness of customers to pay for performance). The high-end of the market (where profitability is greatest) demands higher-quality products and services from incumbent companies (upper red line), overshooting the needs of most low-end and mainstream customers. In a less-profitable segment that incumbents neglect, this provides an opportunity for entrants to gain a foothold. In a disruptive market (lower red line), entry-level companies improve the performance of their offerings and move upmarket (where profitability is highest for them, too), challenging the incumbents' dominance (Clayton M et al.,2015).

3 The ankle-biter economy

In the 18th century, the industrial revolution brought with it strict barriers to entry in businesses, huge investments and high raw material prices, large scale production and inventories, thus favoring large industrial giants. The factors above led to a small number of businesses flourishing back then. But the world seems to have progressed from this scenario, leading into a new dynamic of digitally driven economic revolution by creating a new governing algorithm in which large numbers of admirably aggressive, bumptious individuals and startups can and will bring down established and formerly unassailable big incumbents with regularity (Maney, 2013). In the business world, incumbents are companies, brands, academic institutions, media franchises, and politicians.

This is what is known as the „rise of the ankle-biter economy". The ankle-biter economy represents a turbulent new reality where nothing is sacred or safe. In order to study how this change occurred, we need to first understand how ankle-biters originated.

The term ankle-biters was first used in 1850 by Gary Martin in Harper's Magazine, saying: „And how are you, John?" and, how's Molly, and all the little ankle-biters?" Here the term "ankle-biters" refers to children. We can therefore infer that this term describes the characteristics associated with kids, such as being mischievous, creative, and active (Martin, 1850).

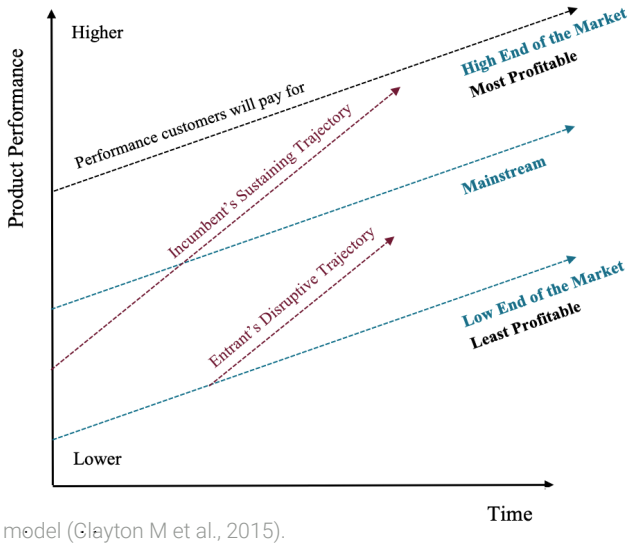

Figure 1 The disruptive innovation model (Clayton M et al., 2015).

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Table 1 Meanings of ankle-biters in different contexts (own representation).

Context	Meaning
Small	When we refer to ankle-biters as small, it refers to their size of business, but the value or volume of their business is hard to quantify.
Niche	The Cambridge dictionary defines the term as an opportunity for a business to provide a product or service that is not currently available which can be interpreted as bringing a unique and new product to market.
Newcomer	A player who has recently entered the market may be inferred here.
Flexible	According to the Cambridge Dictionary, it is something that can change according to the situation, which means that it isn't static.
Invader	Anyone who takes over properties that were previously occupied by others, meaning ankle-biters, are taking away market space and customers from already established companies.
Innovator	The Cambridge dictionary defines it as someone who introduces new ideas and changes

As defined in Partridge's dictionary (1984), the term describes pants styled after the pants worn by Hussars, the Hungarian light cavalry of the 15th century, which had the bottoms tucked inside the stockings to keep them from touching the stirrups. The attributes can also be associated with something that is pliable, flexible, or will take any shape. On the other hand, the term has also got a financial definition, which states, a „small-cap" company is one whose stock is issued with less than half a billion in capitalization. Or maybe it's less than one or even less than two billion (Farlex, 2004). In The Washington's Post (2018), Elon Musk's company SpaceX, while initially described as an ankle-biter, was later described as a serious competitor. According to this, we can conclude that the term is used to describe something that is annoying, but which cannot hurt because it is in its early stages and cannot harm anyone (Koren, 2018). Although the term hasn't been extensively used, it has been employed in a variety of contexts which will help us define it more comprehensively.

The topic of this research paper is part of the Marketing Science Institute's 2018-2020 research priorities. The report describes ankle-biters as ‚small, new entrants eating into firm's market share'. Troy (2018) identifies ankle-biters as small, niche brands contributing to the growth challenges of large consumer goods companies. Previously, Maney described ankle-biters as „large numbers of admirably aggressive and bumptious individuals and startups capable of bringing down established and previously invincible big incumbents frequently". Hiscock (2016) states that small, flexible players may seem like a nuisance to you. They want a piece of your customer base. In fact, they may not even register on your radar. However, this kind of shortsightedness will only increase the vulnerability.

From these descriptions, some characteristics of ankle-biters can be gleaned, such as the fact that they are small, niche, newcomers, flexible, and invading, cutting into the market share of old incumbents. In order to gain a clear understanding of the term ankle-biters, the authors examined each of these characteristics separately.

Therefore, ankle-biters can be defined as „newcomers who are nimble and flexible in their operations and capture the share of incumbents with innovation".

4 Classifying the ankle-biters

Ankle-biters can be categorized according to two criteria:

- Market Reach: Some ankle-biters target niche segments, while others focus on producing products for the mass market.
- The amount of total funding received: This criterion helps determine the size of a particular ankle-biter, or to put it differently, the extent to which the ankle-biter is functioning, and how much it is expected to grow over time.

Four quadrants of the matrix have been named sustainers, breakthrough players, experimenters, and explorers.

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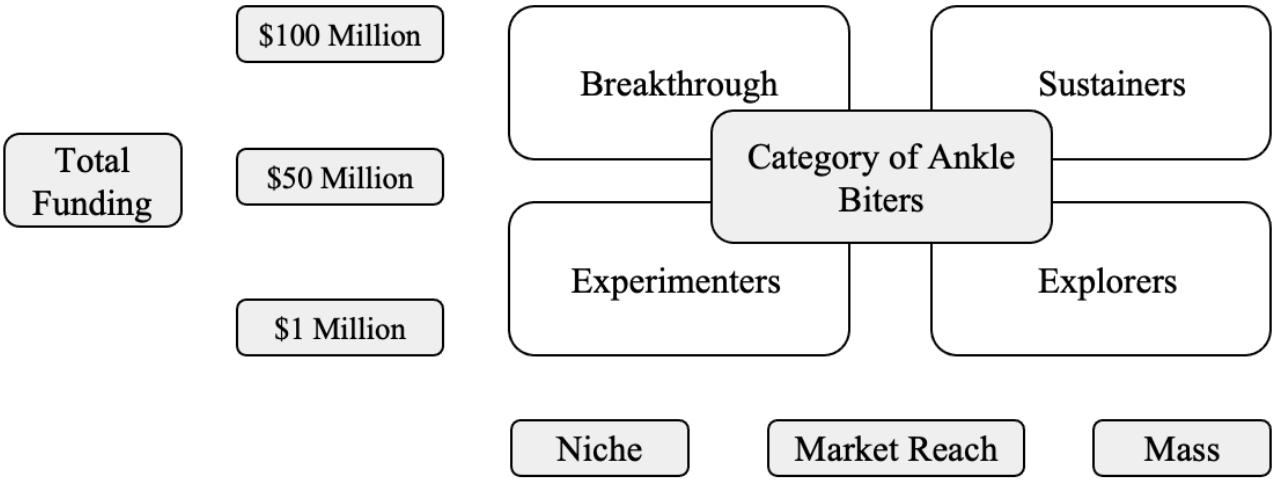

Figure 2 Classification of the ankle-biters (own representation).

5 Lifecycle stages of ankle-biters

Neil et al. (1983) discuss the stages of growth in small businesses. We will examine these stages and see how ankle-biters progress through their lifecycle.

There are five stages for the growth of ankle-biters:

1. In the Existence Stage, you will be in the process of finding customers, getting your products and services to market, and working to provide the cash to fulfill all of this phase's cash requirements. The owner manages everything here, and there is no formal planning or system. A company in the existence stage can be a newly started restaurant or retail store or a high-tech manufacturer that has not yet standardized production or quality.

2. As the business approaches its survival stage, it has customers and focuses on maintaining its revenue and expense relationships. The goal is to generate enough cash to reach break-even and remain in business.

3. At the success stage, owners must decide whether to exploit the company's successes and expand or maintain its stability and profitability so that other activities can be undertaken.

4. The take-off stage involves managing the rapid growth of a business and managing the financing of the growth. Here, the emphasis is on delegating responsibilities by the owner and managing cash flow for continuous growth, operational planning, and strategic planning.

5. The resource maturity stage involves managing a company that has grown and is bringing financial gains. It involves increasing the workforce, professionalizing the systems, and creating strategic plans without sacrificing the flexibility of the organization.

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6 Rise of the ankle-biters

Maney (2013) attributes the rise of ankle-biters to easy access to capital, technology that costs 1/1000 of what it did 15 years ago, and exchange-type platforms offering everything from Chinese manufacturing capacity to skilled engineering labor.

Businesses don't always succeed when they enter the market. First, the sense of ‚urgency' is a factor that contributes to their success. Most new businesses have limited resources and funding. If they can't reach the next milestone, whether it's becoming self-sustaining through sales or getting to the next stage with a venture capitalist, they're doomed. That level of urgency, that drive to move quickly, just doesn't exist inside most large organizations (Stacey et al., 2019).

Second, the decision-making process is decentralized, where decision-making is also delegated to lower levels. As a result, actions can be taken quickly and the results can be achieved quickly and with agility. Uber's General Manager Beth Huddleston stated that they were able to innovate rapidly because of the way they were organized. The decision-making was pushed down as far as possible, resulting in city teams setting prices, negotiating deals with sports teams, and doing all kinds of things that should be handled centrally in a much more mature organization. In that way, he thought, they could get from here to there. At lower levels, decision making can sometimes be a risky business due to lack of experience, or impromptu decisions (Stacey et al., 2019).

The third characteristic is the innovative mindset of small organizations. Innovation is usually left to the top management in large and established companies. Many leaders outright reject the idea of innovating something new out of fear of failure and loss of credibility, which is passed on to their employees as well. Most incumbents follow past successes as their current practices and use them as templates for the future. In this way, people within the same environment suffer from organizational gravity, which prevents them from thinking beyond a limit or stepping outside of their current approach to form a new approach. This is what separates a new entrant from the established players. They explore, take risks and innovate; they do not have any fixed practices (Devaiah and Narang, 2013).

7 Types of Disruptions

Disrupting the market space in several ways is what an ankle-biter does:

1. **Expand market reach:** This includes expanding market reach through digital marketplaces which can serve as bridges between fragmented buyers and sellers. Digital platforms have lower margins, making it difficult for brick and mortar incumbents to compete. While digital platforms provide customers with a large catalog of products without maintaining large inventories, incumbents seem to be losing out on this front as they spend many resources maintaining physical assets. Amazon, which has capitalized on the rapid growth of the internet and displaced many brick and mortar bookstores, is the biggest disruptor in this field.

2. **Converge products:** It involves merging products to create a product that provides more value to the customer. The most prominent example is the smartphone, which integrates everything from an alarm clock to GPS to a music player to a camera and more.

3. **Unbundle products and services:** It involves breaking down mass-market products into narrower, more specific products. In this way, producers can offer more competitive prices for their individual products. Craigslist, for instance, unbundled classifieds from newspapers by being a classified-specific platform, which provides consumers with access to more content.

4. **Turning products to product platforms:** It involves the development of a flexible product that can be further customized by third parties and sold to the final customer. The most well known example of this is the open-source Android OS, which challenged the then well established Symbian OS by allowing third parties to provide various product offerings.

5. **Shorten the value chain:** By eliminating certain stages of the value chain, new entrants aim to shorten the value chain and provide value to customers. In the healthcare sector, for instance, telemedicine is becoming increasingly accepted, which makes healthcare easier and more convenient for customers.

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6. **Unlock adjacent assets:** It includes utilizing the underutilized resources in the adjacent market to meet the demands of the existing market without having to own assets. Uber, for example, operates on this model.

7. **Distributed product development:** Under this model, many third parties participate in the product design and development so that higher value will be generated. This model allows innovation to emerge from multiple sources, for example, Wikipedia uses a similar model to allow third parties to publish data on the platform; similarly, Tripadvisor lets customers post reviews and opinions which disrupted the travel book and magazine market.

8. **Align price with use:** It replaces fixed pricing with usage-based pricing. Instead of having their own data processing units, which would cost around 1.5 million euros, customers can use the Amazon Web Services for almost half the price and can access their data whenever they want.

9. **Connect peers:** A distributed governance structure that enables market participants to interact directly with each other in a trusted environment increases the visibility of interaction data by replacing centralized authority and intermediaries. OpenBazaar, for example, is an open source P2P platform that lets you exchange goods using bitcoins.

8 Ankle-biters in Healthcare Industry

In today's era, traditional hospital-based healthcare is being replaced by home-based healthcare. The advent of robotics, deep learning, data analytics, genomics, and 3D tissue printing will lead to a more virtual, distributed health system. Health data digitization - known as Internet of Things in Healthcare - is growing rapidly across the globe and is being used in delivering healthcare services. IoT has grown exponentially in healthcare as a result of COVID-19. IoT in healthcare is impacted by several rapidly evolving technologies that are converging.

Listed below are some of the medical technology companies in India that are funded by venture capitalists and whose products are thriving in emerging markets, like India, as well as in developed markets, like the United States of America and Europe.

1. The Delhi-based start-up Invictus Oncology has created a drug that penetrates deep into tumors, shrinks them by cutting off their blood supply, and sits on them until they die. This technology was developed by the scientists in Harvard Medical School and further refined by the group of scientists in India.

2. A startup focused on stem cells, Stempeutics Research, is developing a point-of-care medical device for separating stem cells from humans in alliance with Vignani Technologies, a niche engineering services company. The device will be called Stempeuron. A stem cell machine extracts high-quality stem cells out of the tissue quickly, whereas current procedures involve bringing fat tissues to the lab and processing them for isolation of stem cells, which take time, are cumbersome and have a low viability rate.

3. The ‚OncoprintR' technology was developed by Mitra Biotech, a Bangalore-based biotechnology company, to help doctors differentiate with a great deal of accuracy between drugs that work on cancer patients and drugs that don't. Patients no longer have to undergo drug regimens that can lead to side-effects and complications. Mitra has made deals with a number of top hospitals in India and abroad to provide personalized treatment options.

4. Innovative Acer provides a healthcare data analysis platform that uses artificial intelligence. The platform is used in healthcare facilities to keep track of populations' health. The company has developed a cloud-based platform that collects, researches, and provides insight into patient health.

5. Fitness training is available at CureFit both in the gym and at home, under the umbrella of dance, yoga, and workouts. Food delivery services and an online mental wellness platform are available under the brand EatFit, which offers healthy meals, snacks and beverages.

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Table 2 Some startups in the Indian dairy industry (own representation).

Startup Name	Launch Year	Status	Acquired By
Milk Basket	2015	Active	Reliance
Doodhwala	2015	Closed in 2019	–
Daily Ninja	2015	Activea[3]	Big Basket
Supr Daily	2015	Active	Swiggy

6. HealthifyMe transforms a billion lives by promoting health and fitness! Healthy lifestyles are being created by this app, which changes how people stay fit, eat clean, and build healthy habits. Having over 20 million downloads, and a team of 800+ nutrition, fitness, and yoga coaches, HealthifyMe has made a major impact in South East Asia and is poised to expand globally. Artificial Intelligence, combined with Human Intelligence, produces a product that is changing lives. In addition to offering employee wellness solutions, HealthifyMe also offers B2B services to over 100 companies.

9 Are ankle-biters capable of attacking each other?

Ankle-biters are not only a threat to the existing businesses; they also pose a threat to their fellow ankle-biters. Our analysis will be based on the following startups in the Dairy Industry.

From the above table 2, we see that Milk Basket, Doodhwala, Daily Ninja, and Supr Daily launched their platforms in 2015. Out of the four startups mentioned, three business ventures have been acquired and are operating successfully: Milk Basket was acquired by Reliance Group (Baruah, 2021), Daily Ninja was acquired by Big Basket (The Economic Times, 2020), and Supr Daily was acquired by Swiggy (YourStory, 2021).

However, Doodhwala couldn't sustain its business despite disrupting the supply chain and market, reducing the value chain, and turning products into platforms. They failed for many reasons, such as operating on low margins, excessively using cashbacks and discounts, not being clear about their competitive advantage, and facing intense competition from giants. It wouldn't have been so hard for them to swim across the ocean if there had been only one reason for their failure. Doodhwala managed to eat the market share of other retailers selling milk for decades by initially entering the market as an ankle-biter.

However, other ankle-biters came up with an approach that included open innovation, market awareness, continuous competitor analysis, flexibility, and sustainability, plus an understanding of rapid changes in consumers' psychology.

10 Defensive strategies by incumbents against ankle-biters

Singh (2015) highlights that the health of an organization can be sustained over time, much like the health of humans. Organizational health is therefore a powerful lever in a dynamic business environment where dealing with change is an instinct linked to survival.

Startups, which used to be considered ankle-biters, are now not just competitors, but rapacious ones that operate in ways you're not allowed to, often at the edges of regulation. When did startups gain so much power? One of the main reasons is that they have more funding, more capital. Back then, startups were funded with five million dollars; they were ankle-biters. Technology-wise, they were probably a good acquisition, which is what they were hoping for as well. Their budget for research and development is much higher and they spend hundreds of billions of dollars on it (Steve, 2018).

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As a way to defend themselves from ankle-biters, incumbents need to come up with strong defensive moves:

1. **Investment in Startups:** Several incumbents have invested in the new entrants, such as Mahindra and Mahindra, which invested $2 million in a farm equipment rental startup, Gold Farm; and Bajaj Finance, which invested $35 million in mobile wallet maker Mobikwik. George Mitra, chief executive officer at Avendus Wealth Management, notes that business groups invest in start-ups to find out what the next big thing in space can be, as well as to be aware of the ground situation that can help them react accordingly. Investing in companies is primarily about finding out what are businesses that can either complement or disrupt existing ones to diversify the existing ones.

2. **Learn to Innovate:** The ankle-biters are driven by innovation. They look for transformative needs in the market, develop their products to meet those needs, and capture the customers of existing players. The entry of Patanjali in the Indian market as an ayurvedic brand completely disrupted the FMCG sector. In order to solve this problem, Hindustan Unilever Limited (HUL) revived their ayurvedic brand Lever Ayush, which has been successful and is second on the market after Patanjali.

3. **Instead of being first to market, always be first to scale:** While incumbents might lag behind in innovating, they can set the standard for large-scale productions. To capture the market space, large companies must rely on their existing infrastructure and abundance of resources to see what's disrupting the market and surge production more than startups.

In order to get a sense of how disruption is taking place in the real world, the authors will examine different industries and see how some of the new entrants are impacting the market.

11 Disruptions in Different Sectors

1. **Pharmaceutical Industry**

The pharmaceutical industry has seen a number of innovations despite the Covid-19 pandemic, long clinical trials, and years of research and development. State-owned companies perform better on innovation than privately owned companies when it comes to R&D investment. Though private-owned companies invest more in R&D, their innovation output is relatively slower as compared to government-supported firms that receive more government support (Xu, 2021).

The U.S. Food and Drug Administration granted Emergency Use Authorization (EUA) to Johnson & Johnson's single-dose Covid-19 vaccine candidate in 2021. Infected patients with Covid-19 have been treated with Gilead Sciences' broad-spectrum antiviral drug Remdesivir. Additionally, Sanofi, in collaboration with GlaxoSmithKline (GSK), is also developing a Covid-19 vaccine that includes the spike protein and adjuvants that belong to Sanofi and GSK. Moderna has been a pioneer in the development of mRNA-based medicines and is a leader in the field. The Pfizer-BioNTech pediatric Covid-19 was recommended by the US Center for Disease Control (CDC) for children 5-11 years old at the end of 2021 (Chattopadhyay, 2022).

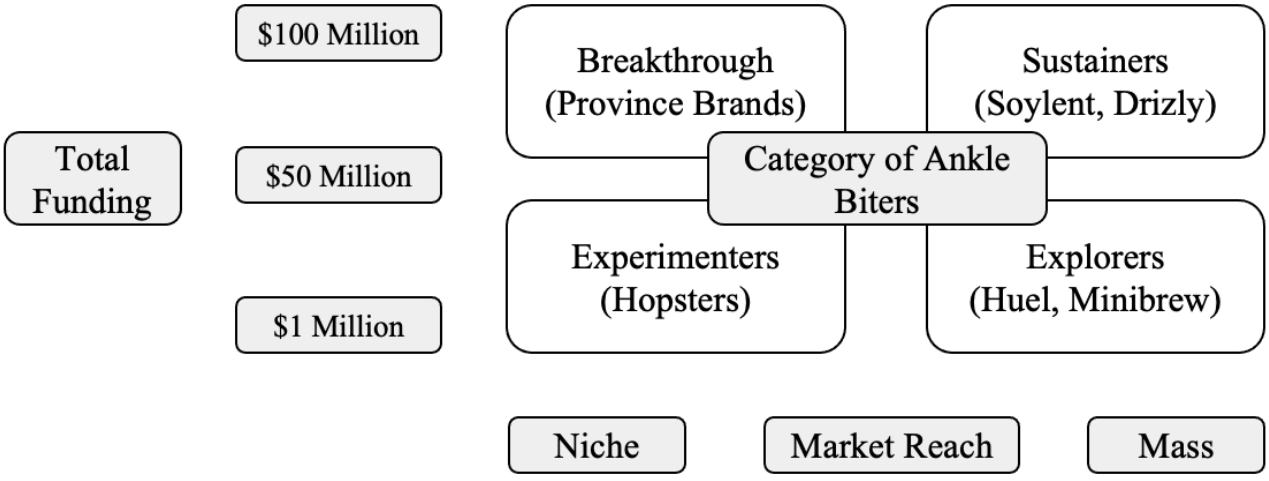

Figure 3 Classification of the examples of ankle-biters according to the matrix (own representation).

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The healthtech sector got a huge boost despite the Covid scare that hung over the industry. Health, wellness and healthcare analytics are among the top subsectors, but the most action this year was in online pharmacies. As a result of the pandemic, online pharmacies got a big boost which required respecting social distancing and other standards. During the tough times of Covid-19, they made access to medicines easier for the consumer. The surge in late-stage funding helped four startups become unicorns this year – Innovaccer, Pharmeasy, Curefit, and Pristyn Care (Jain, 2022).

2. Beauty and Personal Care Industry

The beauty industry has seen several innovations. It can relate to product development, inclusive beauty, evidence-based skin analysis, and incubations.

- **Product Development:** In 2018, Foreo, a Swedish brand that produces beauty devices, released an AI-enabled device, the Luna Fofo. The device monitors skin hydration levels by integrating machine learning and sensors and uses the data generated to customize customers' cleansing routines over time.
- **Inclusive Beauty:** The positioning of new brands like Hims, for example, involves catering to underserved and niche segments such as masculine beauty products. New brands like Hims are offering skincare, hair care, and supplement products for male wellness.
- **Evidence Based Skin Analysis:** Recently launched brands have used artificial intelligence to personalize skincare, such as Atolla, launched in August 2019. Atolla takes advantage of a multi-pronged tech approach to offer personalized serums. It uses AI, a monthly at-home skin test, and a mobile app to develop users' skin health profiles, which are updated based on results of the monthly test, inputs from users regarding season or lifestyle changes, and more.
- **Incubations:** Even incumbents have been innovating to keep up with the competition. Revlon's Flesh, L'Oreal's Seed Phytonutrients, and Unilever's Skinsei are examples of internally developed brands. The acquisition of Modiface by L'Oreal will be a major milestone for the industry, indicating that the future of beauty will be heavily tech-enabled. NYX, a brand owned by L'Oreal, launched a virtual beauty advisor platform last year for customers to test product samples.

3. Beer Industry

There has been a 0.3% decline in beer sales in the US in 2018 (according to Information Resources Inc.). This may be due to competition from competing products such as Hard Seltzer or an increase in consumer awareness of alcohol-free or lighter alcoholic drinks. To deal with these challenges, startups are disrupting the market with products such as cannabis-infused beverages, hangover cures, and wine subscription services.

Category Breakdown:

- **Alternative beers:** It includes non-traditional beers made by startups, such as Province Brand's non-alcoholic beer produced from marijuana, and JoyBrau's first non-alcoholic protein beer aimed at health conscious consumers.
- **At-home devices:** Startups such as PicoBrew and MiniBrew, for example, are making at-home brewing easier and more convenient with their home-brewing machines that make it possible for customers to brew small batches of beer.
- **Delivery Platforms:** Startups are also emerging for on-demand beer delivery services. For instance, Drizly, a US based startup, known as Amazon for Beer, allows customers to order beer from nearby retailers through a mobile app.
- **Experiences:** Some players have started offering their customers experiences as well as beers, such as Hopsters, which allows people to brew their own beer, and Ripples, which prints personalized messages on foamy drinks like beer.

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4. **Meatless Future**

With startups producing high-tech protein products, the meat market is undergoing disruption. Startups are not just competing with frozen meat, but are also creating alternatives. Soylent is a US-based startup that makes meat replacement products such as powders, drinks, edible bars, etc. Over $71 million has been raised from investors including Google Ventures, Andreessen Horowitz, and others. Another startup from the UK, Huel, provides meat replacement shakes, and has raised about $26 million from Highland Europe.

By providing meat replacement products, startups are on their way to chipping away at the market share of the traditional players in the meat industry like Tyson, National Beef, and others.

Startups are also producing plant-based burgers, which means they're increasing options for vegetarians and vegans, while using a meat-like taste to entice meat eaters to consume environmental-friendly protein. One of the most well-known startups in this area is Impossible Foods, which offers its meatless products to commercial markets and restaurants. The company has partnered with Burger King to produce the Burger King Impossible Whopper. (Mettler, 2020).

12 Conclusion and Implications for Business Strategy

As long as innovation exists in any industry, whether it's pharmaceutical, chemical, or health-tech, there will always be ankle-biters. It is likely that ankle-biters will persist and intensify in the years to come, and become a bigger problem in a competitive environment. Businesses need to accelerate innovation at an ever-increasing pace if they want to provide customers with the uniqueness and personalization they desire. The ability to deal with ankle-biters requires market awareness, open innovation, continuous competitor analysis, flexibility, and sustainability, plus a deep understanding of how consumers' psychology is changing rapidly. Among our most important recommendations for business professionals is that they should understand their current business model better, embrace the concept of ankle-biters, and ideally identify new and more flexible future business models.

In order to elaborate on more formal theoretical models, researchers should conduct further empirical studies exploring the definition of ankle-biters, its impact on other ankle-biters, traditional businesses, industries and enterprises. Here the researchers have tried to clarify what ankle-biters are and what strategies they use to become ankle-biters. A further intensive research study is needed to provide a better understanding of ankle-biters' formation, diffusion, and impact on organizations and ecosystems. In light of the fact that ankle-biters exist in every industry, including B2B, B2C and B2G, further research will contribute greatly to our understanding of 1. How new ankle-biters can disrupt markets and 2. What enterprises can do to remain competitive and flexible enough to avoid being eaten by ankle-biters.

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Disclosure statement

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Practitioner's Section

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Product footprint reporting for chemical companies

In the era of environmental sustainability, firms are put under pressure from the political and customers' sides to act, particularly those in high feedstock and energy consuming sectors, like the chemical industry. A trend towards greener products is inevitably reaching intermediate sectors, so that sustainability reporting at product level arises as a necessity. Profound product footprint calculation lays the foundation for the definition of dedicated reduction targets and the development of climate-neutral products. In this article, we outline and compare two product footprint reporting frameworks: GHG Protocol's Product Standard and the EU Commission's Product Environmental Footprint, with the goal to provide firms in the chemical industry with guidance and insights on which aspects are more relevant and critical.

1 Introduction

Nowadays, climate neutrality, circular economy, and green energy are common concepts to many. This is especially true in industrial sectors with relevant impact on the environment caused by, e.g., particularly high feedstock and energy consumption or emissions intensity. The chemical industry can surely be counted among these and actions are already being initiated to prepare for the upcoming changes that are indispensable to achieve environmental neutrality.

Rising awareness for sustainability is gaining influence in social, political, and economic spheres (Verband der Chemischen Industrie, 2021). Customers' increasing requests for sustainable products is only one example for this trend. Furthermore, the challenges of combating climate change, preserving natural resources and establishing a circular economy have been enshrined in international agreements such as the Paris Agreement and the European Green Deal. Within the latter, the European Commission published the „Chemicals Strategy towards a toxic-free environment" (in the following "Chemicals Strategy") in October 2020 which encourages, among others, a substantial revision and tightening of the REACH[1] and CLP[2] regulations to achieve European climate neutrality by 2050 and strengthen human health aspects based on sustainability assessments for chemical substances and products (European Commission, 2020). To meet these political targets, the chemical industry is dependent on the development of appropriate methods and metrics for the identification, definition, and quantification of sustainability key performance indicators (KPIs) especially at the product level. However, assessing a company's or product's environmental impact is only the first, fundamental step towards climate neutrality: companies should exploit this information to identify the main drivers and possibly act on it, reducing their impact in order to achieve international and company-set targets.

Several guidelines and standards, like the International Reference Life Cycle Data System (ILCD) Handbook and assorted ISO standards (e.g., ISO 14040, 14044, 14067), have

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[1] European Union's regulation on "Registration, Evaluation, Authorisation and Restriction of Chemicals" (EC No 1907/2006)

[2] European Union's regulation on "Classification, Labelling and Packaging" (EC No 1272/2008)

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been developed to enable a comprehensive assessment of sustainability key performance indicators. This article provides chemicals companies with some orientation on how to compute and report environmental footprints at product level by performing a theoretical comparison of two selected standards for product footprint accounting, Greenhouse Gas (GHG) Protocol's Product Standard and European Commission's Product Environmental Footprint (PEF).

In Section 2 we introduce the concept of life cycle assessment (LCA) and provide some basic facts about the origins of the two standards. In Section 3 each of these is outlined, GHG Protocol's Product Standard in Section 3.1 and the PEF in Section 3.2. In Section 3.3 we focus on the direct comparison of the two approaches and outline crucial aspects for chemicals companies.

Finally, we give an overview of the discussed topics and an outlook on what lies ahead for the chemical industry in the next years in Section 4.

2 Determining sustainability criteria

Since chemical products are typically intermediates that are further processed in numerous downstream industries, their sustainability is a fundamental ingredient for the overall sustainability achieved after subsequent processing. Famously, a shift towards renewable resources and energy as well as the development and use of recycling processes is imperative to meet the objectives of international goals like European climate neutrality in 2050. Necessary prerequisites are the development and establishment of innovative technologies, e.g., for the production of renewable energies and green hydrogen. Tracking of improvements is essential to achieve transparency towards the general public, investors, employees, customers and regulators. However, the initial assessment of a product footprint marks the central starting point for all further actions. To this end, LCA has been established as a common concept for the determination of product footprints.

Life cycle assessment

LCA allows to derive a product footprint, which provides a comprehensive overview of a product environmental profile and, furthermore, forms a solid basis for the identification of impact hotspots and reveals potential for sustainable product optimization. The International Organization of Standardization (ISO) describes the concept of LCA as follows: "LCA considers the entire life cycle of a product, from raw material extraction and acquisition, through energy and material production and manufacturing, to use and end of life treatment and final disposal. Through such a systematic overview and perspective, the shifting of a potential environmental burden between life cycle stages or individual processes can be identified and possibly avoided." (International Organization for Standardization, 2006, Section 4.1.2)

Following the ISO definition, an LCA should ideally comprise the whole life cycle of the observed entity, even beyond the mere area of control of the reporting firm. Negligence of any part of the life cycle would at the very least weaken the assessment, not revealing the whole picture of the entity's environmental impact. Nevertheless, an assessment on activities beyond the control of the reporting firm will inevitably require assumptions and estimates on the input quantities, weakening the quality of data and, hence, the assessment itself. Due to the manifold processing and usage profiles of chemicals products, this is particularly challenging for chemicals companies.

Various methods and guidelines have already been developed to provide orientation and standardization for accounting and reporting of environmental impacts. In the following, we take a closer look at two approaches for the assessment of product footprints and discuss some associated challenges for chemicals companies.

2.1 Two frameworks for sustainabilty assessment at product level

Both the GHG Protocol and the European Commission developed frameworks for sustainability assessment at product level. While the GHG Protocol is an already recognized international standard[3], the PEF is currently

[3] Due to the fact that many chemicals companies and virtually all large listed international companies refer to the Corporate Standard for calculation and disclosure of their corporate carbon footprint (CCF) (Umweltbundesamt, 2012).

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being further developed by the European Commission to be prospectively integrated into the European regulatory framework.

2.1.1 GHG Protocol – Product carbon footprint

The GHG Protocol is a global initiative coordinated by the World Resource Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) developing guidelines for the measurement, quantification, balancing, and reporting of greenhouse gas emissions at both product (referred to as "Product Standard") and company level (referred to as "Corporate Standard") in close cooperation with NGOs, industry associations and governments. Back in 2011, the GHG Protocol published its first guidance on carbon footprint accounting at product level (product carbon footprint, PCF).

2.1.2 European Commision – Product environmental footprint

In 2011, the European Commission started an initiative to develop a standardized approach for the determination of the environmental impact of products and services based, inter alia, on existing standards like ISO 14040 and ISO 14044. A similar initiative for the determination of the environmental impact of organizations, the Organisation Environmental Footprint (OEF), has also been conducted. However, an initial version of the PEF has been published in 2013, followed by a pilot phase to test its feasibility in practice and going over into the transitions phase.

3. Product footprint calculation for chemicals

Although Product Carbon Footprint (PCF) and Product Environmental Footprint (PEF) share many commonalities in their approach like the application of LCA, one major difference emerges from their overall scope. Whereas the PCF focusses on climate change solely, the PEF considers a much broader spectrum of environmental impacts. Keeping that in mind, we now take a closer look at some of the challenges arising when applying the two approaches to chemicals.

3.1 PCF assessment - The GHG Protocol´s product standard

A PCF records the total sum of greenhouse gas emissions generated by a selected product throughout its entire life cycle and consolidates the result into a single figure in CO_2 equivalent (CO_2e). In line with the resolutions of the Kyoto Protocol, the Product Standard requires to take at least the following six greenhouse gases into account: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Overall, PCF determination according to the Product Standard can be summarized into the following main steps:

1. Boundary setting and scope definition,
2. Compilation of an emissions inventory and data collection,
3. Calculation of inventory results and uncertainty assessment, and
4. Optimization and interpretation.

Overall, the GHG Protocol proposes nine distinct steps. As the intention of this article is a brief overview, some steps have been summarized, and those with minor relevance to our purpose have been omitted (e.g., assurance). Please refer to the original publication for the complete list of steps proposed by the GHG Protocol (2011).

3.1.1 Boundary setting and scope definition

First and foremost is the definition of business objectives and system boundaries to assess which activities shall be covered by the planned PCF assessment. This includes the definition of the product to be observed, the life cycle stages that are to be considered, and production sites relevant for the manufacturing of the selected product. Moreover, the overall objectives of the assessment should be sensibly selected depending on the target audience (internal vs. external).

The GHG Protocol framework distinguishes between three scopes of emissions which are in general applicable for both study types, the corporate carbon footprint (CCF) and PCF quantification (cf. Figure 1). For further details on the scope definitions please refer to the guideline of the GHG Protocol (2004, p. 25).

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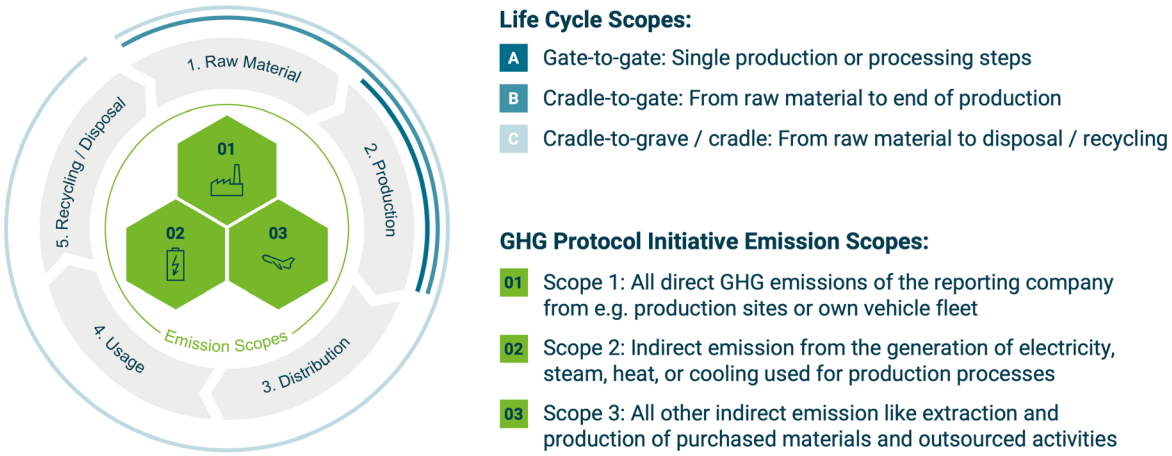

Figure 1 Life Cycle and Emission Scopes are two basic dimensions for boundary setting in carbon footprint studies. While the life cycle scopes define which of the five life cycle stages are considered, the emissions scopes provide information on the level of directness of emissions considered in the calculation. (own representation)

In principle, the Product Standard states that all life cycle stages from cradle to grave shall be analysed in a PCF study (cf. Figure 1). Because of usually diverse areas of application of chemical products, it is almost impossible to carry out a well-founded assessment of all life cycle phases beyond the control of the reporting firm. Too many generic assumptions about further processing, use, lifetime, and disposal may lead to a rough approximation resulting in an impairment of the PCF validity. Therefore, manufacturers of intermediate products can reasonably pursue the cradle-to-gate approach narrowing down the observed life cycle phases to the production of raw materials and manufacturing of the intermediate product until the reporting company's exit gate (cf. Figure 1). However, an assessment of the gate-to-grave part can still be made on a qualitative level, as proposed by the European Commission (2013, p. 44).

Another mandatory step is the definition of a unit of analysis which shall reflect a meaningful unit of the product of interest. For final products it shall be given as a functional unit allowing a measurement of the function of a product and thus, facilitating the comparison of the impact of different products at a functional level. An example for functional unit is the amount of PET granulate that is needed to produce a water bottle for transportation of 1 L of water.

Since chemical products usually end up in numerous applications, the specification of a functional unit is hardly possible or even meaningful. The Product Standard states that the specification of a simple unit of analysis, e.g., in kg of product, suffices in this case.

3.1.2 Emissions inventory and data collection

Once system boundaries and unit of analysis are defined, the compilation of an emissions inventory is performed. A process flow chart shall be used to identify relevant inventory items within the system boundaries, reaching from processes and activities over consumables and raw materials to waste. The comprehensiveness of the emissions inventory is a critical factor for the overall quality of the PCF and forms the basis for subsequent data collection.

Three types of data serve as input for the PCF calculation:

- Direct emission data: emissions directly released during a process or activity which can be determined e.g., by direct measurement or stoichiometry of the underlying chemical reaction;
- Activity data: particular amounts and units describing each activity causing emissions, emerging either from financial data (e.g., the amount of electricity purchased for the production process in EUR) or process data (e.g., the amount of electricity consumed by production process in kWh);

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- Emission factors: factors applied for the conversion of activity data into CO_2e.

The preferred way to obtain direct emissions and activity data is through collection from specific processes in the studied product life cycle, the so-called primary data. In case of insufficient infrastructure for the measurement or collection of primary data, generic industry-specific values may be used, the so-called secondary data.

Regardless of whether primary or secondary data are used, the assessment of data quality in terms of technological, geographical, and temporal representativeness, as well as completeness and reliability, is always obligatory. The availability of high-quality data sets for activity data and emission factors remains a central challenge to achieve a high-quality PCF.

Ultimately, the acquisition of emission and activity data based on the company's individual production processes forms the most solid, tangible, and accurate foundation for PCF determination.

3.1.3 PCF calculation

The PCF calculation shall reflect a product's impact on climate change over a time span of 100 years. Thus, the application of the most recent 100-year global warming potential (GWP) factors from the Intergovernmental Panel on Climate Change (IPCC) is mandatory. Emitted greenhouse gases for each activity are captured in emission factors. Finally, all activity data are multiplied by their respective emission factors and GWP factors and summed up to create the PCF.

However, multifunctional and highly interconnected chemicals production processes cause a high degree of complexity within the calculation step. For example, the energy used in a process must be distributed among the main and all co-products manufactured and further processes.

The most obvious distribution approach is direct allocation, i.e., the breakdown of emissions to different products through a certain metric based on, e.g., relations of their physical properties or economic values. However, the Product Standard states that allocation should be avoided wherever possible and proposes three different methods for doing so (GHG Protocol, 2011, p. 60 - 77):

1. Process subdivision: Break down the multifunctional process into distinct sub-processes that do not rely on allocation anymore (cf. Figure 2).
2. Redefining the unit of analysis or functional unit: Circumvent allocation by inclusion of the co-product or its function into the assessment, respectively.
3. System expansion: Directly determine the co-product emission share if a comparable process for the exclusive production of the co-product is known.

Allocation avoidance methodologies are often insufficient for obtaining robust and reliable PCF results and thus, allocation is indispensable for PCF studies of many chemical products. In this case, the underlying physical relationship of product and co-product should be used in the first instance to allocate the shares of emissions to the outputs of the multifunctional process.

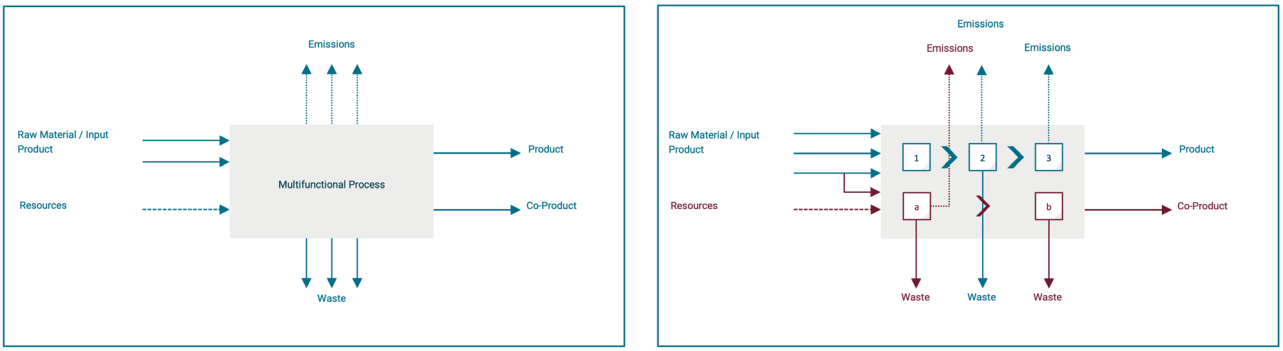

Figure 2 The multifunctional process and its solution by subdivision modified from European Commission (2010, p. 73 & 76). Whenever possible a subdivision into several monofunctional processes shall be performed.

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In case the physical relationship of the product and co-product cannot be established or is not known[4], economic allocation may be applied if the market values of the product and co-products reflect the respective emission shares at the point where they leave their common process. Additionally, the market values of the co-products shall not be significantly influenced by brand effects or other factors that cause a distortion of the emission shares.

The Product Standard also allows for the use of further relationships between process outputs, provided they reflect an adequate allocation of emission shares regarding their impact on climate change. This proposed application of allocation is also consistent with the requirements of ISO 14044 (International Organisation for Standardization, 2006). Moreover, in case it is not obvious that one allocation procedure is more suitable than another, at least two different allocation approaches shall be applied and compared to allow for a justified and sound identification of the most appropriate one.

Methods used for allocation (for avoidance thereof) shall be anyhow disclosed and consistent within one PCF study or between similar products and furthermore thoroughly described and justified.

3.1.4 Interpretation of results and setting of reduction targets

The interpretation of PCF results aims to identify impact hotspots, enabling the derivation of optimization potential and emission reduction targets. Reporting guidelines further ensure extensive documentation for disclosure of the PCF results to provide transparency and traceability for stakeholders and customers. For more details on interpretation and optimization, please refer to GHG Protocol (2011).

3.1.5 Limitations of the product standard

The Product Standard provides a rather broad framework for the definition of system boundaries and scoping recommendations. For example, regarding definition of the unit of analysis or the respective functional unit. Usage of specific product rules[5] and sector guidelines is encouraged if available, reviewed by a reliable stakeholder group and not contradictory with the requirements of the Product Standard. As the application of product rules is not mandatory, PCF results are not necessarily comparable between companies, even if the considered product, the observed life cycle stages, and the underlying manufacturing processes as well as planned use and disposal are equal.

Developing product (group) specific criteria and assessment rules is one of the overarching aims of the European Commission's PEF approach at which we now take a closer look.

3.2 PEF assessment – Holistic product environmental profile

The PEF approach aims to provide a standard in line with the already developed ones and, moreover, increase clarity, transparency, and traceability of product environmental impacts. Consumers will benefit directly from increased comparability and transparency, while a standardized approach can possibly reduce the evaluation and disclosure burden for companies.

Since the PEF is a multi-step approach following similar main steps as the Product Standard, the following paragraphs will only highlight significant differences between the two frameworks. A significant difference to the PCF is the development of so called "Product Environmental Footprint Category Rules" (PEFCRs) that provide additional guidance on PEF calculation steps for specific product categories. Details on PEFCRs are given at the very end of Section 3.2.

3.2.1 Boundary settings and scope definition

The overall scope of the PEF far exceeds that of the PCF. In addition to climate change, 13 further impact categories are measured and evaluated within a PEF study. Those categories include, e.g., ozone depletion and ecotoxicity for aquatic fresh water as well as ionizing radiation, acidification, and different types of resource depletion. Specific impact category indicators (e.g., CO_2e for climate change or human exposure efficiency related to U-235 for ionizing radiation)

[4] For example, for multiple co-products that do not have one common, appropriate physical allocation factor regarding the unit of analysis.
[5] E.g., application of product category rules as they are defined by ISO 14025:2006 according to GHG Protocol (2011, p. 24-25).

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and individual impact assessment methods are assigned to each impact category, leading to a more restrictive methodological framework compared to the GHG Protocol's Product Standard.

Although a PEF aims for a holistic environmental assessment, the methodology also allows for application of combined approaches where only the cradle-to-gate part of the life cycle is analyzed quantitatively. This is especially relevant for the chemical industry as a producer of intermediate products.

In contrast to the Product Standard, the PEF Guide always requires the definition of a unit of analysis which "qualitatively and quantitatively describes the function(s) and duration of the product" (European Commission, 2013). Moreover, the definition should include the function or service provided, its extent, the expected level of quality, the lifetime of the product and its category.

Since a product category determines the population of comparable products, its definition significantly influences the PEF's applicability. The definition of a product category should be restrictive enough for a meaningful product comparison while ensuring that the number of products is not too limited to guarantee a sufficient foundation for comparability within one category. To achieve this, the application of Classification of Products by Activity (CPA) codes (European Statistical Office, 2008) or the usage of a consumer-centric approach is recommended. The typically multifunctional range of applications for chemical products makes assignment to a single consumer centric product category nearly impossible, though.

3.2.2 Data collection and data quality

The usage of a process diagram is recommended for data collection to display all processes and activities within the defined system boundaries in a systematic and comprehensive way (cf. Figure 3). This facilitates the compilation of the mandatory inventory and a structured data acquisition in PEF studies.

In line with the Product Standard, collection of primary data is preferred in PEF assessments and particularly relevant if results shall be used for B2B or B2C communication.
The PEF's overarching requirements on data quality in terms of technological, geographical, and temporal representativeness, as well as completeness and reliability are also congruent to the Product Standard.

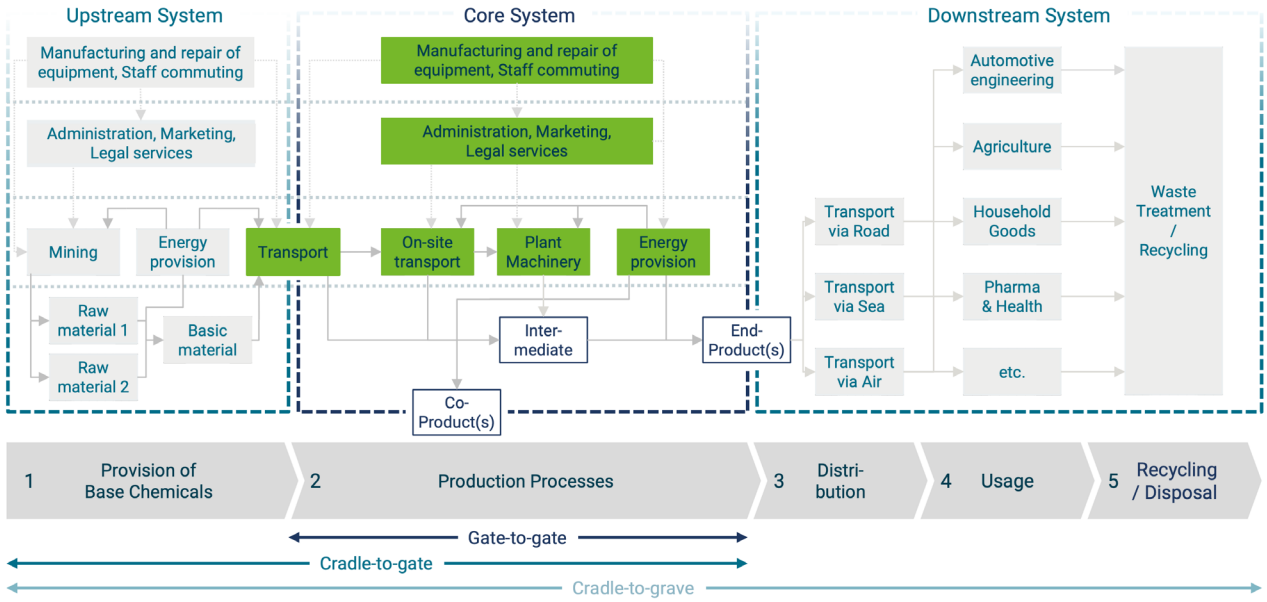

Figure 3 Schematic representation of a process diagram for the compilation and description of all processes laying within the defined system boundaries (e.g., within selected life cycle stages). To this end, a process map must cover all relevant activities not only under the control of the reporting firm itself (core system) but also processes and activities of the corresponding upstream and downstream systems, if applicable. (own representation)

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3.2.3 Impact assessment

To ensure comparability of PEF results, a dedicated assignment of impact assessment methods to each of the 14 impact categories is prescribed. For the impact category climate change, the baseline IPCC method shall be applied. This method reflects a 100-year horizon and is thus, consistent with the PCF methodology described in Section 3.1.

During the so called "classification", all inventory items must be assigned to their respective impact categories. Afterwards, the characterization of impact categories is performed through multiplication of inventory data with their corresponding characterization factors (e.g., emission factors in case of climate change). Classification and characterization inherit the challenge of modelling multifunctional processes as described in Section 3.1.3. In the PEF, allocation shall be preferably circumvented by subdivision or system expansion. If unavoidable, physical relations should be chosen over economic relations. In further congruence with the PCF framework and ISO 14040 / 14044, consistency, disclosure, and justification of applied allocation methods is always mandatory.

3.2.4 Interpretation of PEF results and disclosure

Once the impact assessment has been completed, the most relevant impact categories shall be identified. To this purpose normalization and weighting may be performed, although neither is mandatory in the PEF. The approach of normalising and weighting the impact categories according to PEF displays a specific extension of the recommendations of ISO 14040 and ISO 14044. In addition, normalization is classified as recommended and weighting as optional (European Commission, 2013, p. 2).

First, all impact assessment results are normalized by a reference value corresponding to reference entity and year. Such a reference value could be, e.g., the respective impact value of each impact category for Europe (observed entity) in 2021 (reference year). To this end, the reference value displays a fixed point of reference towards which the impact categories of the product of interest are normalized. Afterwards, the normalized impact categories are weighted by application of weighting factors "which reflect the perceived relative importance of the environmental footprint impact categories considered" (European Commission, 2013, p. 49). A precise guideline on the determination of such weights is not given in the PEF and shall generally be provided within specific product category rules.
Second, weighting of impact assessment results has the purpose of making them comparable given their relative importance. Weighting could be also used for aggregation of results across impact categories to obtain an aggregated figure. This reflects, though, a subjective perception on the relative importance of each category and is rather informative in the context of company internal reporting.

Careful selection and determination of the reference values for normalization is a critical point as the relative relation of impact categories can lead to a distortion of their relevance.

3.2.5 Category rules for comparative assertions

Product environmental footprint category rules (PEFCRs) serve as supplements to the PEF guide and aim to contribute to a high degree of comparability between studies belonging to the same category. Complementary instructions reach from the dedicated specification of system boundaries and relevant life cycle stages over the definition of the unit of analysis to the disclosure of product-category-specific necessary assumptions and limitations of PEF studies.

In 2019, the European Commission's Joint research Center (JRC) published the "Suggestions for updating the Product Environmental Footprint (PEF) method" and proposed the introduction of a representative product (RP) for each product category. However, a comprehensive and useful definition of such a RP that shall display an average case for the environmental impact of a product category based on all products in this category sold in the EU while reflecting the current technological potential is demanding (European Commission, 2019). The wide range of applications for chemical products makes it very challenging to identify suitable RPs. Overall, the definition of an appropriate RP is an iterative process incorporating RP definition, the conduction of a PEF-RP study and the according analysis and refinement of the RPs definition.

Based on PEF-RP study results, each PEFCR comes with a list of mandatory company-specific data and / or a list of secondary data that may be used in case no primary data or data of insufficient quality are available. This facilitates

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and reduces the data collection burden for reporting companies while ensuring higher comparability between PEF studies. Moreover, dedicated guidelines for handling multifunctionality minimize further methodological differences between PEF studies within the same category. PEFCRs also provide factors for the two optional steps normalization and weighting. After their application, impact categories may be ranked from largest to smallest. The (at least three) top positions contributing to at least 80% of the total product environmental impact are the relevant impact categories according to the PEFRC guide. Whereby the total environmental impact displays the sum of the environmental impacts from all categories observed. Moreover, the most relevant life cycle stages, processes, and elementary flows[6] shall be identified in a similar way (Umweltbundesamt, 2018, p. 50).

To compensate for the possible distortion of relevance of impact categories, PEFCRs provide a balanced set of normalization and weighting factors. Nevertheless, a report from the Umweltbundesamt states that the normalization and weighting factors used in the pilot phase need to be revised to yield a more realistic representation and, moreover, claims that a threshold of 90% would be more appropriate (Umweltbundesamt, 2018, p. 89).

Overall, the interpretation of the PEF results should highlight environmental profile hotspots allowing for identification of possible optimization, reduction, and compensation potential. The PEF guide and PEFCRs also provide detailed instructions for the documentation and reporting of PEF results to the public to ensure comparability between disclosed assessments.

So far, only a limited number of economic sectors and product categories have been covered by the PEF framework. In particular, the call for new members in the current transition phase also refers to the sectors of „Materials and intermediate products" as well as "Chemistry-based final products". Hence, the definition of chemicals-specific product categories, the determination of respective RPs and the development of PEFCRs still remains open (European Commission, 2018).

3.3 PCF or PEF?

Based on the discussed aspects in Sections 3.1 and 3.2, Table 1 provides an overview of selected requirements and key attributes of the two approaches. Please refer to the individual standards of the European Commissions (2013) and the GHG Protocol (2011) for details on topics not covered in this article like, e.g., review, assurance, or reporting.

Although the overview of the two frameworks yields no apparent dominance of one over the other, at a more attentive look differences appear.

The GHG Protocol framework displays an internationally valid and recognized market standard. For carbon footprints, the Product Standard may be preferred especially because of its conformity with the broadly applied Corporate Standard. However, if a broader assessment of the environmental impact is planned, the Product Standard will not cover impact categories other than climate change. Additionally, comparative assertions cannot be made if merely the Product Standard is followed. Here, references to appropriate product rules would be necessary.

For companies in the EU, the PEF will more likely resemble potential future regulatory requirements, should reporting become mandatory. Moreover, the PEF offers guidance on a broader reporting framework incorporating further impact categories. For carbon footprints, the PCF and PEF frameworks are mostly consistent, with a slightly higher flexibility for the first (as already described in Section 3.2). Nevertheless, the PEF will prospectively offer the possibility to be easily adapted for orientation on the soon to be published PEFCRs, hence allowing to also make comparisons with further products in the same category.

Moreover, regarding reliability and trustworthiness, the reporting and disclosure of such environmental footprints shall be based on profound assurance or even certification processes. To this end, the PEFCRs intend to derive uniform audit processes allowing for high comparability of PEFs in the future while the PCF already provides guidance for the development of a more individualized assurance process in

[6] An elementary flow refers to material or energy entering or leaving the studied system that naturally occurs in the environment and has not been processed or produced by human activities (International Organization for Standardization, 2006, Section 3.12).

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Chapter 12 "Assurance" and 13 "Reporting" of the original publication of the GHG Protocol (2011).

Hence, an answer to the question cannot be given a priori and the decision should be made depending on the strategic plan of the company and its targets.

Table 1 Summary and comparison of the essential aspects of PCF and PEF methodologies, based on the comparison of key requirements of the two methods in the PEF guide (European Commission, 2013, pp. 92).

Topic	GHG Protocol´s PCF	European Commission´s PEF[7]
Target Audience	B2B and B2C	
Validity range and maturity of the approach	■ Recognized, widely applied international market standard	■ European assessment approach currently under development (transition phase ongoing)
Overarching objectives	■ Identification of emission hotspots and reduction targets ■ Transparency towards stakeholders and public ■ In-house and external applications	■ Assessment of comprehensive and comparable environmental profiles ■ In-house and external applications
Impact categories & assessment methods	■ Assessment of one single impact category: climate change (incl. land use change) ■ Application of latest IPCC GWPs for 100-year horizon for all GHGs in the Kyoto Protocol	■ Assessment of 14 predefined impact categories ■ Specified assignment of Life Cycle Impact Assessment (LCIA) methods to single impact categories
Boundary setting & scoping decisions	■ Preference of Cradle-to-Grave approach ■ Cradle-to-Gate accepted for intermediate products with unpredictable use profiles	■ Cradle-to-Grave as default approach ■ Acceptance of Cradle-to-Gate at least in combination with a qualitative Gate-to-Grave assessment
Data quality criteria	■ Technological, temporal, and geographical representativeness ■ Completeness ■ Reliability	■ Technological, temporal, and geographical representativeness ■ Completeness ■ Parameter uncertainty ■ Methodological appropriateness and consistency ■ For processes accounting for at least 70% of contributions to each impact category, at least "good quality" level for both specific and generic data

[7] Please note that all listed aspects refer to conduction of a basic PEF solely. Further specifications provided by PEFCRs are not included, unless mentioned explicitly.

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Topic	GHG Protocol´s PCF	European Commission´s PEF[7]
Data collection	■ Preference of collection and usage of primary data, in particular for processes under the control of the reporting company ■ Acceptance of usage of secondary data like industry averages accepted in case of missing or inappropriate primary data (quality)	■ Preference of primary data (PEFCRs explicitly specify processes for which collection and usage of primary data is mandatory), especially for processes under the control of the reporting company ■ Allowance for usage of generic data for processes not under the control of the reporting entity in case of higher appropriateness or representativeness of secondary data (e.g., primary data is missing) ■ Need for compliance of data sources for generic data with the requirements of PEF and PEFCRs with ELCD and ILCD as preferred sources
Multifunctionality & allocation	1. Avoiding allocation by subdivision, redefining the unit of analysis or system expansion 2. Allocation based on the underlying physical relationship 3. Allocation based on the underlying economic relationship or further criteria	1. Avoiding allocation by subdivision or system expansion 2. Allocation based on a relevant underlying physical relationship 3. Allocation based on other criteria
Interpretation of results	■ Identification of GHG emission hotspots ■ Uncertainty assessment (at least qualitative uncertainty of significant processes) ■ Setting reduction targets ■ Comparison and tracking of inventory changes over time	Mandatory: ■ assessment of the robustness of the PEF model ■ identification of hotspots ■ estimation of uncertainty ■ conclusions, limitations and recommendations Optional: ■ completeness check ■ sensitivity check ■ consistency check

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4 Conclusion

Reporting the environmental impact of chemical products can be challenging but is becoming almost unavoidable due to the growing pressure from the client and regulatory sides at both the local and global level. To this end, chemicals companies can refer to already available standards, two of which are outlined in this paper. Guidance on how to proceed and even target comparable assessments, for example with the goal of upselling environmentally advantageous products, is provided by the two frameworks discussed. Particular challenges arising for chemicals companies during implementation of the two frameworks as well as possible actions for handling thereof can be found at the end of this section (cf. Table 2).

Achieving readiness at an early stage could be advantageous for firms, allowing them to meet clients' expectations and enhancing competitiveness. Setting up a data platform for the attribution of sustainability KPIs at an early stage moreover offers further possibilities for optimization based on the impact analysis of single products or product portfolios, incentive schemes for management, transparent tracking of decarbonization paths and more. In any case, calculation of a product footprint should only be regarded as a first step to measure the status quo and set as well as track emission reduction targets.

Activities for emissions reduction in the climate change impact category are, inter alia, highly dependent on the provision of renewable energy and electrification, especially since reduction of total energy consumption is only a limited option for chemicals companies. Pilot plants for e-crackers and green ammonia production are only two examples for advancements that have already been initiated to substantially decrease the greenhouse gas emissions of chemicals. Long innovation and investment cycles for highly specific plants also contribute to the fact that setting and achieving reduction targets, especially in consideration of the time frame for the European Green Deal and the Chemicals Strategy, remain no easy tasks for the chemical industry.

Even with a fully functioning and comprehensive framework for reporting of sustainability KPIs, the task of achieving a greener chemistry remains a long way off. Innovation and optimization with respect to new criteria is also necessary to keep up with the ambitious targets set by the international strategic trends.

Hence, in the next decades the chemical industry will face many difficult challenges and at the same time probably also foster innovation of processes, corporate culture, and mindset. The establishment of profound and reliable standard procedures for the quantification of chemicals' product environmental footprints will most probably be an essential building block for the transformation that lies ahead.

Table 2 Summary of the most challenging aspects in implementing the two approaches for chemicals companies and suggestions for handling thereof. Also, we give an indication whether the PCF or PEF framework supports the proposed solution approach by the "x" in the last two columns.

Topic	Challenge for chemicals companies	Possible approach for handling of challenge	PCF	PEF
Boundary setting, especially life cycle scoping	■ Manifold actions in life cycle stages outside the system boundaries of chemicals companies, causing challenge in investigation of life cycle stages behind the reporting company's outbound gate (cf. Figure 1)	■ Application of the cradle-to-gate approach for intermediate products ■ However, meaningfulness of qualitative assessment of the remaining gate-to-grave part, if applicable	X	X

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Topic	Challenge for chemical companies	Possible approach for handling of challenges	PCF	PEF
Definition of unit of analysis / functional unit	■ Challenge for definition of a meaningful functional unit due to manifold application areas of chemical products	■ Usually, definition and usage of a simple "unit of analysis" for intermediate products of complex value chains, e.g., 1 kg of chemical product	X	
Solving multi-functionality	■ Often unfeasibility of avoiding allocation due to the nature of highly integrated and nested multifunctional chemicals production landscapes	■ Thorough assessment of at least two different allocation approaches for determination of the most suitable one ■ If applicable, usage of common allocation rules, either based on existing product category rules (PCR) or published methods, e.g., BASF methodology (BASF, 2021)	X	X
Data availability and quality	■ Typically, low availability of activity data from production plants, especially regarding necessary granularity ■ Often limited availability and poor quality of impact factors from secondary sources	Multi-step procedure for data gathering[8] 1. collection, search, and usage of primary data, e.g., from own production plants and suppliers 2. usage of secondary data from external sources like, e.g., life cycle inventory databases 3. data proxies or expert judgements 4. acceptance and disclosure of data gaps	X	
Interpretation	■ Typically, insufficient comparability between product footprints from different companies due to relatively broad methodological frameworks and assessment rules	■ Application of common rules for specific products (e.g., PCRs), wherever possible ■ Prospectively, application of PEFCRs allowing for higher comparability of PEF studies from different companies ■ Disclosure of applied methodology and potential shortfalls, e.g., regarding allocation procedures or data gaps		X

[8] Overall, comparably high data availability for the climate change impact category and thus, better prerequisites for solving this challenge through steps 01 – 03 within a PCF study.

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5 List of abbreviations

Abbreviation	Description
B2B	Business-to-business
B2C	Business-to-consumer
CCF	Corporate Carbon Footprint
CLP	Classification, Labelling and Packaging
CO_2e	CO_2 equivalent
CPA	Classification of Products by Activity
GHG	Greenhouse gas
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization of Standardization
KPIs	Key Performance Indicators
LCA	Life Cycle Assessment
PCF	Product Carbon Footprint
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PFCs	Perfluorocarbons
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RP	Representative Product
UBA	Umweltbundesamt (German Environment Agency)
VCI	Verband der Chemischen Industrie
WBCSD	World Business Council for Sustainable Development
WRI	World Resource Institute

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Commentary

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After COVID, What's Next for Pharma Supply Chains?

If the world's dependence on pharmaceutical technology wasn't already obvious, COVID-19 brought a dramatic reminder as companies like Moderna, Pfizer, BioNTech, and Johnson & Johnson delivered needed vaccines. Now, pharma executives are seeing the success tempered by reality as significant new risks challenge the global supply chain and the industry.

While recent, pandemic-induced disruptions have focused attention on global supply chain vulnerabilities for pharmaceuticals and other industries, the challenges facing pharmaceutical companies are broader and deeper than these. The reason is a convergence of complications, including substantial environment, sustainability and governance (ESG) issues and a rising wave of government scrutiny, that are landing squarely on the sector's supply chain vulnerabilities.

The impact is real and already visible. COVID-19-related breakdowns have affected pharmaceutical companies, with manufacturing interruptions that have caused suspension of clinical drug trials in some cases and even delayed introductions of new key drugs. Key concerns are blocked supplies of needed medicines, and, as a second order, foregone revenue.

These kinds of pressures have refocused attention on potential vulnerabilities in healthcare's global supply chains and with it a kind of economic nationalism that is pushing manufacturers to bring their far-flung factories, processes, and jobs back onshore, or establish a presence in certain markets.

The impact becomes even more profound when set against climate and sustainability concerns that are putting real pressure on pharmaceuticals and biotechs to decarbonize their supply chains.

To safeguard their achievements and remain competitive, pharmaceutical and biotech organizations must protect the ongoing viability of product supply networks against the growing risks by increasing resiliency and reducing their carbon footprints.

Have pharmaceuticals overcommitted to a global model?

Pushed by costs, talent shortages, and the growing availability of overseas contract manufacturing organizations (CMOs), companies in recent years have embraced biopharma supply chains that rely on suppliers in all parts of the world. The resulting network is a highly interconnected global supply chain, with significant dependency on certain countries—not only China, but Eastern Europe, and others—now established for active pharmaceutical ingredients (APIs), while Europe has become the major exporter of finished products (Figure 1).

The complexity of this growing network brings management challenges: international trade issues, increasing margin and cost pressures, demand uncertainty, high volatility, and increasingly complex technologies to manage, all in a highly regulated environment.

What were seen as savvy outsourcing moves that increased sourcing flexibility and lowered costs are now cause for concern as companies are witnessing the greater risks of extreme globalization. This naturally differs from company to company. Generics players, for example, typically have more exposure to lower-cost country sourcing and production than innovative pharma companies.

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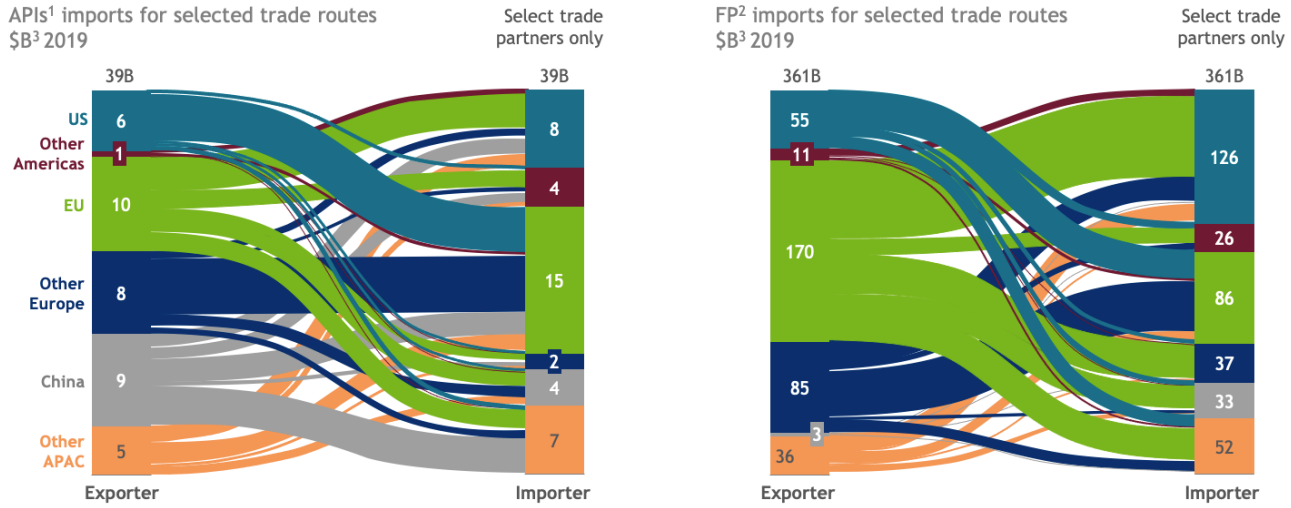

Figure 1 Highly globalized biopharma supply chains rely heavily on internatiobal trade (IHS Markit; Global Trade Atlas; BCG analysis).

A pre-pandemic movement in the United States and Europe to encourage companies to shift supply chains back onshore has become stronger in recent months from governments that see increased urgency to secure supplies of essential medicines and reduce dependence on China. The result is increasing protectionist sentiments and growing pressure to localize supply chain footprints.

While specific legislation and regulations are evolving with the changing environment, the primary concern for pharmaceutical and biotech companies today is governments that are imposing or considering various carrot-and-stick policies that apply indirect pressure, such as procurement bans, trade restrictions, and access incentives.

In the US, the Biden Administration and lawmakers are developing policies to strengthen domestic manufacturing in several critical industries. In 2021, Biden signed an executive order to review supply chains to reduce foreign dependence on key technologies, including pharmaceuticals (Tankersley and Swanson, 2021).

Likewise, EU leaders have expressed similar concern in the wake of the pandemic and subsequent supply chain disruption. "The crisis has shown that we must continue to produce in our country and on our continent", French President Emmanuel Macron said in June 2020, announcing measures aimed at relocating pharmaceutical factories to France (Teller Report, 2020).

Increasing focus on supply chain sustainability

In the wake of the pandemic, the climate discussion that has been brewing for a decade or so is taking on sudden urgency, with increasing stakeholder pressure on companies to take action on supply chain decarbonization.

Although pharmaceuticals are not commonly grouped, in the public's perception, among heavy-polluting smokestack industries, environmental watchdogs are calling them out, like other chemicals companies, as a significant contributor to global carbon emissions. A study by Belkhir and Elmeligi (2019) published in the Journal of Cleaner Production found that the pharmaceutical industry's carbon emission intensity is 55% higher than the automotive industry's. The key point is the increased attention to the pharmaceutical industry's carbon footprint. Companies' emission levels range widely, as they are driven by company size, technology, and the overall product supply set up. For example, pharma companies that are producing mainly small-molecule drugs (based on active pharmaceutical ingredients that are made via chemical synthesis) have, other things being equal, higher emission levels than biologics.

Investors are taking it seriously. BlackRock, Inc., the world's largest asset management company, has set the ambitious goal of having all of the assets it manages (over $10 trillion worth) reach net zero emissions by 2050. It punished 53 companies in 2020 for climate inaction, voting at annual

1 Active pharmaceutical ingredient; international harmonized system (IHS) codes 2924, 2930, 2931, 2936, 2937, 2941.
2 Finished Product; codes 3002, 3003, 3004, 3006.
3 Figures represent trade volumes between selected geographies only calculated based on reported imports for countries. Excludes intraregion trade (e.g. within EU).

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meetings against the re-election of directors. Chief executive Larry Fink reaffirmed Wall Street's changing attitudes in his annual letter to CEOs in January 2022, explaining that companies must "focus on sustainability not because we're environmentalists, but because we are capitalists and fiduciaries to our clients." (Fink, 2022)

"Most stakeholders – from shareholders, to employees, to customers, to communities, and regulators – now expect companies to play a role in decarbonizing the global economy," Fink wrote.

Regulators and the public have sustainability in their sights as well. The EU proposed tougher 2030 emissions targets, with potential impacts for chemicals and pharmaceutical manufacturers, (European Commission, 2021) and polls show growing numbers of consumers are demanding positive change from the companies they buy from (Nielsen IQ, 2019).

And the goals will become harder, not easier, to achieve, as more companies attempt to address Scope 3 carbon emissions. According to the Greenhouse Gas (GHG) Corporate Protocol, part of the global carbon emissions framework on climate change, Scope 1 refers to emissions created directly by the organization; Scope 2 emissions are those created by power companies and utilities that supply a company's energy. Scope 3 emissions designate pollution created by an organization's extended network of suppliers and customers. Because the organization doesn't directly control these emissions, identifying, measuring, and reducing them is much more difficult. But to environmentalists—and, increasingly, investment leaders like BlackRock—it is becoming an important area of focus because the vast majority of emissions (percentages in the 80s and 90s are typical) fall under Scope 3 (Figure 2; BCG analysis[4]). While the GHG Protocol requires companies to identify and report Scope 1 and 2 emissions, more companies are trying to identify Scope 3 emissions as part of their carbon reduction planning.
Companies are clearly taking the issue to heart as well—and that, in turn, puts pressure on peers that lag behind. Corporate commitments are growing significantly. Over 2,000 companies, across industries, have pledged to meet science-based targets, as of the end of 2021, roughly double compared to a year earlier (Eckart et al., 2022).

Several pharmaceutical companies (e.g., Abbvie, AstraZeneca, BMS, GSK, Johnson & Johnson, Merck, Novartis and others) have committed to science-based, carbon-neutral, and net-zero targets, for both Scope 1-2 emissions (targets ranging from 2025 to 2040) and also Scope 3 emissions (2030 to 2050), see Figure 3.

A study by My Green Lab (2021) concludes that just 4% of the world's largest publicly-traded pharmaceutical and biotech companies have adopted climate commitments that align with the UN's Intergovernmental Panel on Climate Change (IPCC) to limit global warming to 1.5 °C.

The way forward for pharmaceutical supply chains

Pharmaceutical companies must take action to cope with increasing threats from political and natural risks as well as global climate requirements, and network resiliency and sustainability must be top priorities. If there is a silver lining in this, it is that the global supply chain is a vector for numerous risks, and companies may be able to address multiple threats—climate, government pressure, business resiliency—through improvements in this one critical area of the business.

To be sure, it is a very complicated task, and it requires an end-to-end view along the whole supply chain. Given the range of disruptions and company product supply setups, prioritized and tailored strategies are required—there is no one-size-fits-all solution.

An appropriate, strategic approach will entail identifying areas with the highest risks, evaluating risk tolerances, establishing redundancies, installing risk mitigation strategies, and actively engaging suppliers and customers regarding carbon emissions.

Companies must begin with appropriate assessments of supply chain risks, for the improvement of resiliency, and of emissions challenges, to enhance sustainability.

Next, companies should view steps to build resilience and sustainability through a double lens of a) impetus to change, and b) ease of adjustment. Impetus to change requires an assessment of the magnitude of supply chain risks, how essential a product is for patients as well as company

4 BCG analysis refers to internal, non-disclosed analyses based on client data and company information.

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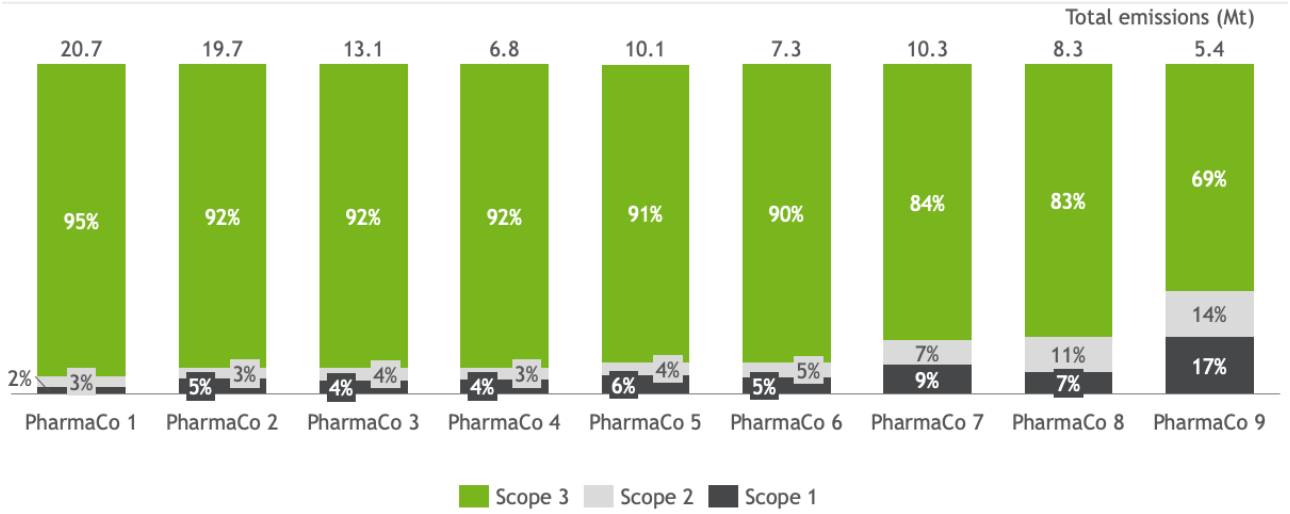

Figure 2 Majority of emissions in pharma fall under Scope 3 (Company Annual Reports; BCG analysis).

revenue, and current and future regulatory requirements. The other requirement, ease of adjustment, demands an understanding of the comparative difficulty involved in adjusting the current product supply setup. This includes numerous inputs, such as technical feasibility, capabilities and skills, regulatory factors, costs, and interdependencies and redundancies in the production network.

While each organization's approach will depend on its particular circumstances, companies have a range of levers they can use. To improve resiliency, options range from reevaluating the make-versus-buy strategy to reshoring part of the manufacturing footprint to protect against country risks (Figure 4). To address Scope 3 emissions, companies can work with existing API suppliers or qualify new suppliers to shift the manufacturing base to improve overall carbon emissions. In downstream areas they can reconsider the distribution strategy, such as the mix of transportation modes or moving distribution centers closer to end markets.

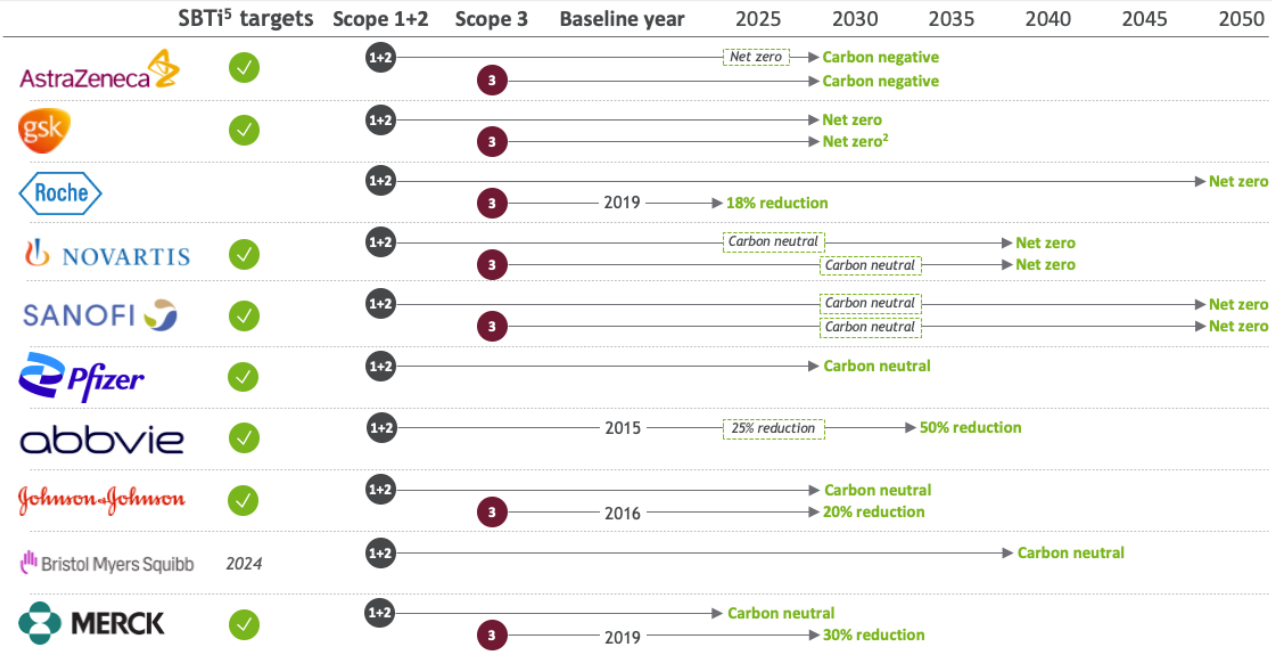

Figure 3 PharmaCos set ambitious targets, including Scope 3. Net zero emissions across full value chain for Biopharma (AstraZeneca, 2025; GSK, 2030; Roche, 2050; Novartis, 2040; Sanofi, 2050; BCG analysis).

5 Science Based Targets initiative. This is a list of representative companies that have publicly announced SBTi targets (approved and committed to be approved within 24 months). The list is non-exhaustive by nature and does not mean that companies that are not listed here do not have set targets.

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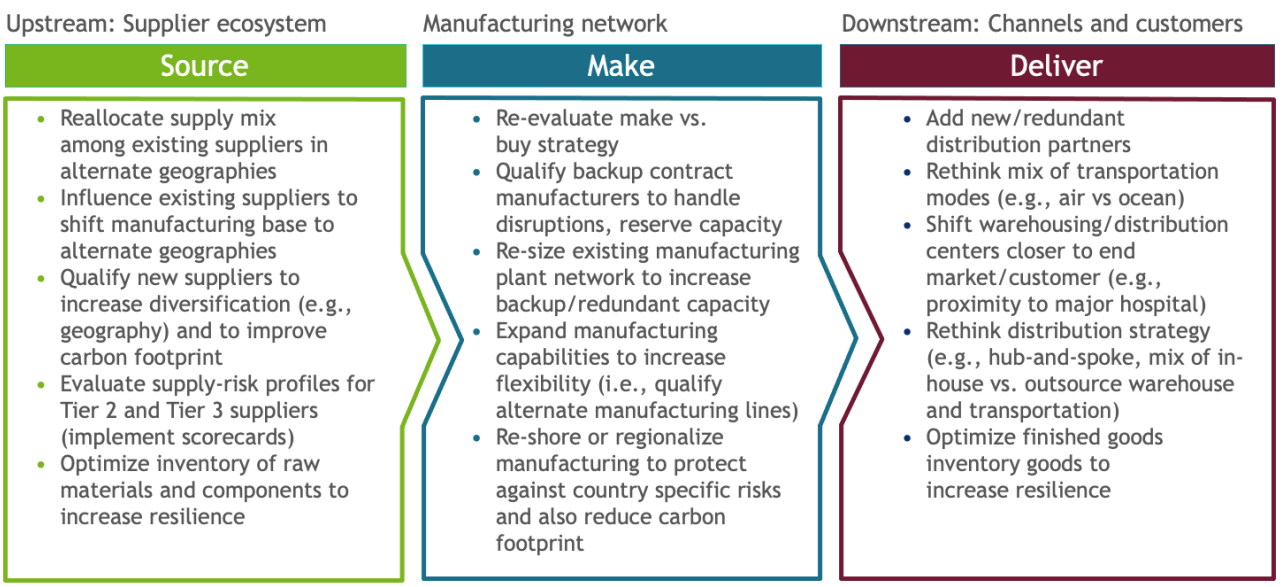

Figure 4 Levers across the supply chain (BCG analysis).

The time horizons for different steps vary widely. For example, we see more and more companies discussing a region-to-region, product supply-network approach. Changing supply routes, building new sites, and the like, takes time—years rather than months, and might not be economically feasible for every product given the regulatory requirements. Fundamentally adjusting global supply networks will be a multi-year journey, and an important part of a coherent strategy to promote a resilient and sustainable product supply network.

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