JOURNAL OF
BUSINESS CHEMISTRY

The academic journal for management issues in the chemical industry

Volume 21

Issue 3

Universität Münster

provadis Hochschule

ISSN 1613-9623

JOURNAL OF
BUSINESS CHEMISTRY

Vol.21, Iss.3, October 2024

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.

Publisher

The Journal of Business Chemistry (Online ISSN 1613-9623) is jointly published by Prof. Dr. Jens Leker (affiliated with the Institute of Business Adminstration, University of Münster) and Prof. Dr. Hannes Utikal (affiliated with the Center for Industry and Suistainability, Provadis School of International Management and Technology). It is published every four months as an open access journal.

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JOURNAL OF
BUSINESS CHEMISTRY

Vol.21, Iss.3, October 2024

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Letter from the Editor

Dear Readers,

Sustainability is a recurring topic for our Journal. The October issue focuses on the intersection of sustainability, corporate governance, data management in the chemical industry and M&A activities in the global battery industry. These articles collectively emphasise the pivotal role of sustainability, innovation and financial management in determining the trajectory of industries that are pivotal to the global effort to combat climate change.

The first contribution of this issue is an interview with Prof. Dr. Martin Artz. He is the director of the Accounting Center at the University of Münster. Prof. Artz highlights the growing integration of sustainability in corporate governance, driven by regulation and customer demand since the Paris Climate Agreement. Key challenges include defining strategy, improving education, and developing effective measurement and governance systems. Financial management plays a crucial role, though firms often struggle with integrating non-financial metrics. Successful companies like Vaude and dm-drogerie show sustainability's long-term benefits, especially in response to ESG demands. We thank Prof. Artz for taking the time and sharing his view on the influence of sustainability on corporate governance.

The article by Dr. Martin Kirchner, Dr. Frank Martin Petrat, Marvin Graf and Dr. Oliver Busch, entitled „SUScube - An innovative approach to sustainability data management from practice", presents a novel data management system that may be of interest to those seeking new solutions in this field. Evonik Oxeno has developed a Power BI-based dashboard, called „SUScube", with the aim of addressing inefficiencies in managing sustainability data. The aim was to meet customer expectations for reliable and credible sustainability information while enhancing internal data usability. This system, based on a certified Life Cycle Assessment model of their production sites in Marl and Antwerp, serves as a „single point of truth" for sustainability data, offering an efficient, user-friendly interface. Furthermore, additional enhancements will be made to this system with new features to improve functionality.

Additionally, Tim Greitemeier, Carina Albrecht, Reba Brockington, Sebastian Eggers, Lars Hansner, Niklas Kamp (Director at EY-Parthenon), Dr. Hauke Simon (Partner at EY- Parthenon) and Prof. Dr. Simon Lux contributed with their article: "International M&A transaction volumes along the battery value chain: Strategic investment implications." This study examines international value streams in the global battery industry, focusing on mergers and acquisitions to track innovation strategies across key markets. Analyzing 913 deals from 2018 to 2022, the research highlights North America as the largest contributor to deal value, especially in 2021. The study also demonstrates that product manufacturers and enablers primarily drive these value streams, underscoring their pivotal role in the industry.

Please enjoy reading the third issue of this year, we are grateful for the support of all authors and reviewers for this insightful 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/ and subscribe to our newsletter.

Andrea Kanzler, (Executive Editor)

ISSN 1613-9623

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BUSINESS CHEMISTRY

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How sustainability changed corporate governance

Interview with Prof. Dr. Martin Artz. He is leading the Institute of Management Accounting & Control at the University of Münster.

Prof. Dr. Martin Artz's research focus is on the areas of management accounting and control, Sustainability Measurement, data-driven performance measurement and strategy implementation.

1. How has the integration of sustainability performance management evolved in corporate governance strategies over the past decade?

Companies that have seen specific aspects of sustainability as a key driver of business success have always measured and managed these specific sustainability dimensions. If we take for instance, biological food or fair trade policies for fashion or coffee, some companies have engaged, maybe for a share of their product portfolio, in sustainability for a long time. What is new – and that has started around the Paris Climate Agreement – is that all companies start broader initiatives to capture their sustainable impacts due to differences in customer recognition and particularly upcoming regulation in many countries.

2. What key metrics or indicators do you believe are most crucial for assessing sustainability performance in today's economy?

I would like to differentiate between two groups of metrics here: if sustainability is key for the company's business model, then the business model and the specific key drivers of business success define the relevant sustainability metrics. For instance, the fashion company engaged in sustainable products may care about metrics to capture supply chain policies such as child labor or safety at local production plans and their customers' willingness to pay for this product segment. The second group of companies is broader and addresses a broader set of stakeholders and the public due to the visibility of the topic and regulatory initiatives in many countries. Here, some of the "classis" are certainly CO2 emission equivalents, safety violations in the supply chain, or diversity in corporate governance such as gender quota.

3. How do you see the role of controlling departments evolving in facilitating and driving sustainability initiatives within organizations?

I think the financial management department in companies can – if well prepared and ready to accept the resulting challenges – get into the driver's seat of the change. Accounting and controlling have always been responsible for defining measurement standards, transferring real practices into financial and non-financial metrics, consolidating budgets, taking care of reporting processes, and integrating numbers into performance management practices. This experience and history make them the ideal candidate to facilitate the change. However, we should also note that their competence mainly refers to "traditional", financial measures and corporate accounting systems are often not ready to integrate non-financial metrics to the same degree as financial metrics. This means financial management departments and their self-understanding and role need a change in case they would like to drive the change towards sustainability.

4. What are some common challenges companies face when implementing sustainability performance management systems, and how can they overcome these obstacles?

I see four challenges: strategy, education, measurement, and governance. All these four areas are interlinked to each other. Strategy does not mean that firms need a sustainability strategy. But they clearly must define the role of sustainability for their strategy. Is it part of the business model? Is it a reputation issue? Is it part of facing regulatory challenges? The importance of different subdimensions of sustainability for the firm's strategy is a precondition for

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performance management. Second, education. Companies need to enhance the education level of their employees about sustainability: its importance, its measurement, and management. This refers to expert knowledge in certain areas as well as to basic knowledge for all employes in the organization. Third, measurement. Conventional enterprise resource planning and accounting systems are not tailored to certain dimensions of sustainability that may require to process non-financial measures such as quantities (instead of costs) or safety violations. Even if we look at more traditional costing: most costing systems can calculate product margins per period but calculating product lifetime costs (including potential savings due to recycling) is a challenge. Finally, governance. Organizations need to redefine roles and responsibilities along sustainability.

5. In your opinion, what are the most effective strategies for ensuring alignment between sustainability goals and overall corporate strategy?

Alignment challenges are the same for any type of goals, including sustainability. Ensuring clarity of objectives (and why these objectives matter now to the organization), designing incentives which may also include compensation, delegating decision rights, and approving budgets, as well as ensuring that organizational members have the knowledge and skill set to contribute effectively to the organizational objectives. I think what makes sustainability targets special is to explain organizational members their particular importance now and to invest in education. Many managers understand and accept financial objectives such as profit goals. Sustainability goals, often measured in non-financial terms are new.

6. How do you assess the impact of sustainability initiatives on long-term financial performance, and what evidence suggests a positive correlation?

This is indeed a tricky question since it is usually hard to estimate "what would have happened in case we did not do the initiative." But I think it is also an essential question because companies must estimate their financial returns for any type of investment. And even if some sustainability investments are done as a social initiative, transparency about their effects and costs is essential. One way, of course, is tracking academic studies on effects on certain initiatives. Another way is using historical firm data and exploit whether some changes in the past have shown some desirable performance effects.

7. Could you provide examples of companies that have successfully integrated sustainability into their corporate governance practices, and what lessons can be learned from their experiences?

The answer to this question requires a clear-cut definition of sustainability, which is probably tough. I would, therefore, like to answer the question from a different angle: there is probably no company that has not successfully integrated some aspects of sustainability since long-run existence is a natural objective of any company and a significant driver of firm value. Oil and gas companies invest heavily in renewable energy, tobacco companies innovate healthier products, and McDonald's has changed its business model significantly over the years, including the introduction of salad in menus and recyclable plastics. Although one may criticize these efforts as too small, they underline that responding to customers or regulators is part of good management. Of course, of particular interest are companies that are doing exceptionally well with a remarkable focus on sustainability in their corporate governance, such as the Outdoor company Vaude (particularly sustainability in materials and recycling) or dm-drogerie marketing (particularly employee orientation and work culture). We know from research that returns to investments in sustainability are often underestimated when they are done. For instance, companies treating their employees well enjoy exceptionally high financial performance in the long-run, even though the objective has never been to earn these returns in the first place.

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8. With the growing focus on environmental, social, and governance (ESG) factors by investors, how do you see the landscape of corporate governance evolving in response to these demands?

We observe changes in practice in firms incorporating sustainability into their governance structures. Some firms have already done this for a long time since certain aspects of the environmental or social dimensions have been part of their competitive advantage. Others are more recently changing due to more recent changes in expectations from investors, suppliers, customers, or regulators. The range of corporate governance changes is broad, ranging from formal elements such as adjusting compensation systems, creating new executive roles (e.g., Head of Sustainability), or changing investment policies to informal ones such as a change in corporate norms and guidelines. However, what we also observe is that firms that do not see sustainability practices as part of their competitive advantage are reluctant to adjust their governance completely. For instance, for incorporating sustainability metrics in their compensation systems for top executives, we observe that more or less all firms started to do so, but only for a minor share of firms; these dimensions are really impactful for bonus pay.

ISSN 1613-9623

JOURNAL OF BUSINESS CHEMISTRY

Vol.21, Iss.3, October 2024
URN: urn:nbn:de:hbz:6-55918722080
DOI: 10.17879/55918720584

Practitioner's Section

Dr. Martin Kirchner*, Dr. Frank Martin Petrat, Marvin Graf*** and Dr. Oliver Busch******

SUScube - An innovative approach to sustainability data management from practice

The increasing importance of sustainability goes hand in hand with higher demand, more visibility and a more intensive exchange of sustainability data and information, both along the value chain and within a company. Previous ways of managing this data and information are inefficient, slow and error-prone. The goal for Evonik Oxeno[1] was therefore to develop an application that (a) primarily satisfies customers' needs for reliable and credible sustainability data while increasing the efficiency of data provision, and (b) improves the usability and presentation of sustainability data internally. In short, the ambition was to create a „single point of truth" for sustainability data with an appealing user interface. Oxeno's solution, a Power BI-based dashboard called „SUScube", was developed in 2021, has been in use since then and is continuously being expanded with further functionalities. At its core, SUScube is based on an external certified Life Cycle Assessment (LCA) model of Oxeno's production sites in Marl and Antwerp.

Business Conditions and Business Needs

The well-known economist Peter Drucker once said: „If you can't measure it, you can't manage it." This quote also applies to the topic of sustainability. Customers, investors, competitors, politicians and, last but not least, society are attaching more and more importance to the topic of sustainability, and this inevitably means that already today and even more in the future, business will have to provide answers to the following questions in order to remain competitive:

- What is the carbon footprint / environmental impact[2] of our products?
- What are the biggest factors influencing our product carbon footprints?
- What are the Scope 1, 2 and 3 emissions[3]?
- Where are the biggest levers for improving our sustainability performance?
- What CO_2 saving potentials can be identified in the individual production plants?
- What effect would switching to greener alternatives (raw materials, electricity, etc.) have on our carbon footprint?
- etc.

* Dr. Martin Kirchner, Evonik Oxeno GmbH & Co. KG, martin.mk.kirchner@evonik.com
** Dr. Frank Martin Petrat, Evonik Oxeno GmbH & Co. KG, frank-martin.petrat@evonik.com
*** Marvin Graf, Evonik Operations GmbH, marvin.graf@evonik.com
**** Dr. Oliver Busch, Evonik Oxeno GmbH & Co. KG, oliver.busch@evonik.com

[1] Evonik is a major producer of C4 chemicals with more than 50 years of experience. The C4-Chemistry business unit was spun off in 2023 as Evonik Oxeno GmbH & Co. KG and is currently preparing to become an independent company. Among other things, Evonik Oxeno produces precursors for plastics, coatings, lubricants and specialty chemicals at our plants in Marl and Antwerp and place great importance on resource-saving production and the use of new technologies.

[2] In order to assess the environmental impact of products the most common approach is conducting an LCA (Life Cycle Assessment). A detailed description about the principle and the framework for an LCA is provided in the ISO 14040 standard (ISO, 2006). ICCA provides a practical guide on conducting LCAs (ICCA, 2013).

[3] A definition of Scope 1, 2 and 3 emission is provided by the World Resources Institute and World Business Council for Sustainable Development (WRI and WBCSD, 2011)

JOURNAL OF BUSINESS CHEMISTRY

Vol.21, Iss.3, October 2024
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In recent years, Oxeno observed that sustainability information and data are no longer just requested, but demanded, especially from customers with the regulatory environment (e.g. Corporate Sustainability Reporting Directive, CSRD) playing an important role here (CHEManager, 2023). And the message is clear: Even if there are currently no noticeable consequences, companies that cannot or do not want to meet the requirements for an adequate provision of sustainability data, will run the risk of no longer being a preferred supplier and thus losing business in the foreseeable future. In addition to that, it can be said that end markets close to the end consumer and with higher-margin products, ask more for this data and information. In particular, as the fight against climate change is one of the most pressing issues, the product carbon footprint (PCF) was and is the focus[4]. This is also the reason why most of the attention in the development of the SUScube was put there, although other environmental impact categories related to water consumption, pollution, waste, etc. can also be assessed.

But sustainability data management is not only playing an increasingly important role externally. Sustainability data and information are also becoming ever more important for e.g.

- the management of companies in the context of binding sustainability goals (e.g. Science-based Target Initiative (SBTi; more information is available here: https://sciencebasedtargets.org/)),
- the identification of improvement levers in production processes,
- the management and prioritization of investments and
- the targeted further development of the product portfolio towards more sustainability.

Regardless of the interest group, it is clear that it is important to set up the process of data and information provision as quickly, robustly and credibly as possible and to make communication reliable, easy to understand and transparent. Previous ways of managing this data and information – so far mostly via a wide variety of Excel files and often by different people – are inefficient, slow and error-prone (see Figure 1). With SUScube this has now been significantly simplified and improved.

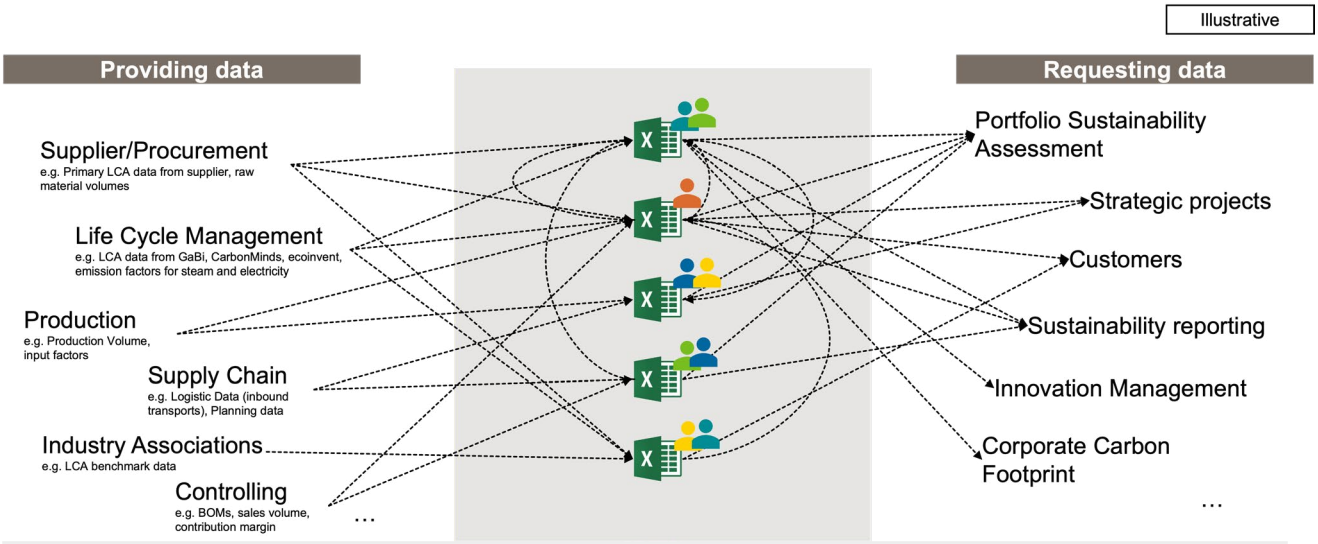

Figure 1: Illustrative example of current practice of data provision and exchange based on Excel

[4] An overview of the relevance of the topic of climate change and the KPI Product Carbon Footprint is provided by the following sources, among others: Abbass et al. (2022), European Commission (2024), TfS (2024)

JOURNAL OF BUSINESS CHEMISTRY

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SUScube: Description and functionalities

Oxeno's solution to e.g.

- retrieve and provide sustainability data for customers and other stakeholders,
- identify potentials for improvement in the individual production plants or
- display the corresponding Scope 1 and 2 emissions aggregated in absolute numbers at site level

all in a user-friendly interface is a Power BI-based dashboard called „**SUScube**".

SUScube was developed in 2021 and has been in continuous use since then, with ongoing expansion to include additional functionalities. The core of SUScube is based on an externally certified Life Cycle Assessment (LCA) model of Oxeno's sites in Marl and Antwerp (see Figure 2). Moreover, SUScube is connected to standardized production and financial data from SAP. The consistent application of data warehouse principles enables the generation of various data slices as per the requirements of customers and other stakeholders. Currently, SUSCube already offers a variety of different data (Product-specific data, Customer-oriented data, absolute values) and analysis-/evaluation options. Some of them are described in more detail in the following sections.

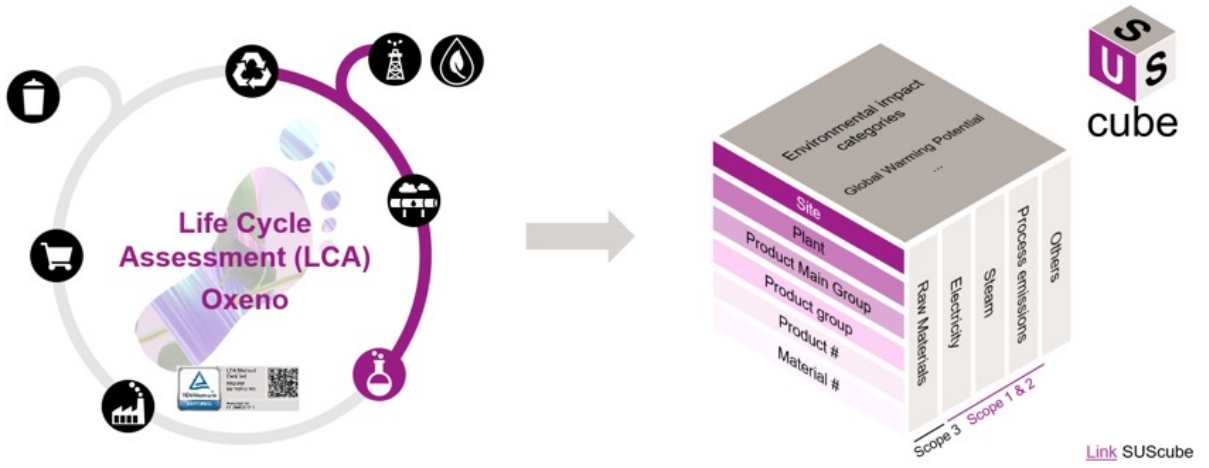

Figure 2 Oxeno holds a TüV Rheinland certification for its cradle-to-gate LCA model, which is the base for SUScube

Drill-Through functionality

Currently, SUScube provides access to all LCA results on product level allowing to perform so-called „drill-throughs" (see Figure 3). It is possible to fan out values step by step down to the lowest data level, e.g. to the purchased raw materials. This is always relevant if you want to know, for example, what are the main factors influencing the product carbon footprint. Another field of application is production, where a systematic evaluation of possible fields of action to further improve your Scope 1 and 2 emissions is enabled. Last but not least, for innovation this feature serves as a starting point for the targeted development of more sustainable processes and/or products.

LCA environmental impact categories

Since all LCA results are loaded into the dashboard, in addition to the carbon footprint, other environmental impact categories related to water consumption, pollution, waste, etc. as well can also be evaluated.

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BUSINESS CHEMISTRY

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Figure 3 Drill-trough function in SUScube

Scenario Analysis

SUScube also has the option to play through scenarios (see Figure 4). For example, it is possible to simulate how the product carbon footprint would change if fossil raw materials were substituted by renewable ones or the production is run by 100% green electricity. This helps, for example, to select the right raw materials in purchasing and thus supports the medium to long-term optimization of raw material and product flows from a sustainability perspective or to make well-founded decisions when purchasing energy. In addition, SUScube users are able to show their customers the sustainability potential in terms of e.g. product carbon footprint improvement that can be leveraged by switching to more sustainable product alternatives. Customers can then use this information to e.g. calculate the effect on their Scope 3 savings target, which again supports decision making.

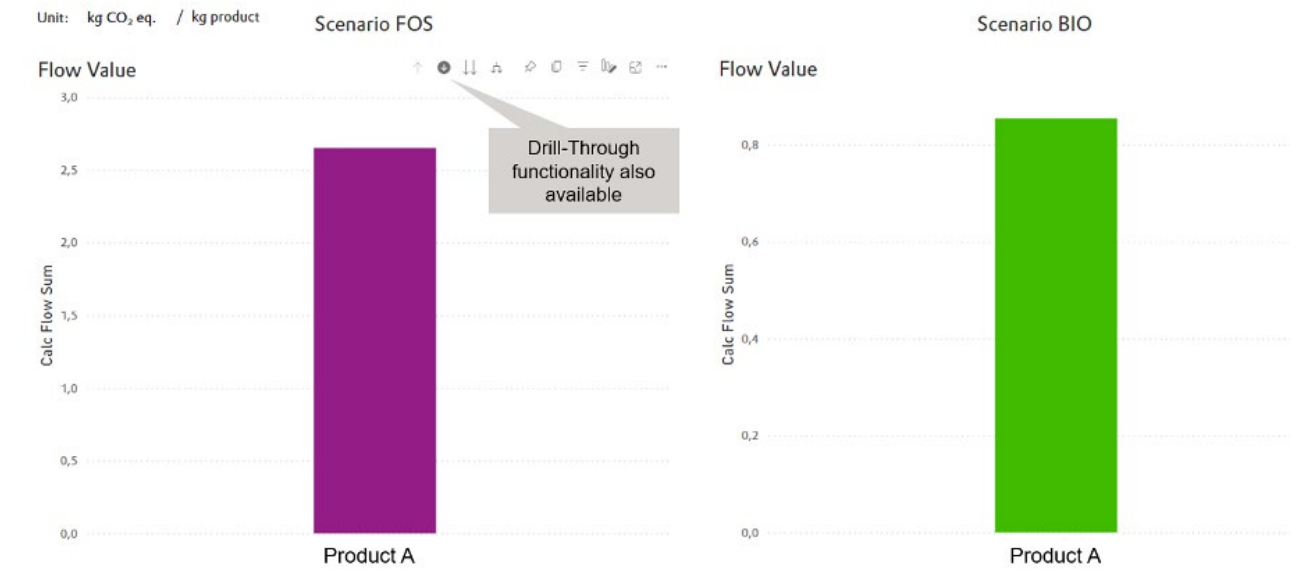

Figure 4 Scenario Analysis function in SUScube

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LCA One-Pager generation

In order to ensure the most systematic and uniform customer communication possible, the SUScube also has templates for LCA results (LCA One-Pager). On an appealing user interface, Marketing Managers for instance are guided through a context menu in which the respective product, the location and – if needed – the raw material category according to ISCC-Plus (most leading certification system for bio, bio-circular and circular feedstocks and products, (ISCC, 2024)) are selected. The corresponding information and data is then automatically loaded into the template via the Power BI dashboard, which can then be saved as a PDF and sent to the customer without any further approval process (see Figure 5). From a marketing perspective this improves customer communication significantly with regard to sustainability data by proceeding faster, more reliably, more systematically and therefore more professionally. This functionality also meets the above-mentioned demand of customers regarding high quality sustainability data. Being a frontrunner here, provides the opportunity for companies to create value in terms of higher customer loyalty and the securing of market shares.

Last but not least, the modular nature of the data model allows to react quickly to new or changing requirements and adapt the SUScube reports - including the LCA One-Pager - accordingly or develop new ones.

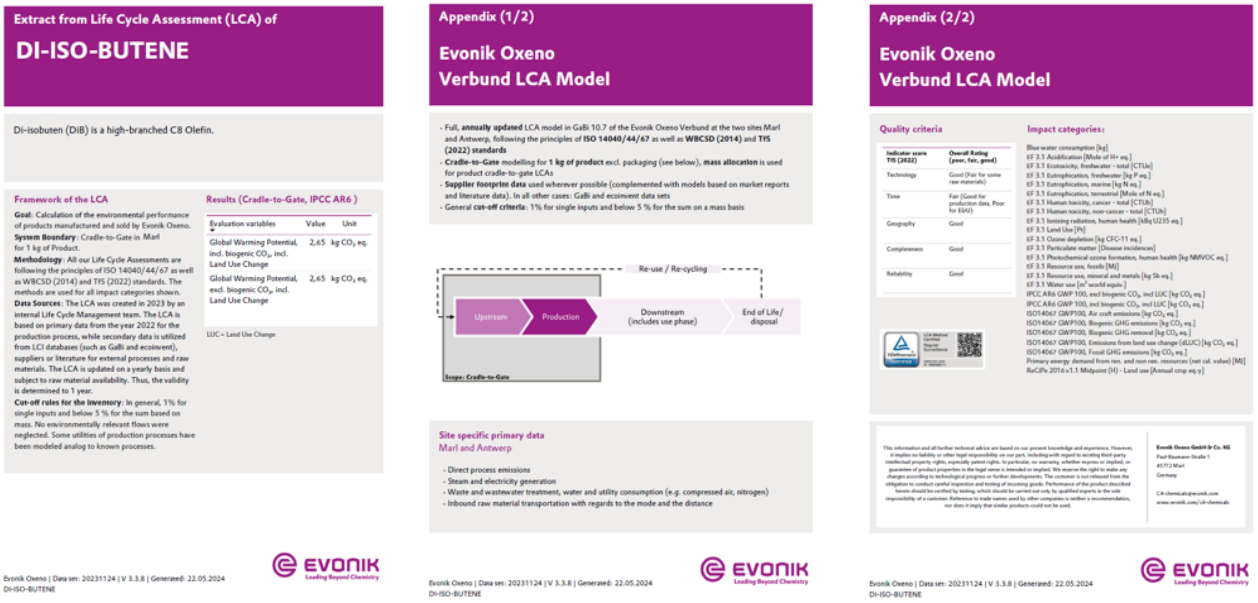

Figure 5 Example of final LCA One-Pager including appendix with additional information

Outlook: Functionalities

SUScube is already used and will be more integrated in the annual strategic management process to derive, control and review Oxeno's goals and the degree to which Oxeno has achieved its ambitions. SUScube serves as the single point of truth for obtaining the data needed for the analysis and projections. By combining standardized financial and production data from SAP as well as LCA data, novel KPIs (e.g. Contribution Margin [EUR]/t of emitted CO_2) for managing sustainability more effectively in the future can be developed and applied.

Furthermore, it is planned to use the SUScube as a database for supplier footprint data and thus make this information more easily available to other departments, who need access to this information.

Last but not least, the SUScube is an important building block in the context of Oxeno's digitalization activities towards a data-driven organization. In the next stage of expansion, it is planned to process and make available the increasing data volumes in a high-performance Spark cluster[5], in order to be able to efficiently provide the data volumes that will increase immensely in the future.

[5] A Spark Cluster is a group of computers that work together to process large amounts of data quickly and efficiently. It is used for big data processing and analytics (Karau et al., 2015).

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SUScube: An innovative approach in terms of sustainability data management

SUScube is characterized by several innovative aspects, the most important of them are briefly described below, namely the LCA modelling approach, which is the basis for SUScube, the linking of a wide variety of data sources and the establishment of a versatile and scalable data model.

LCA modelling approach

In 2021 Oxeno decided to renew its existing LCA, which was already conducted in 2012 for the first time. However, instead of just updating the model, it was determined to set up the LCA model from scratch in order to be able to meet today's and tomorrow's needs of providing LCA data to customers and other stakeholders. The following section provides a short overview of the most significant improvements compared to the 2012 LCA model:

1. To ensure seamless integration of the LCA model into the existing structures, the Bill of Materials (BOMs) from SAP were utilized as the structural foundation for the development of the LCA model. This guarantees that all products present in SAP can be easily linked to the LCA model and vice versa.
2. Oxeno has also come up with a concept for how to import mass and energy balance data into the LCA model as automatically as possible in order to avoid the manual feeding of data, which is very time-consuming and error-prone, especially against the background of the large amounts of data.
3. Finally, this new kind of LCA model also considered the aspect of conducting scenario analysis by applying global parameters in the LCA model for easily changing parameters (e.g. electricity mix, raw material mix, etc.). This makes it very easy to evaluate changes in the product carbon footprint or other environmental impacts when switching from e.g. a fossil to a bio-based feedstock. It is crucial to highlight this aspect as it facilitates communication with customers by enabling to accurately quantify potential CO_2 reductions. This, in turn, assists customers in understanding the impact of changing Oxeno's raw material base on their sustainability targets.

Linking different data sources

A data model was developed that links relevant standardized data (e.g. from LCA, SAP and Production) and makes it available in a so-called OLAP cube (OLAP = Online Analytic Processing). This innovative approach overcomes the drawbacks of distributing data across all over the organization. The data is no longer available in different files, and in different server folders which have to be brought together in a time-consuming and, not least, error-prone process. Rather, an automated transformation workflow ensures that the data is automatically transferred to the data model. Once in the data model, users can carry out evaluations according to all dimensions that are spanned in the model and thus implement a wide variety of use cases very flexibly. The versioning of the data model ensures traceability („single point of truth") and uniqueness of the data at all times.

Building a scalable data model

Due to the amount of data, the data sources described above can no longer be entered into an Excel spreadsheet (Excel does not have enough rows to cover all data and it is foreseeable that further dimensions will continue to enlarge the model in the near future). Therefore, a business intelligence tool was chosen that on the one hand has a wide distribution in the organization and on the other hand is performant enough to evaluate the amount of data with acceptable latency times. So Power BI was the tool of choice, which can be made available to selected and authorized people in the organization by publishing it as a service. Due to the projected increase in the size of the data model, a transfer of the transformation workflow into a high-performance system based on a Spark cluster was started. This means that there is no anticipated upper limit due to the amount of data to be processed and the scalability of the approach is ensured.

Transferability of the approach

To answer the question of transferability, it is worth taking a brief look at the sources on which the SUScube is based and the means by which the data is transformed and made available.

The LCA model, which is the data basis for the SUScube, draws on the following sources for emission factors: Direct emissions reports, site-specific emission factors for electricity, steam and other utilities, primary data for raw materials (if available, otherwise secondary database values are used). The mass and energy balances come from the

Vol.21, Iss.3, October 2024
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respective production information management system (PIMS), transport data comes from the logistics department, and the BOMs form the structure of the LCA model. The actual LCA model was created using the software Sphera™ LCA for Experts 10.8 software, formerly known as "GaBi". Due to a lack of interface in LCA for Experts, data is exported via the csv file format. These files are then processed and loaded into Power BI.

In sum, it can be said that the SUScube has all the prerequisites to be implemented by other organizations in a similar way (knowing full well that each organization has its peculiarities and it is likely to adapt the concept at one point or another), as it relies on inputs / tools / competencies which should be widely available .

At this point, it should not go unmentioned that the SUScube was purely developed and implemented in-house and without the involvement of external IT consultants in a small and agile project team. This provides the opportunity to continuously develop the SUScube easily and quickly without incurring external costs.

Benefits of SUScube

Meeting customer's demands

Just like suppliers, Oxeno's customers are also pursuing ambitious sustainability goals, with the topic of greenhouse gas reduction clearly dominating here. With regard to the value chains, the proportion of CO_2 footprint from raw materials increases more and more the closer you get to the end consumer. This is why, in addition to Scope 1 and Scope 2 targets, which essentially affect the respective company's own scope of action and are thus largely controllable internally, Oxeno's downstream value chain partners are also increasingly setting themselves scope 3 targets. These are essentially aimed at reducing the CO_2 footprint coming from raw materials. In order for customers to manage their Scope 3 goals effectively and efficiently, they depend on the following aspects:

- **Data Availability**: It may sound trivial, but in order to manage their Scope 3 goals, customers need information on the product carbon footprints of their purchased goods. In the best case, this information is based to a large extent on primary data. If you don't get any information about the PCF values of your suppliers, you have no choice but to calculate with assumptions and estimates, which leads us directly to the next point – reliability.
- **Reliability**: Customers need reliable and high-quality data. In 2021, Oxeno therefore completely recreated its Verbund LCA (see above) with the aim of serving current and future customer requirements in the best possible way. A building block in this LCA strategy was to have the LCA model externally certified to ensure that the LCA model complies with applicable ISO standards and chemical sector-specific rules. In order to always be able to provide customers with the latest LCA values, it was also decided to carry out annual updates of the LCA model and to perform external certification at regular intervals. This ensures that methodological developments, process technology innovations as well as updated primary data are always taken into account in the LCA model, leading to a very high level of reliability and trustworthiness for customers.
- **Transparency**: The LCA model is used, for example, to calculate the PCF values for Oxeno's products, but is only suitable to a limited extent in the context of customer communication. This requires a different vehicle, which has been created with the so-called „LCA One-Pager". The LCA One-Pager is a document that can be generated from the SUScube and provides all LCA-relevant information (System boundaries, Functional unit, Environmental impact category methodology, TfS Quality indicators, etc.) in an appealing and clear layout for customers (see Figure 5). The LCA One-Pager also features a QR code that refers to the external certificate of Oxeno's LCA model (see paragraph "SUScube: Description and functionalities")
- **Speed**: Among other things, you distinguish yourself with a very good customer service if you provide customers with comprehensive support, advise them, value them, anticipate their needs and respond quickly to their inquiries. In particular, the last two points are addressed and made possible by SUScube. While it is not yet common practice to have LCA data accessible for the entire product range, Oxeno have positioned itself as pioneers in this area. Furthermore, internal processes have been optimized in such a way that the desired LCA data can be generated easily and quickly by the respective marketing and sales managers via the LCA One-Pagers mentioned above and shared with customers within a couple of minutes.

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In summary, with the SUScube and the underlying LCA model, Oxeno positions itself as an innovative supplier, who supports their customers in their journey to reduce scope 3 emissions with credible data by applying efficient internal processes.
Furthermore SUScube enables the marketing and sales team to provide LCA data to partners promptly in a standardized, comprehensive and comparable manner.
What should not be forgotten in conclusion is that the LCA One-Pagers are a good starting point for more intensive follow-up discussions and thus open the door for potentially further business (e.g. when it comes to product alternatives with lower PCF).

Contribute to improving competitive position

While sustainability was a more or less voluntary topic ten years ago, it has now developed into a firmly established topic that, if not addressed, entails a financial risk that is not to be underestimated in the future (e.g. by not meeting regulatory requirements, poor financing conditions on the capital markets, reputational risk (Cox et al., 2022)). Likewise, the topic of sustainability offers companies, if they approach it effectively and efficiently, opportunities to differentiate themselves in the market and thus be (more) economically successful. SUScube addresses both: Value creation and Cost savings.

Value Creation

For Oxeno, sustainability is more than just "Compliance" and "Risk mitigation" (see Figure 6). It is about differentiation and the generation of competitive advantages which leads to value creation (Berns et al., 2019).

Against this background, SUScube is one important strategic vehicle, as Oxeno is able to

- respond quickly and with high quality to the needs of their customers and
- provide high quality sustainability data for 100 % of their product portfolio.

This increases Oxeno's reputation as a leading company in terms of sustainability data management. Together with other sustainability activities, Oxeno is thus laying the foundation for remaining the preferred supplier in the future and accompanying customers on their sustainability journey. With products from the eCO series and RFP series (see Figure 7), Oxeno already offers alternatives to fossil products and is aiming to sell them on a larger scale and accelerate the transition towards more sustainability.

Figure 6 Ambition level of Oxeno with regards to sustainability

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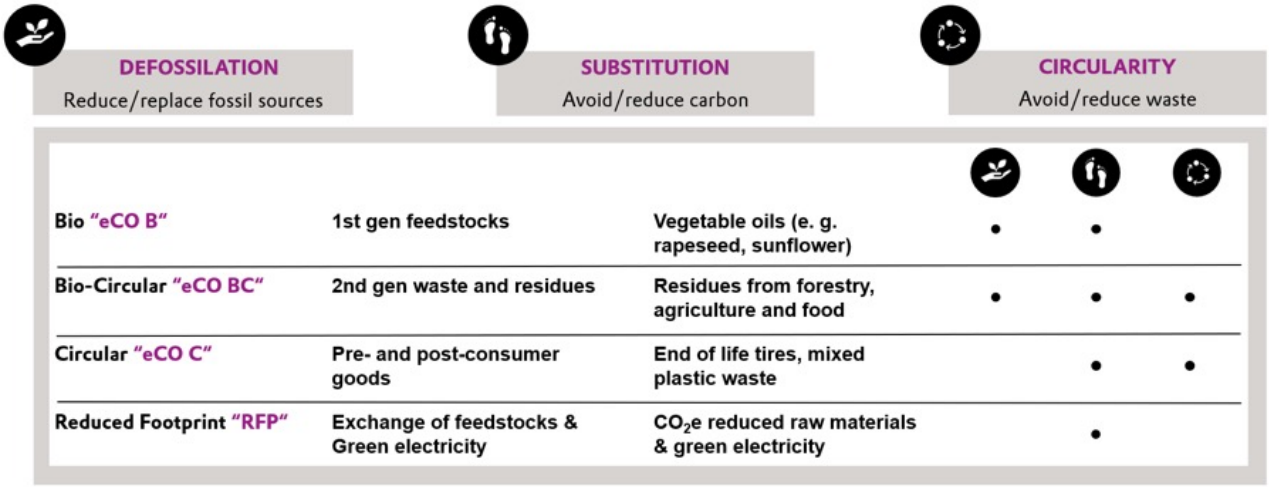

Figure 7 Overview of eCO and RFP Product Portfolio of Oxeno

Cost savings

Oxeno's plans are also to use the SUScube to control and monitor Scope 1 & 2 emissions in the future. The transparency of carbon footprint data enables Oxeno to enhance the efficiency of reducing Scope 1 and 2 emissions, which, against the backdrop of rising costs such as CO_2 certification expenses from the Emission Trading System (EU-ETS), will help to identify further cost saving potentials in the future.

In addition, the SUScube offers numerous internal advantages: By creating a single point of truth for sustainability data, there is exactly one central location that holds sustainability data and from where likewise, different use cases can be operated. Be it in the context of an investment calculation that addresses the topic of CO_2 savings, in the context of the strategy dialogue with the board (CO_2 development over time from an organizational point of view) or in the provision of product carbon footprint (PCF) data to customers. In all cases, the SUScube helps to save time and thus costs, by e.g. eliminating the need to go through numerous different Excel files to gather all the relevant data. As a result, operational work is reduced and an organization-wide standardized communication is ensured.

The following points are particularly noteworthy in this context. For the marketing teams, for example, lengthy coordination processes are now no longer necessary. The abovementioned LCA One-pagers are generated from the SUScube and since the data on the LCA One-Pager is already approved, it can then be sent directly to the customer.

Against the sake of more efficient and less complex processes as well as the intuitive front-end, the SUScube was very quickly adopted by the various users from marketing, production, purchasing and strategy and there were no greater challenges in the roll-out and implementation phase. In the end, no major effort had to be put into training; again a point where costs have been saved.

In order to develop the SUScube in this way, a wide variety of skills was needed, which were found in-house and thus without incurring external costs. A lot of improvements have already been implemented thanks to the great feedback of users and customers. This is where the advantage of having developed the SUScube itself becomes particularly apparent – changes, customization and updates can be implemented very quickly and without additional external costs.

One last point that should be emphasized in this chapter is that the development of the SUScube now also generates a much better understanding of Oxeno's data landscape and the people responsible in each case and can now work better on further optimization and harmonization.

In summary, with SUScube an application has been developed and implemented that creates value for a wide range of stakeholders:

- With SUScube, business needs of partners in terms of efficiency, reliability and credibility when it comes to sustainability data exchange are addressed
- The user-friendly interface in combination with preapproved data allows fast and intuitive extraction and distribution of requested information. The inefficient, slow and error-prone practice of using various Excel files by different people is eliminated.
- Oxeno and its partners can trust the data as the single point of truth approach reduces possibility of errors for sustainability data and increases its reliability
- SUScube supports the exchange process with customers and other partners and promotes dialogue in the context of sustainability along the C4 value chain

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URN: urn:nbn:de:hbz:6-55918722080
DOI: 10.17879/55918720584

Conclusion

Sustainability is becoming increasingly important for customers, investors, competitors, politicians, and society, and businesses need to provide answers to sustainability-related questions to remain competitive. Providing sustainability data and information as quickly, robustly, and credibly as possible and making communication reliable, easy to understand, and transparent is essential. SUScube, a Power BI-based dashboard, offers a solution. SUScube is to be seen as a strategic vehicle for Oxeno and is based on a modular and scalable data model, links different data sources and has all the prerequisites to be implemented by other businesses in a similar way. Or to put it in other words: Sustainability is about fulfilling customer demands, by operating responsibly, by taking care of our employees and by ensuring to operate within our planetary boundaries. In order to reach this target, the SUScube is an important piece of the puzzle, as it helps compiling and analyzing the various data in an appealing and structured way.
In response to the question of the added value provided by SUScube, the following points can be summarized as key takeaways:

1. Meeting customer demands: With SUScube, businesses can provide their customers with high-quality sustainability data in a standardized, comprehensive, and comparable manner. This helps to improve customer communication and build trust, leading to increased customer loyalty and a better reputation.

2. Simplifying processes: SUScube simplifies the process of data and information provision by providing a user-friendly interface and automating the transformation workflow. This eliminates the need for lengthy coordination processes and the use of various Excel files, saving time, reducing the risk of errors and ultimately generating cost savings.

3. Supporting decision-making: SUScube allows businesses to evaluate different scenarios and simulate the impact of switching to more sustainable alternatives, helping them make well-founded decisions when purchasing energy or selecting the right raw materials in purchasing.

4. Facilitating communication: SUScube creates a single point of truth for sustainability data, which facilitates communication with different stakeholders within as well as outside of the organization. This helps for example to optimize internal processes and improve cross-functional collaboration (e.g. in terms of investment projects).

That being said, SUScube and the externally certified LCA model behind it are an important building block in the context of businesses' digitalization activities towards a data-driven organization and in positioning Oxeno as a proactive company in terms of sustainability. In this context, it should be emphasized once again that 100% LCA data coverage is not yet standard. The same applies to the way in which data is provided in the form of the LCA One Pager. This is also being recognized by customers and their feedback, which has been consistently positive so far.
For the future the plan is to develop SUScube as the central platform for the management of sustainability data. Ideas for further development are numerous, such as the integration of primary data from suppliers as well as the further development of the transformation workflow into a high-performance system based on a Spark cluster that ensures the scalability of the approach.
If this paper has shown one thing, it is that it is essential to have a functioning sustainability data system in perspective, because: In the traditional business world, we are used to preparing and reading quarterly financial statements, annual financial statements and KPIs. In the future, we will handle sustainability data just as naturally. SUScube is one solution to embark on this journey and to be able, to serve future requirements in the best possible way and thus generate competitive advantages.

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URN: urn:nbn:de:hbz:6-55918722080
DOI: 10.17879/55918720584

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URN: urn:nbn:de:hbz:6-55918721789
DOI: 10.17879/55918720299

Practitioner's Section

Tim Greitemeier[a,*] Carina Albrecht[a], Reba Brockington[a], Sebastian Eggers[a], Lars Hansner[a], Niklas Kamp[b], Hauke Simon[b] and Simon Lux[a,c]

International M&A transaction volumes along the battery value chain: Strategic investment implications

The objective of this study is to examine the international value streams associated with the battery industry, which plays a pivotal role in the global effort to combat climate change. This research provides an in-depth analysis of mergers and acquisitions (M&As) in the global battery market, as a tool for monitoring the innovation strategies of global enterprises in the various regional key markets. Prior research has demonstrated the efficacy of data science methods in the analysis of M&A data across a range of industries and technological domains. An exploratory analysis of a dataset comprising 913 deals from 2018 to 2022 was conducted to investigate the foreign and domestic contributions of North America, Europe, and Asia in relation to individual segments of the value chain. The results highlight North America as the most substantial deal value contributor, peaking in 2021, within the region and investment balance with other key markets. Further, the findings demonstrate that the value streams are largely driven by product manufacturers and enablers.

Keywords: Mergers & Acquisitions; Value chain; Batteries; Data Science; Value stream; Innovation

Introduction

In line with its commitment to achieving carbon neutrality, both society and the global industry have been actively engaged in a long-term process of electrification (Despeisse et al., 2023). The two most significant technological developments are stationary energy storage systems, which facilitate the short-term storage of electricity derived from renewable energy sources, and the ongoing expansion of electric vehicles (EVs), which will ultimately result in a reduction of current emissions from internal combustion engines (ICEs) in the transportation sector (Rísquez Ramos and Ruiz-Gálvez, 2024). Both technologies are based on batteries, particularly lithium-ion batteries (LIBs), which represent a significant cost factor, accounting for approximately one-third of the total cost of an EV (Carlier, 2023). These costs are distributed across the entire value chain, commencing with the extracted powder, and concluding with the implementation in the final application (Bernhart, 2014). This includes the transportation and production of the cells, modules, and packs within gigafactories (Yuan, 2023). A reduction in costs can be

[a] University of Münster, Institute of Business Administration at the Department of Chemistry and Pharmacy, Leonardo Campus 1, 48148 Münster, Germany.
[b] EY-Parthenon, Friedrichstraße 140, 10117 Berlin, Germany.
[c] Fraunhofer Research Institution for Battery Cell Production (FFB), Bergiusstrasse 8, 48165 Münster, Germany.
* Corresponding author (timgreitemeier@uni-muenster.de)

Vol.21, Iss.3, October 2024
URN: urn:nbn:de:hbz:6-55918721789
DOI: 10.17879/55918720299

pursued through a variety of levers within the value chain, including the reduction of production scrap and the recycling of active materials from used battery packs (Ciez and Whitacre, 2019). Further improvement opportunities arise from the advancement of manufacturing. This incorporates both incremental innovations, which entail the continuous enhancement of process expertise, and radical innovations (Duffner et al., 2021), such as the introduction of dry coating (Ryu et al., 2023). The latter has the potential to serve as a pivotal foundation for the industrialisation of all-solid-state batteries (ASSBs), representing an innovation with the capacity to exert a profound impact on future trends and costs in the context of electrification at the technology level (Randau et al., 2020). In addition to the aforementioned innovations, there are numerous other examples of innovations in the battery industry whose origins are in a state of constant flux (Wang et al., 2023; Xiao et al., 2023).

Research and development (R&D) conducted by companies and academic institutions emerges as a particularly prominent driver (Roper and Hewitt-Dundas, 2013). The reinforcement of R&D and the subsequent enhancement of innovative strength offer a potential competitive advantage for the respective companies or entire regions (Wörter et al., 2010). The consolidation of this growth is achieved, among other means, through the injection of financial incentives, which also include tax reductions and grants (Choi, 2022; Knoll et al., 2021; Mitchell et al., 2020). In the field of battery R&D, such incentives are primarily driven by the respective regional governments with the objective of assisting companies to maintain their relevance within the global value chains (Campagnol et al., 2022; Li et al., 2024; Zhu et al., 2022). Notable examples include initiatives addressing climate change on a global scale, such as the United States' (US) Inflation Reduction Act and Europe's Green Deal, as well as the RISING project in Japan, which is focused on the advancement of novel battery technologies. As a technology leader, China regularly promotes investments allocated to this industry as part of their 5-year plans (Fraunhofer ISI, 2024).

In addition to the examination of government investments in the battery sector, data science methods can be employed to obtain information on technological innovations. In 2024, An and Cho employed bibliographic data to obtain information on international R&D collaborations within the entire battery industry through the application of a network analysis (An and Cho, 2024). In order to obtain an overview of the distribution of expertise along the value chain within a gigafactory cell production, a novel keyword-based patent analysis was also implemented (Greitemeier and Lux, 2024). Despite the growing number of data science-based analyses (Aaldering and Song, 2019; Ahlgren et al., 2023; Hemmelder, 2023; Malhotra et al., 2021), there has been a distinct lack of examination of data from M&As within this context thus far.

M&As represent one aspect of open innovation, facilitating the rapid acquisition of technical knowledge and the generation of productive synergies (Chesbrough, 2010). The application of M&As is categorised as a driver of innovation yet is also subject to critical assessment in other studies. On the one hand, M&As facilitate the expansion of the knowledge base without the necessity for high innovation risks (Cassiman et al., 2005; Cohen and Levinthal, 1990). On the other hand, M&A activity has the potential to weaken competitiveness within the respective industry, which may result in a reduction in research and development (R&D) investments and an impediment to innovation (Hall, 2010). The merits of M&As are a topic of considerable debate in academia. Nevertheless, numerous studies based on M&A data have already been successfully conducted in the fields of agriculture (Hong and Chen, 2022; You and Lio, 2024) and technological expansion (Jin et al., 2024). With regard to the emerging energy industries, Zhu et al. as well as Zhong et al. conducted work to assess the impact of M&As on innovation and performance of enterprises in China, whilst the latter provided a deeper insight into the LIB industry (Zhong et al., 2023; Zhu et al., 2024). The study demonstrated that the number of completed M&As in Chinas LIB industry has increased significantly, from 87 in 2016 to 272 in 2022 (Zhong et al., 2023).

The preceding studies have demonstrated that the analysis of M&A data can provide a deeper understanding of innovation know-how and collaborations within the battery industry. Given the prevailing focus of previous research on the energy sector in China, there is a notable absence of analysis concerning global cooperation through M&As. Moreover, the existing literature has not yet considered the individual value streams separately in the context of M&As. Consequently, this study employs an analytical approach to examine M&A data for a more profound understanding

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URN: urn:nbn:de:hbz:6-55918721789
DOI: 10.17879/55918720299

of the global value streams within the battery value chain. Furthermore, the objective is to ascertain the principal regions of each value chain segment, thus facilitating the formulation of strategic implications for investors. This includes the identification of regions that are of vital importance and the way they collaborate on a global scale. Additionally, it entails the determination of value chain segments that represent the most significant targets for M&As and, consequently, innovation. Ultimately, the regional distribution within each segment of the battery value chain is identified.

Materials and Methods

The flow chart proposed for the analysis of M&As consists of three phases of analysis that lead to implications for investors (Fig. 1).

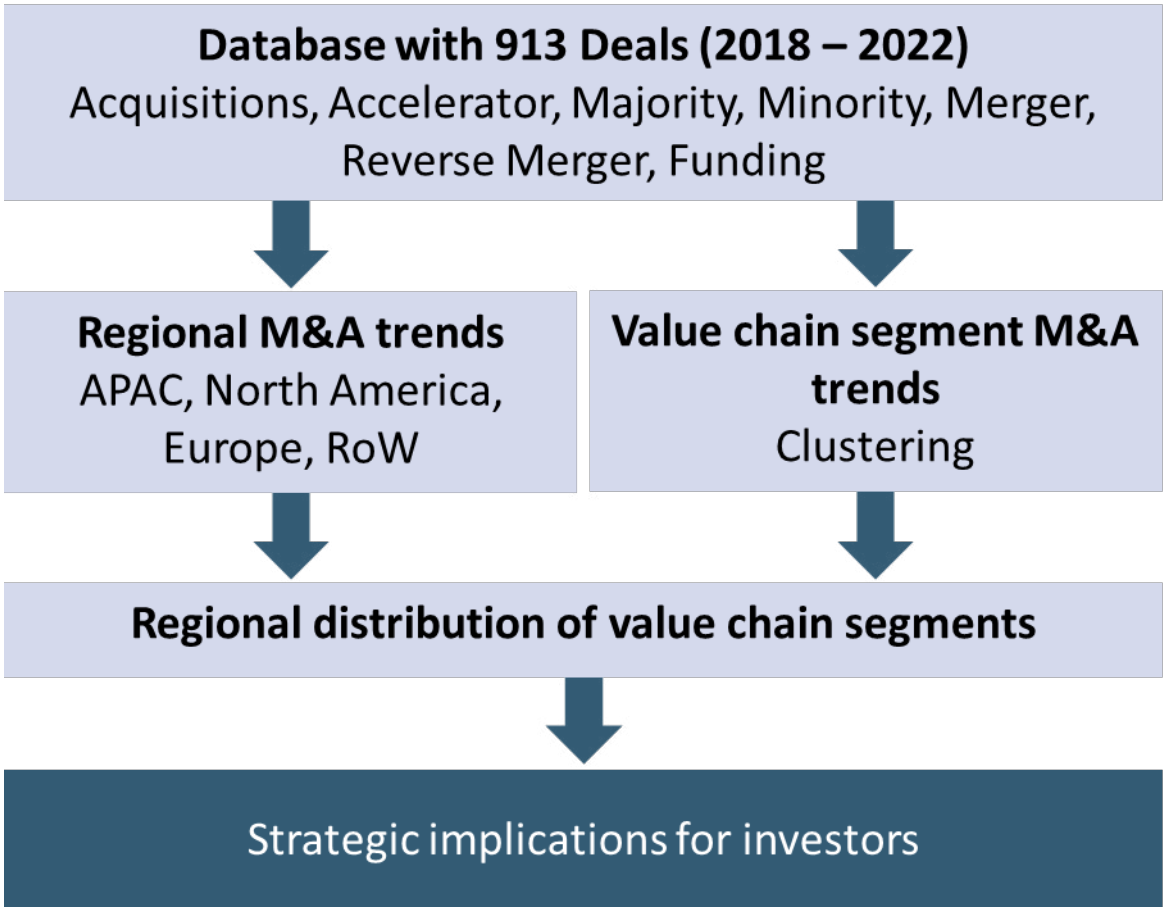

Figure 1: Flow Chart of M&As analysis systematics.

The initial dataset, comprising over 2000 deals, was collected via a combination of public information, pitchbooks and secondary research, including expert interviews. Subsequently, the dataset was reduced to just over 1400 deals. Further exclusion of deals in the renewable energy sector, healthcare, agriculture, and media reduced the dataset to 913 deals. The final dataset of 913 deals was filtered, clustered, and categorized. Categorization was done by adjusting sub-segments (Table 1).

After pre-processing the dataset, the first step is to examine the value flows within and between regions. The analysis period is defined as 2018 to 2022, as M&A deal values significantly increased during this time, but also see some interference due to the COVID-19 pandemic. For the regional breakdown, the three largest competitors, Asia-Pacific (APAC), Europe, and North America, were selected for analysis. The remaining countries are aggregated as the Rest of the World (RoW). The dataset presents

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URN: urn:nbn:de:hbz:6-55918721789
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business transactions sorted by year and region, allowing examination of regional developments throughout the value chain. In the second phase of analysis, the previously applied categorisation into value chain segments enables the examination of the development of each cluster. The third phase combines the first two phases and is used to assess the geographical distribution of each value chain segment.

Table 1: Screening approach by value chain segments, deal broad subsegments, and deal subsegments.

Value chain segment	Deal broad subsegment	Deal subsegment
Material production	Anode/Cathode material; Lithium; Others	Different materials
Cell component manufacturer	Anode/Cathode foil; Electrolyte; Separator	Different materials
Cell manufacturer	Energy storage; EV; Electrical appliances; Others	Subdivision by use of rare materials
Pack manufacturer (including modules)	Energy storage; EV; Production	Subdivision by use of rare materials
Product manufacturer	Energy storage; EV; Supply	Subdivision by use of rare materials
Enablers	Energy storage; Battery management; Charging infrastructure; Distributors; Software	Individual subdivision
Recycling		
Others		

Results

Regional M&A trends

After the final processing the dataset contains 913 deals worth a total of 141 billion US-Dollar (USD). Fig. 2 presents the regional distribution of the annual a) number of deals, and their corresponding b) deal values. Considering the number of deals in a), a steady overall increase from 2018 to 2022 becomes evident, apart from 2020 due to the impact of the COVID-19 pandemic. In 2022, the number of deals reaches a new high of 278, indicating the ongoing rise of the battery industry (Zhao et al., 2021). In this year, APAC has taken the lead with 127 deals, which may indicate a future dominance of this region in the upcoming years. In previous years, the number of deals was evenly distributed across the selected regions, consistently ranging from 50-69, while the RoW reported less than 10 deals each year. In contrast to the amount of deals, the deal values in b) reach their high of 82,098 million USD in 2021, which is dominated by North America with a value share of 74% in this year. The increase of 325% compared to the previous year can be attributed to the occurrence of mega deals, which are defined as deals with a value greater than 3,000 million USD. Although the distribution of deal values was relatively even in 2018 and 2019, it became distorted by several mega-deals in the following years. In 2022, Europe and APAC held the highest value, with North America dropping to third place. The proportion of deal values that are unknown, and which could potentially affect the results, consistently ranged between 13% and 18% throughout the analyzed period. Therefore, this lack of information can be disregarded for the purposes of analysis.

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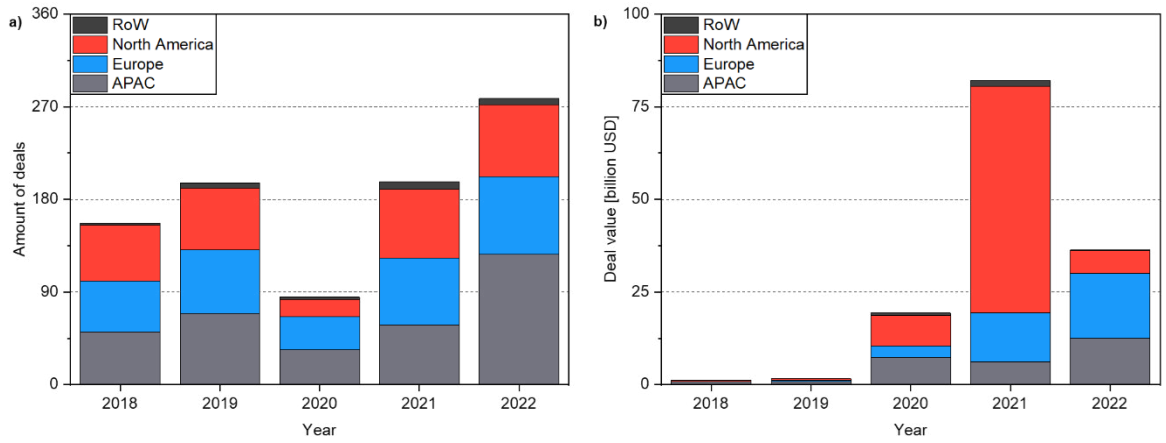

Figure 2: Regional distribution of the annual a) number of deals, and b) deal values.

In Fig. 3 the transaction volumes (in millions of USD) between North America, Europe, and APAC in the battery sector from 2018 to 2022 are illustrated. The analysis did not consider the RoW, as their accumulated deal value is only around 2%. North America leads in both domestic and foreign investment, with a total worth of 111,440 million USD. This trend is further reinforced by the IRA, which has given North American companies a sustainable competitive advantage in the US and has driven domestic investments (Bistline et al., 2023; Slowik et al., 2023). Despite the lower deal volumes in Europe and APAC, all three regions primarily focus on domestic investments, with a share above 70%. The APAC region is particularly interested in boosting its domestic markets, with an investment share of 84%, thereby indicating a distinction between APAC and North America and Europe. This trend is also evident in the value of foreign investments, where the connection between Europe and North America sums up to 26,216 million USD, representing a share of 55% of the total foreign investments. As the APAC region, particularly China, Japan, and South Korea, leads the way in battery innovation, the tendency towards domestic investments may suggest a desire to expand their dominance (Beuse et al., 2018; Nedopil, 2023; Stampatori et al., 2020). In this case, it is necessary for North America and Europe to strengthen their position and further expand their connection with the APAC region to increase competitiveness in this booming industry. In certain instances, such as the collaboration between Tesla and Panasonic (Jiang and Lu, 2018), this has already occurred. However, it is crucial to intensify this process in the coming years. Given the intense competition for a competitive market position in the battery sector, this is a matter of critical importance.

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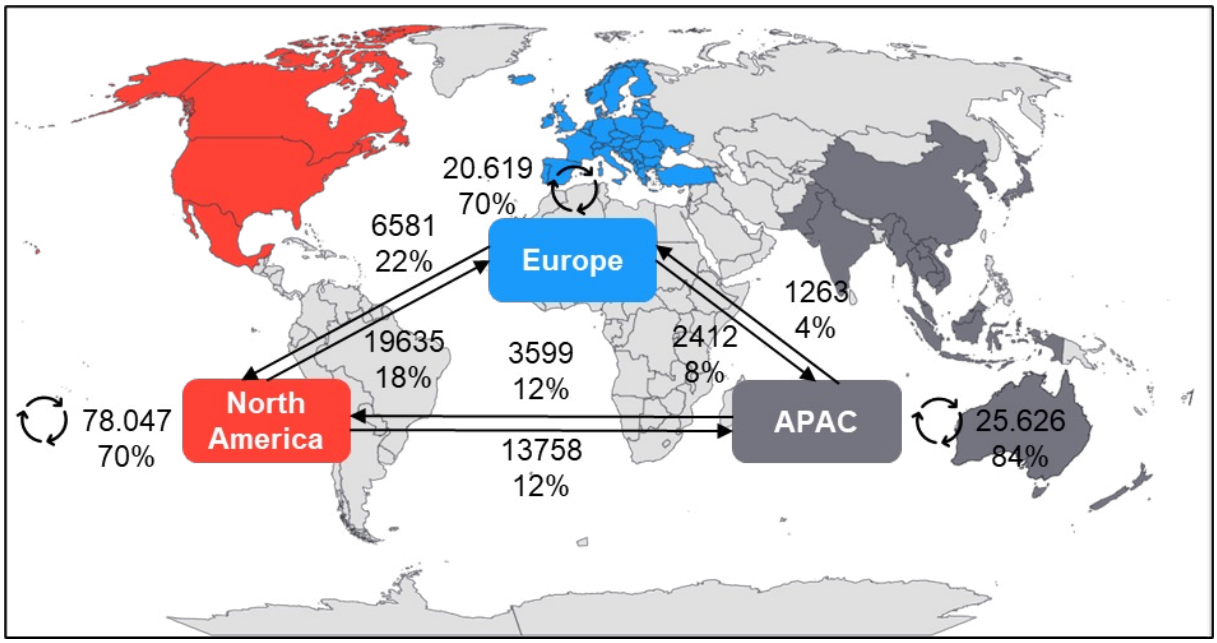

Figure 3: Deal values of M&As in billion USD from 2018 to 2022 between North America, Europe, and APAC.

Value chain segment M&A trends

In this part of the study, the annual number of deals and their corresponding deal values are analyzed regarding their value chain segments (Fig. 4). The data in a) indicates that product manufacturers and enablers are the most active deal makers. In 2022, product manufacturers completed a record-breaking 77 deals across all segments, but their growth rate of 24% between 2018 and 2022 is relatively low compared to other segments of the value chain. The recycling segment, which has experienced a growth of 750%, has gained increasing importance over the years. This is consistent with current R&D and policy efforts to expedite the advancement of recycling processes and the transition to circular economy models (Bird et al., 2022).

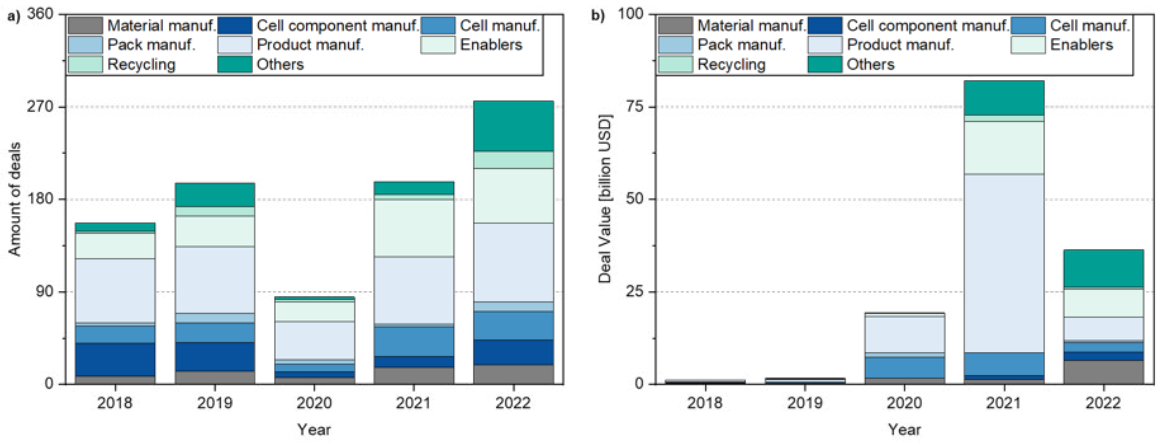

Figure 4: Value chain segment distribution of the annual a) number of deals, and b) deal values.

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In the record year 2021, the product manufacturer segment was the main contributor of value, accounting for 59% of the deal values in b). It can be inferred that North American product manufacturers played a significant role in the major deals of 2021. In 2022, the deal values are more evenly distributed, with the segment ‚Others' leading with a deal value of 10,145 million USD. As the ‚Others' segment includes innovations and trends that do not currently fit into any known cluster, the increase in investment in recent years indicates a growing interest in this sector, which offers many developments in the near future and are maybe outside "classical" segments of the value chain.

Regional distribution of value chain segments

The final step in this analysis is to examine the regional distribution of each value chain segment (Fig. 5). As a consequence of some of the deals being assigned to multiple process steps, the total number of deals and the total value of the deals increased in comparison to the previous results. Both the number of deals and the total deal value are dominated by product manufacturers. The distribution of deals is evenly spread across the top three regions. However, North America has the highest deal values in this segment, suggesting that North American product manufacturers, such as Tesla and a variety of start-up's, are the most influential in the battery industry (Liu, 2021; Thomas and Maine, 2019). In combination with the previous results, which indicate increasing deal values from North American product manufacturers, it can be deduced that they want to strengthen their position and increase their market share in this segment of the value chain. Overall, it can be inferred that deal activity is highest in Europe across most parts of the battery value chain, but North American manufacturers generate the highest deal values. Currently, the APAC region dominates materials and cell component manufacturing, with companies such as LG Chem, Samsung and CATL leading the world in cell production (Statista Research Department, 2024). When considering the ‚Others' segment, which has seen significant growth in recent years, North America is leading the way, particularly in terms of deal values. This success probably can be attributed to the internationally acknowledged R&D in the top universities and the national laboratory system, which pushes innovations in this field (Dutta and Reynoso, 2020).

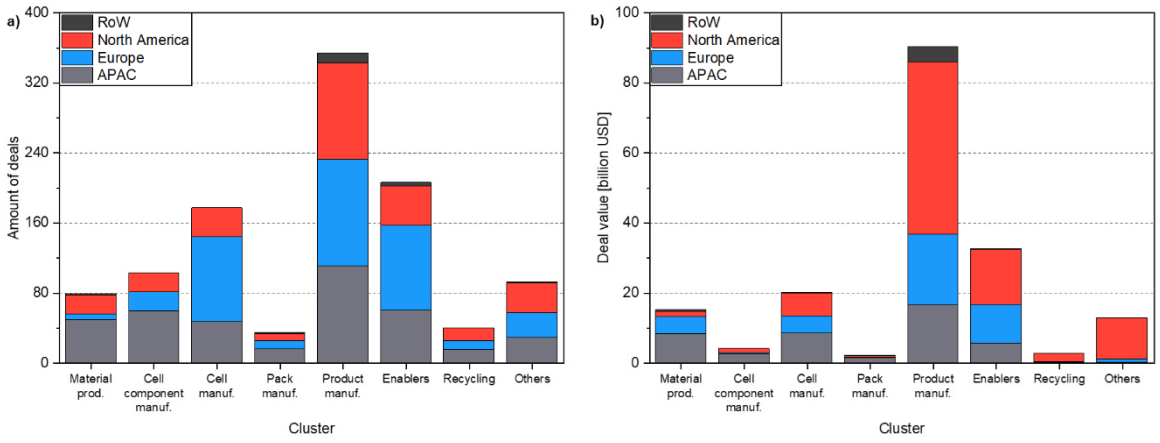

Figure 5: Regional distribution of each value chain segment regarding the a) number of deals, and b) deal values (Interval 2018-2022).

Conclusion

The study effectively developed a framework to extract strategic insights for investors and policymakers from M&A data in the battery sector. This data facilitated the identification of various trends within the value chain and international competition.

Regional M&A activity analysis reveals that while deals span all regions, North America has generated the highest deal value from both domestic and foreign investments, notably enhanced by the implementation of the IRA. Europe and the APAC region are striving to improve their market positions,

Vol.21, Iss.3, October 2024
URN: urn:nbn:de:hbz:6-55918721789
DOI: 10.17879/55918720299

evidenced by significant growth in deal numbers and values. The analysis indicates that product manufacturers are the largest contributors to M&A activity, followed by enablers. In 2021, North American product manufacturers dominated the scene, likely completing several mega deals. The rising share of the ‚Others' segment suggests advancements and potential innovations outside traditional value chain segments.

The findings indicate a relationship between the North American region and the product manufacturer segment. Additionally, the initial segments of the value chain are primarily led by the APAC region, while the latter segments are deal value leaders in North America.

These insights yield the following strategic implications. First, investors should diversify their investments to mitigate risks and enhance returns. The less prominent value chain segments - pack manufacturing and recycling - present a promising avenue for growth and innovation, particularly recycling due to its increasing necessity. Second, target investment regions differ by segment, as primary production expertise resides in the APAC region, indicating a key market to watch for technology trends. Conversely, the latter segments of the value chain are predominantly in North America, suggesting that investments in the US are favourable for these areas.

However, the study has limitations, including minor inaccuracies in the dataset. For example, there may be discrepancies between listed and operational regions, as company headquarters do not always align with their manufacturing sites. Furthermore, relying exclusively on M&A deals may not fully represent each segment. Future research could incorporate analyses of foreign direct investments to reveal additional deal value trends and provide further insight into the strategic implications. Moreover, this research can be further developed by extending the analysis period and investigating correlations and ratios. This would enable the identification of the underlying rationale behind the deals, which could be achieved by industry interviews.

CRediT authorship contribution statement

Tim Greitemeier: Writing - original draft, Visualization. **Simon Lux:** Writing – original draft, Supervision. **Carina Albrecht:** Methodology, Formal analysis, Visualization, Software. **Reba Brockington:** Methodology, Formal analysis, Visualization, Software. **Sebastian Eggers:** Methodology, Formal analysis, Visualization, Software. **Lars Hansner:** Methodology, Formal analysis, Visualization, Software. **Niklas Kamp:** Methodology, Formal analysis. **Hauke Simon:** Writing – original draft, Methodology, Formal analysis.

Declarations of interest

None.

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JOURNAL OF BUSINESS CHEMISTRY

ISSN 1613-9623