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Model Evaluation of Post-M&A Success Metrics in the German Biopharmaceutical Industry

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Abstract

Purpose: This study evaluates the success metrics of post-merger and acquisition (M&A) activities in the German biopharmaceutical industry, focusing on small- and medium-sized enterprises (SMEs). It examines how metrics such as economies of scale, economies of scope, market share, clinical success rate, and efficient allocation of personnel and resources affect post-M&A revenue.

Design/Methodology: The study uses partial least squares structural equation modeling (PLS-SEM) to analyze data from a survey of 384 biopharmaceutical SMEs in Germany. The survey targeted senior management involved in M&A processes, with the analysis assessing the reliability, convergent validity, and discriminant validity of the success metrics, and the statistical significance of the structural path coefficients.

Findings: The results indicate that efficient allocation of personnel and resources, as well as clinical success rate, significantly impact post-M&A revenue. In contrast, economies of scale, economies of scope, and market share do not significantly affect revenue. The study also emphasizes that while M&A activities can lead to operational efficiencies and cost savings through synergies, these benefits alone do not ensure revenue growth without effective resource management and innovation. Internal efficiencies and clinical outcomes are more critical than market expansion strategies.

Originality/Value: The study introduces a novel methodology for evaluating different success metrics in post-M&A performance within the biopharmaceutical industry using PLS-SEM. The combination of success metrics and their impact on post-M&A revenue is identified as a relatively unique research contribution.

Keywords Mergers and acquisitions (M&A), post-M&A success metrics, German biopharmaceutical industry, structural equation modeling (PLS-SEM), operational efficiency, revenue growth

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1. Introduction

Mergers and acquisitions (M&As) are frequently used as one of the most popular strategic business approaches to produce value and synergy in the pharmaceutical and biotechnology industries, as well as other industrial sectors. In 2021, the total value of worldwide M&A deals in the life science industry sector was US$ 108 billion total which is roughly 40% of the value of biopharma M&A in 2019 (Ernst and Young, 2021). The unrelenting and rising demand for fresh and innovative pharmaceutical and biotechnology assets is one of the primary drivers of M&A transactions in the life science industry (Schweizer, 2002). Further advantages of such transactions are an immediate access to a wide range of distribution channels, new technologies, interesting product pipelines and desirable market positions (Schweizer, 2012). Moreover, one of the main drivers for M&A transactions in the biopharmaceutical industry is an unrestrained need for new and innovative life science products, which is founded by unmet medical needs and rising expectations on behalf of patients (Schweizer, 2002). In addition, as argued by Pervaaz (2010), the rise in M&A activity may be explained by both direct and indirect triggers, such as health care reform in the US, greater regulatory pressure, weak research pipelines, and a rise in generic competition. Furthermore, sales growth and access to innovation improves. Due to the consolidation of different pharmaceutical and biotechnology sectors and the favorable interest rate situation in Germany, growth of M&A activities is going to be constant. Even though the motives for M&As differ, there are certain commonalities. Expiring patents for blockbuster drugs, drying pipelines, and competition from generic brands, for example, will increase the number of M&As and concentrate the market of German and global pharmaceutical and biotechnology corporations (Danzon, 2007).

Despite the increasing tendency for biopharmaceutical M&A, recent research proves that there is not an assured rate of success (King *et al.,* 2008; Papadakis, 2005). Between half and three-quarters of M&A transactions end in failure due to factors such as overpaying, misleading acquisitions motive, and challenges in the post-acquisition integration process (Agrawal and Jaffe, 2000; Datta and Grant, 1990; Schweizer, 2002; Sirower, 1997). For example, after their merger, Hoechst Roussels' market share dropped by more than 50%, Ciba-by Geigy's more than 20%, and Glaxo Wellcome's by more than 15%. Shares of pharmaceutical businesses that were not involved in mergers, such as Schering-Plough/Pfizer, increased by 40-80%. Further research studies by Heracleous and Murray (2001) argue that most mergers have not delivered shareholder value; but rather destroy it. A review of frequently used antecedent variables on M&A performance by King *et al.* (2004) found that there is not a clear link from certain variables to the acquisition firm’s performance.

It can be stated that the current empirical research has not clearly and repeatedly identified those variables that impact on the acquiring firm’s performance. Furthermore, it is argued that researchers have not looked at the ‘right’ set of variables and therefore should pay more attention to the non-financial variables that are currently under-represented in theory and research. Therefore, a common unanswered question is whether M&A motives are successful contributors to a company's turnover or if they reduce it.

The purpose of this paper is to evaluate different post-M&A success metrics and their relationship to post-M&A revenue of biopharmaceutical companies. The research seeks to add valuable primary data, as well as knowledge about different success metrics for cooperation's and future M&A analysis in the biopharmaceutical industry.

2. Literature review, research context and hypotheses development

The objective of this paper is to present and evaluate different post-M&A success metrics and investigate their relationship to post-M&A revenue of biopharmaceutical companies. For this purpose, financial- and perception-based performance measures of post-M&A success were determined and presented as part of a comprehensive literature review.

2.1 Financial performance measures for M&As

One strategic aim of a business is to make a satisfactory return on capital after the M&A process. Such return can be measured using different ways. For example, fields that are related to finance use objective measures such as share-price movements and accounting data. The most popular evaluation for post-M&A performance are short-term financial measures, accounting-based performance measures and long-term financial performance measures (Thanos and Papadakis, 2012). The use of accounting metrics come from the idea that one can assess the post-M&A performance by looking at the pre- and post M&A revenue it occurred. The intention for this is that the difference in revenue measures the economic performance of a firm in an appropriate and accurate way. In accounting studies such success measures are expressed as the change of the net income, return of equity (ROE), return on assets (ROA), return on sales (ROS), profit margin, growth rates, revenue and liquidity (Bruner, 2004; Pilloff, 1996).

However, financial performance measures in the short term may not measure actual performance and may just reflect the current investor expectations, which could be very different than what might actually happen to the company (Papadakis and Thanos (2010)). Analysts are sceptical of traditional accounting-based measures as they reflect past performance and are imperfect in their effort as they measure only the economic performance of the company (Papadakis and Thanos, 2010; Montgomery and Wilson, 1986). Another limitation is that they do not capture the effect of events such as M&As (Larsson and Finkelstein, 1999; Papadakis and Thanos, 2010).

M&A reviews are often just about the company's immediate performance. They often fail to look at how M&As can impact the company's long-term goals or objectives and therefore painting an inaccurate picture of M&As success (Thanos and Papadakis, 2012). Financial post-M&A performance measures may be affected by outside variables, biased to reflect expectations, subject to manipulation, and they can only be used for companies with an access to financial data reports (Brouthers *et al.*, 1998; Thanos and Papadakis, 2012).

In the future, M&As will be ongoing, however acquisition performance is still up for debate. Papadakis and Thanos (2010) found that most management scholars have used financial performance measures like short-term financial performance, accounting performance, long-term financial performance to assess post-M&A performance.

Sporadically management scholars have used retrospective surveys in aspects such as divestiture, innovation performance and integration process performance to assess post-M&A performance.

2.2 Perception-based performance measures for M&As

A central perception-based performance measure is the retrospective subjective assessment of M&A activity. Within these assessments, key respondents such as Chief Executive Officers (CEOs), Chief Financial Officers (CFOs), Directors, Managers and Consultants rate the degree to which individual subjective performance measure, which have been set before the M&As, are met after the M&A (Thanos and Papadakis, 2012). Such perception-based performance measures can be highly individualised and aligned with the respective M&A objectives, as discussed in the upcoming sections. Literature analysis by Thanos and Papadakis (2012) revealed that retrospective assessment of M&A performance has been used in total by 17.5% of researchers on the topic of M&A performance. Brouthers *et al*. (1998) suggest that key success factors, such as "the measure of M&A performance" should be used by managers for better understanding the achievements resulting from M&As, rather than just relying on financial performance measures like the shareholder value. *'Key success factors allow managers to measure performance on each objective, not just a single objective,'* (Brouthers *et al.*, 1998, p 348). Researchers as Brouthers *et al*. (1998) and Schweizer (2002) propose to assess the success or failure of M&As by measuring the key success factors after the M&A. As discussed by Dess and Robinson (1984) perception-based measures are justified in cases where financial measures of performance are not available. The perception-based evaluation of post-M&A performance has some benefits, including the ability to evaluate performance in a composite way and consideration of the various M&A-related goals (Larsson and Finkelstein 1999; Brouthers *et al*. 1998). However, it should be mentioned that perception-based evaluation of post-M&As performance is limited by respondent bias, erroneous memories of the past, signs of post-rationalization and familiarity with the specific M&A (Thanos and Papadakis, 2012). Additional research on the formation of success factors and their relationship to post-M&A performance is advised by scholars such as Schweizer (2012) and Haleblian *et al*. (2009). This is consistent with Haleblian *et al*. (2009), who highlighted the need for a fit between M&A success metrics, the topic of analysis, and the issue of interest in order to quantify M&A performance successfully. According to Brouthers *et al*. (1998), managers may see M&As as successful if they compare the M&A's success to specified goals that are often established at the outset of M&A transactions.

2.3 The biopharmaceutical industry

The biopharmaceutical industry is an industry sector that produces drugs utilizing biotechnology processes. It is (as well as the pharmaceutical industry) characterized by a) a high investment volume b) special knowledge and technologies and c) a long breath (timelines), which is expected in the development of new drugs, due to the long clinical trials, approval procedures and failures. Common biopharmaceutical products are monoclonal antibodies, vaccines, recombinant proteins, non-recombinant cultured-derived proteins, blood/ plasma-derived products and cultured cells and tissues (Walsh, 2003). Such development and manufacturing of novel and cutting-edge life science products needs highly specialized skills and know-how, substantial financial resources,

handling of complex technologies and rapid switch to innovative technologies (Schweizer, 2012). Companies that cannot afford such pace and magnitude of technological changes, but still want to remain competitive, need other strategies. According to Schweizer (2012), M&As are a possible strategy for overcoming a lack of knowledge, reducing R&D costs and increasing the number of potential products in a pipeline. These arguments could be the reason for a wave of M&A, not only in the German biopharmaceutical market, but also in countries such as the USA, France and Switzerland.

Based on the literature review on post-M&A success metrics in the biopharmaceutical industry and in accordance with a study performed by Leschik *et al.* (2020), the following post-M&A success metrics have been chosen for the development of a research framework and hypothesis formulation.

2.4 Efficient allocation of personnel or resources

According to Danzon *et al.* (2007), the biopharmaceutical industries in the United States are research-intensive, with an average R&D to sales ratio of 18% in 2003. In order to increase the R&D-to-sales ratio, it makes sense that a biopharmaceutical M&A enables the participating firms to combine their R&D efforts more effectively. In accordance with LaMattina's (2011) findings, merged firms spend less on R&D due to the effective allocation of R&D operations. An excellent example is the pharmaceutical firm Pfizer, which merged with Wyeth in 2006 and spend 11% of revenues on R&D after the merger compared to 16% prior to the merger. However, every efficient allocation of human resources into departments like R&D, production, warehousing etc. comes down to post-M&A culture and people integration issues. According to Buono and Bowditch (1989), the human aspect of M&As is typically overlooked because they might result in a disturbance of culture and an increase in stress. As further argued by Buono and Bowditch cultural differences are considered as one of the major reasons why M&A fail. However, Schweizer (2005, 2009) argues that differences in terms of national cultures do not play a major role in the successful post-M&A integration. A research study from Leschik *et al.* (2020) argue that a successful organization/ culture integration post-M&A is an important success factor. Furthermore, Schweizer (2005, 2009) argues that after an M&A the fluctuation of R&D people is much less than compared with top managers in the biotechnology industry. This is in line with Ranft and Lord (2000) which argue that it is more important to retain the specialist as they know how to operate the machines and apply the technologies. It is therefore suggested that the efficient allocation of human resources and resources following an M&A positively affects economies of scale and economies of scope, hence maximising value and total production. Production efficiency is the process of maximising the value of products and services produced with a given set of resources, taking into consideration the costs of those resources. Additionally, efficient allocation of employees and resources reduces research and production costs, hence facilitating economies of scale and economies of scope. This is in line with Schweizer (2005, 2009) which argue that M&As provide advantages like better access to more resources, advanced technologies and better trained and skilled personal. In both instances, economic growth is the result. Efficient allocation of resources and staff following an M&A improves the emphasis on the concurrent development of many products.

Consequently, the following hypotheses are suggested:

H1: The post-M&A success metric *"Efficient allocation of personnel and resources"* has a positive impact on the post-M&A success metric *"Economies of scale"*.

H2: The post-M&A success metric *"Efficient allocation of personnel and resources"* has a positive impact on the post-M&A success metric *"Economies of scope"*.

2.5 Economies of scale and economies of scope

Companies engage in M&As to consolidate their operations and lower production costs, boost output, enhance product quality, acquire new technology, or introduce wholly new products. In this instance, the prospective efficiency includes managerial efficiency (Pautler, 2003). According to Farrell and Shapiro (2001), operational efficiencies may result from economies of scale, production economies of scope, consumption economies of scope, improved resource allocation (more resources in the hands of better managers), moving to a less expensive production technology or asset configuration, improved use of information and expertise, enhanced concentration on the firm's core competencies, and a more effective combination of assets.

According to Danzon *et al.* (2007), Cockburn and Henderson (2001)), and Ravenscraft and Scherer (1987), large biopharmaceuticals companies frequently justify M&As by claiming economies of scale and economies of scope. Mergers allow for the removal of redundant biopharmaceutical facilities, resulting in short-term cost reductions to balance the negative impact of falling revenues on net profits and long-term economies of scale (Danzon *et al.*, 2007). According to Sharma and Ho (2002) and Kurdas (1998), economies of scale reduce the cost of production through size, but economies of scope relate to complementarity and make joint production of items more cost-effective than individual production. In biopharmaceutical industry M&As that are rationalized by economies of scale, reduce manufacturing costs as a result of the cheaper combined production of more products (like drugs). On the other hand, economies of scope results from the pooling of tasks such as research and development, quality assurance, financing, and marketing. DiMasi, Hansen and Grabowski (2003) established that new medication R&D is a lengthy and expensive process. Therefore, it may be predicted that cooperative R&D operations on novel pharmaceutical drugs sparked by M&As will lower research, discovery, and development expenses, making them more efficient than R&D activities conducted individually and thereby add positive aspect to economies of scope. Although the focus of economies of scale and economies of scope is cost reduction, it is important to note that both strategies can indirectly influence an increase in revenue. For example, cost reduction can enable the company to invest into R&D activities resulting in higher R&D-to-sales ratio or into marketing initiatives to boost demand for new drugs (Schweizer; 2009; Danzon *et al.*, 2007; Kumar and Gupta, 2023). However, it is important to mention that the primary aim of economies of scale and economies of scope is not necessarily to directly foster revenue growth; instead, it is an indirect potential consequence of the cost advantages obtained. Anyhow, it is suggested that economies of scale and economies of scope have a positive link with firms' post-M&A revenue through more drugs sold, as the M&As will reduce production costs, boost output, and make it less expensive to jointly create new goods (Cockburn & Henderson, 2001; Danzon *et al.*, 2007; Sharma & Ho, 2002).

Consequently, the following hypotheses are put forward:

H3: The post-M&A success metric *"Economies of scale"* is positively related to post-M&A revenue of biopharmaceutical companies.

H4: The post-M&A success metric *"Economies of scope"* is positively related to post-M&A revenue of biopharmaceutical companies.

2.6 Market share

Numerous economists view an active market for firms as an essential safeguard against poor management. Mitchell and Mulherin (1996) view an active market for corporate assets as advantageous because it facilitates a more effective reallocation of resources from relatively inefficient enterprises to efficient ones during periods of industry contraction or industrial instability.

In the biopharmaceutical industry, M&As provide substantial benefits for strengthening the acquirer's pipeline and, consequently, the market power of a prospective blockbuster drug. According to Danzon *et al*. (2007), the biopharmaceutical industry's share of worldwide sales expanded from 20% in 1985 to 48% in 2002 as a result of M&As. Further, Danzon *et al*. (2007) believes that for a fully integrated biopharmaceutical firm with shortcomings in its product pipeline, a merger with a company with a strong product pipeline but inadequate marketing and sales capabilities might produce value. Consistent with Heralceous and Murray's (2001) views, combining businesses with strong product pipelines might provide corporations with more expertise from which blockbuster pharmaceuticals could emerge, hence enhancing the market strength of the company. Pervaaz (2010) contends that competitive advantages may be realised when M&As lead to the extension of service line portfolios into generic and consumer products. A increased market share appears to be an essential post-M&A success metric as it would boost pharmaceutical and biotechnology businesses' sales and financial standing. According to Bohlin, Daley, and Thomson (2000), the motivation to expand market share justifies mergers and acquisitions. According to Divya and Arisham (2013), the motivations for pharmaceutical and biotechnology M&As are to expand market share and rapidly introduce innovative drug products. Consequently, it is believed that the post-M&A success metric market share has a positive relationship with revenue.

Therefore, the following hypothesis is proposed:

H5: The post-M&A success metric *"Market share"* is positively related to companies' revenue post-M&A.

2.7 Clinical success rate

According to DiMasi *et al*. (2003), the clinical approval success rate is the probability that a biopharmaceutical new drug candidate enters the clinical testing pipeline and is authorised for sale. In contrast, the attrition rate represents the rate at which investigational drug candidates are withdrawn from successive phases of clinical testing (DiMasi *et al.*, 2003). Powell and Brantley (1992) argue that it is uncommon for a single biotechnology company to have all of the required expertise and organisational capabilities for effective clinical testing. Before national authorities permit the sale of novel drug candidates, clinical testing of drug compounds must pass many clinical research stages, beginning with toxicity studies on animals and progressing to human

clinical Phases 1–3. In order to develop proof-of-concept clinical trials for the first human studies and get marketing clearance for the novel drug compound, certain clinical information is necessary (Kola and Landis, 2004). After a M&A, pharmaceutical and biotechnology companies have a strong interest in concentrating their clinical trial expertise and resources to maximise the clinical success rate and decrease attrition rate. According to DiMasi (2001), biopharmaceutical companies acquired novel chemical entities (NCEs) had a greater clinical success rate than their own developed NCEs. According to Pavlou and Reichert (2004) and DiMasi (2001), the successful approval of a new drug will boost the merged company's revenues.

Consequently, the following hypothesis is proposed:

H6: The post-M&A success metric *"Clinical success rate"* is positively related to biopharmaceutical companies' revenue post-M&A.

2.8 Research framework

Individual post-M&A success metrics were discovered during the literature review to correlate with post-M&A performance stated as the revenue difference between pre-M&A and post-M&A, and to contribute to the development of the final study framework. Specifically, *H1 – H6* are incorporated into the final study research framework, as shown in Figure 1.

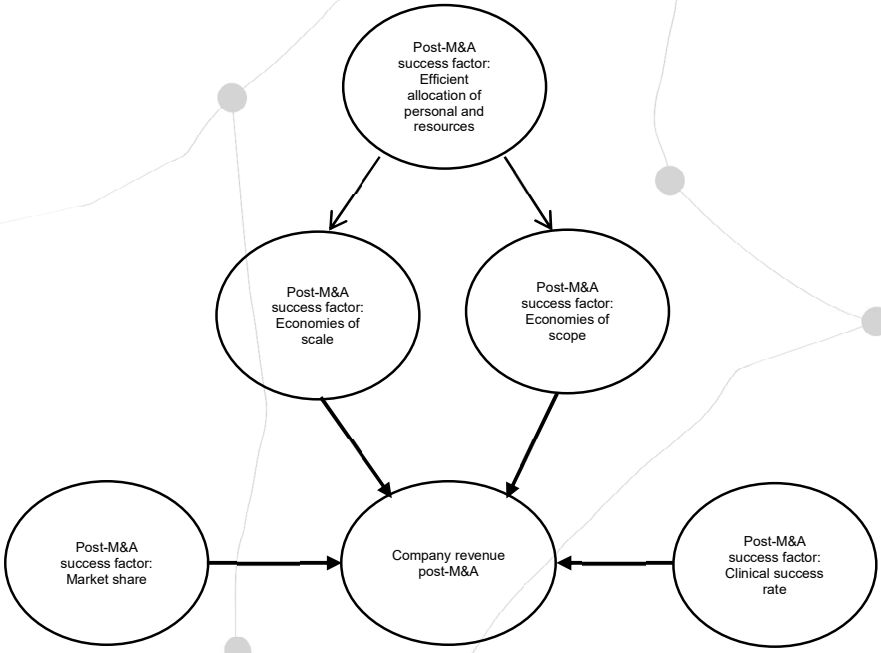

Figure 1. Research framework for Hypotheses 1 – 6

In conclusion, it is claimed that the post-M&A success metrics economies of scale and economies of scope are both indirectly associated to corporate performance post-M&A since M&As will reduce manufacturing costs, boost outputs, and reduce the cost of combined product development (Cockburn and Henderson, 2001; Danzon *et al.*, 2007; Sharma and Ho, 2002). In addition, the cost of production will decrease as a result of more efficient production technology and effective asset combination. According to

Pervaaz (2010), Heracleous and Murray (2001), and Danzon *et al.*, (2007), an increase in market share as a consequence of an M&A would result in an increase in drug sales, and is therefore positively correlated with the post-M&A turnover. The post-M&A success metric clinical success rate is examined by DiMasi *et al.*, (2003), DiMasi (2001), Powell and Brantley (1992), Kola and Landis (2004), and Pavlou and Reichert (2004) and is believed to positively correlate with post-M&A revenue as authorised drug candidate sales increase. The post-M&A success metric efficient allocation of personnel and resources positively effects the post-M&A success metrics economies of scale and economies of scope.

3. Data collection methods

In order to explore post-M&A success metrics and their effect on post-M&A revenue, German small- and medium-sized (SME) biopharmaceutical companies were requested to complete a survey questionnaire to collect direct evidence of management viewpoints. German SME companies determine with over 90% the German biopharmaceutical landscape (Biocom, 2021). In addition, according to a list of biopharmaceutical M&As in Germany from 2002 to 2016, the bulk of M&As occurred between German small- and medium-sized companies (Leschik, 2017). In total 384 small and medium-sized biotechnology and pharmaceutical companies in Germany were selected as participants in the online questionnaire study. In order to increase the validity of the study, only managing directors, chief managers, and managers involved in M&A processes (CEOs, CFOs, COOs, CBOs, chief medical officers, and vice presidents) of such companies were chosen as the primary expert participants, as they typically initiate and conclude the M&A negotiation process and have the expertise and knowledge to execute such M&A deals. Managing directors, CEOs, CFOs, COOs, CMOs, and CBOs of 384 pre-selected SEM organisations were invited to participate via the social networking site Linkedin during the participant selection procedure. A pre-test of the final version of the questionnaire was conducted with volunteers from the pre-selected Linkedin list. The pre-test was useful for modifying the style and readability of the questions, as well as determining the content validity of post-M&A success metrics. In addition, additional items were implemented, as they were considered important to the research question. Before asking participants about M&A-specific success metrics, the survey questionnaire collected basic background information about persons and companies. As part of a matrix question, participants were asked to give their perception on the performance on a variety of post-M&A success criteria, which were measured on a Likert scale ranging from 1 to 7 (1 = very important / 7 = not important at all).

In order to optimize construct validity and reliability, post-M&A success metrics are measured using multi-item measures. The scales are generated from prior research and/or derived from relevant literature, and then adjusted as necessary. Using multiple items helps to average out errors and specificities that are inherent in single items (DeVellis, 2012). Multiple-item measures are inherently more reliable than single-item measures because they permit the computation of correlations between items, which, if positive and producing a high average correlation (i.e., a high coefficient alpha), indicate the internal consistency of all the items in representing the presumable underlying attribute (Bergkvist and Rossiter, 2007). According to Bergkvist and Rossiter (2007), a

second theoretical rationale for multiple-item measures is that a multiple-item measure captures more information than a single-item measure. Table 1 summarise the multiple items used to quantify the post-M&A success metrics.

Multiple items	Acronym for item	Post-M&A success metric
Better economies of scale	EScale1	Economies of scale
Greater efficiency in production	EScale2	
Lower operating and financing expanses	EScale3	
Decrease cost of production	EScale4	
Improved economies of scope	EScope1	Economies of scope
Cheaper joint development of new products	EScope2	
Value creation through complementary skills	EScope3	
Increase in overall clinical success rate	CSR1	Clinical success rate
Enhancement of biopharmaceutical clinical testing and their approval for marketing	CSR2	
Growth of approved clinical tested drug compounds	CSR3	
Reduction of the attrition rate	CSR4	
Efficient reshuffling of personnel and resources	EAoPR1	Efficient allocation of personnel and resources
Resourceful sharing of capabilities	EAoPR2	
Efficient allocation of personnel and resources	EAoPR3	
Strengthen the pipeline and market power	MS1	Market share
Increase market shares	MS2	
Gaining access to new markets	MS3	

Table 1. Definition of post-M&A success metrics using multiple items

4. Results

During the three-month runtime of data collection, 37 completely filled-out surveys were gathered. Out of the 37 participants, 43% worked in a managerial position with a focus on M&As, followed by 24% CEOs, 11% CTOs, 8% CFOs or COOs, and 6% consultants or chief medical officers (CMOs). A remarkable amount of 37.8% of participants were engaged in at least one M&A deal, followed by 32.4% of participants who were involved in two M&A processes. It is interesting to note that in total 16.2% of participants were involved in more than four M&A processes. Most of the participants, in total 48.6%, were employed at R&D companies, followed by 29.7% which were employed at companies offering R&D and manufacturing. Only a small fraction of 10.8% were employed at Contract Manufacturing Organisations and only 8.1% at Clinical Research Organisations.

4.1 Partial least square – structure equation modelling

Structural equation modelling (SEM), especially partial least square equation modelling (PLS) as a multivariate analytic approach, was selected to analyse the hypotheses H1-H6 of the research framework as it allows researchers to integrate unobservable factors measured indirectly through indicator variables (Hair *et al.*, 2017). PLS-SEM works efficiently with small sample sizes and complex models and makes practically no assumptions about the underlying data. Furthermore, PLS-SEM relies on a nonparametric bootstrap procedure to test coefficients for their significance (Hair et al, 2017). This is important, as the defined latent variables due to the small sample size are non-normally distributed. Despite the fact that researcher like Hair *et al.* (2017), and Barclay *et al.* (1995) often cite the 10-times rule, which says that the minimum sample size should be 10 times the maximum number of the arrowheads pointing at a latent variable anywhere in the PLS-path model, researcher like Chin and Newsted (1999) and Cassel *et al.* (1999) suggest using sample sizes between 20 and 40, using the 'rule of 5'. As there is still inconclusive statement in research literature regarding sample size behavior in PLS-SEM and PLS-PM (McIntosh *et al.*, 2014) and due to the reliable and valid results from the evaluation of the measurement model and structural model, it was decided to perform the PLS-SEM analysis using the software Smart-PLS version 3. The most important measurement model metrics for PLS-SEM are reliability, convergent validity and discriminant validity. For the structural model, the most important evaluation metrics are R^2 (coefficient of determination), f^2 (effect size), Q^2 (predictive relevance) and the size and statistical significance of the structural path coefficients (Hair *et al.*, 2017).

4.2 Evaluation of the measurement model

The subsequent latent variables are operationalized as reflective constructs: post-M&A success metrics economies of scale, economies of scope, market share, clinical success rate and efficient allocation of personnel and resources.

Construct reliability and validity is the primary criterion for evaluating the reflective model. All indicator loadings, with the exception of item EScale3 from the post-M&A success metric economies of scale (outer loading: 0.672) and item MS1 from the post-M&A success metric market share (outer loading: 0.58), are below the recommended value of 0.7, indicating that indicator reliability is adequate. Despite their modest item loadings, further research of measurement models revealed that measures of reliability, convergent validity, and discriminant validity supported the usage of the EScale 3 and MS1 item models. Construct reliability was tested using composite reliability. All composite reliability values (0.83–0.96) in the measurement model exceed the 0.7 criterion, ensuring construct reliability. Cronbach's alpha, which provides an estimate of the reliability based on the intercorrelations of the observed indicator variables, was used to assess internal consistency reliability. All Cronbach's alpha values - 0.71 for post-M&A success metric efficient allocation of personnel and resources; 0.77 for post-M&A success metric market share; 0.85 for post-M&A success metric economies of scale, 0.89 for post-M&A success metric economies of scope and 0.95 for post-M&A success metric clinical success rate) are above the 0.7 threshold, indicating internal consistency reliability.

The degree to which a measure correlates positively with other measures of the same construct is known as its convergent validity (Hair *et al.*, 2017). The convergent validity is evaluated by calculating the Average Variance Extracted value (AVE). The AVE values of the measurement model range from 0.63 to 0.87, which is substantially over the minimum threshold of 0.50. Consequently, the reflective constructions' measures have high degrees of convergent validity. The assessment of the reflective measurement model also includes discriminant validity. According to Hair *et al.* (2017, p. 115), discriminant validity refers to the amount to which a construct is empirically distinguished from other constructs. Establishing discriminant validity signifies that a construct is distinct and captures phenomena that are not captured by other constructs in the model. The Fornell-Larcker criterion is used to assess discriminant validity. It compares the square root of the AVE values to the correlations of the latent variable. Each construct's AVE should have a square root bigger than its highest correlation with any other construct (Hair *et al.*, 2017). The measurement model also fulfils these criteria because the square roots of the AVEs in Table 2 shown in bold (clinical success rate = 0.935; economies of scale = 0.834 and economies of scope = 0.907; efficient allocation of personnel and resources = 0.798; market share = 0.795) are all greater than the correlations of these constructs with other latent variables, indicating that all constructs are valid measures of distinct concepts.

	Post-M&A success factor clinical success rate	**Post-M&A success factor efficient allocation of personnel and resources**	**Post-M&A success factors economies of scale**	**Post-M&A success factors economies of scope**	**Post-M&A success factor market share**	**Company revenue post-M&A**
Post-M&A success factor clinical success rate	**0.935**					
Post-M&A success factor efficient allocation of personnel and resources	0.119	**0.798**				
Post-M&A success factors economies of scale	-0.192	0.541	**0.834**			
Post-M&A success factors economies of scope	-0.166	0.562	0.686	**0.907**		
Post-M&A success factor market share	-0.053	0.511	0.585	0.519	**0.795**	
Company revenue post-M&A	0.451	0.318	0.319	0.241	0.281	**1.000**

Table 2. Fornell-Larcker criterion results for the partial least squares measurement model

In addition to the Fornell-Larcker criterion, the heterotrait-monotrait value (HTMT), is used to evaluate the discriminant validity (Hair *et al.*, 2017). As suggested by Hair *et al.* (2017), the HTMT values should be tested to see whether they are significantly different from 1 in order to demonstrate discriminant validity. The Smart-PLS's bootstrapping option was utilised for this purpose. As seen in Table 3, all HTMT values are less than the 0.85 cutoff value.

	Post-M&A success factor clinical success rate	**Post-M&A success factor efficient allocation of personnel and resources**	**Post-M&A success factors economies of scale**	**Post-M&A success factors economies of scope**	**Post-M&A success factor market share**	**Company change in revenue post-M&A**
Post-M&A success factor clinical success rate						
Post-M&A success factor efficient allocation of personnel and resources	0.2					
Post-M&A success factors economies of scale	0.239	0.684				
Post-M&A success factors economies of scope	0.184	0.696	0.781			
Post-M&A success factor market share	0.233	0.679	0.701	0.594		
Company revenue post-M&A	0.451	0.375	0.331	0.256	0.217	

Table 3. Results on discriminant validity, heterotrait-monotrait values

Table 4 summarizes all evaluation parameters of the measurement model. All model evaluation parameter, with the exception of item EScale3 and MS1, have been met, providing evidence of the reliability and validity of the measurement model.

Latent variable	Indicators	Convergent Validity			Internal Consistency Reliability		Discriminant Validity
		Loadings	Indicator Reliability	AVE	Composite Reliability	Cronbach's Alpha	
		> 0.7	> 0.5	> 0.5	0.6–0.9	0.6–0.9	HTMT confidence interval does not include 1 and is below threshold value of 0.85
Post-M&A success metric efficient allocation of	EAo PR1	0.841	0.717	0.636	0.840	0.713	Yes
	EAo PR2	0.741	0.549				
	EAo PR3	0.808	0.652				
Post-M&A success metric economies of scale	EScale 1	0.817	0.667	0.695	0.900	0.850	Yes
	EScale 2	0.876	0.767				
	EScale 3	0.672	0.451				
	EScale 4	0.942	0.887				
Post-M&A success metric economies of scope	EScope 1	0.896	0.802	0.823	0.933	0.893	Yes
	EScope 2	0.913	0.833				
	EScope 3	0.913	0.833				
Post-M&A success metric market share	MS1	0.582	0.338	0.632	0.832	0.771	Yes
	MS2	0.973	0.946				
	MS3	0.782	0.611				
Post-M&A success metric clinical success rate	CSR1	0.951	0.904	0.875	0.965	0.953	Yes
	CSR2	0.958	0.917				
	CSR3	0.914	0.835				
	CSR4	0.917	0.840				

Table 4. Summary of evaluation parameters of the measurement model

4.3 Evaluation of the structural model

The evaluation of the structural model was performed on assessing the evaluation criteria's like R^2 (coefficient of determination), f^2 (effect size) and the size and statistical significance of the structural path coefficients. According to Hair et al. (2017), the coefficient of determination (R^2 value) is a measure of the model's predictive power. The coefficient of determination value of the endogenous construct for post-M&A revenue is 0.382, whereas the coefficient of determination for post-M&A success metric economies of scale is $R^2 = 0.293$ and for post-M&A success metric economies of scope $R^2 = 0.315$. As described by Hair *et al.* (2017), the change in the R value when a specified exogenous construct is omitted from the model can be used to evaluate whether the omitted construct has a substantive impact on the endogenous constructs. This measure is referred to as the f^2 effect size. The endogenous construct clinical success rate has a high effect size of 0.431 on the corresponding exogenous construct post-M&A revenue. The construct economies of scale have a low effect size of 0.08 on post-M&A revenue, whereby the endogenous construct economies of scope ($f^2 = 0.003$) and market share ($f^2 = 0.008$) have no effect on the exogenous construct post-M&A revenue. As mentioned above, a bootstrap approach from SmartPLS (5, 000 bootstrap samples) was used to analyse the statistical significance of the path models. According to Ringle et al. (2022), problems related to collinearity of variables in the model can arise when using standard PLS-SEM bootstrapping. To exclude such collinearity problems, it is useful to determine the variance inflation factor (VIF). The VIF of the model was uniformly below the threshold value of 5.

Results regarding the path analysis reveal that both post-M&A success metrics *"Economies of Scale"* and *"Economies of Scope"* show no significance on company post-M&A revenue and therefore not support H3 and H4. However, the post-M&A success metric *"Efficient allocation of personnel and resources"* reveal a significant result ($p < 0.01$ and $ß = 0.541$) on post-M&A success metric *"Economies of Scale"* and a significant result ($p < 0.01$ and $ß = 0.562$) on post-M&A success metric *"Economies of Scope"*. Therefore, the results support H1 and H2. Furthermore, the direct path between post-M&A success metric *"Market Share"* and post-M&A revenue is $ß = 0.086$ and $p > 0.666$, indicating that the path is insignificant and not supporting H5. The post-M&A success metric *"Clinical success rate"* show a high significance of $p < 0.01$ and a path coefficient of $ß = 0.529$ on post-M&A revenue and support the hypothesis H6.

Overall, these findings support H1, H2 and H6 used in the path model design as all estimated coefficients are positive. H3, H4 and H5 are not supported. Figure 2 summarises the PLS research framework results of the post-M&A success metrics and their evaluation on the M&A performance.

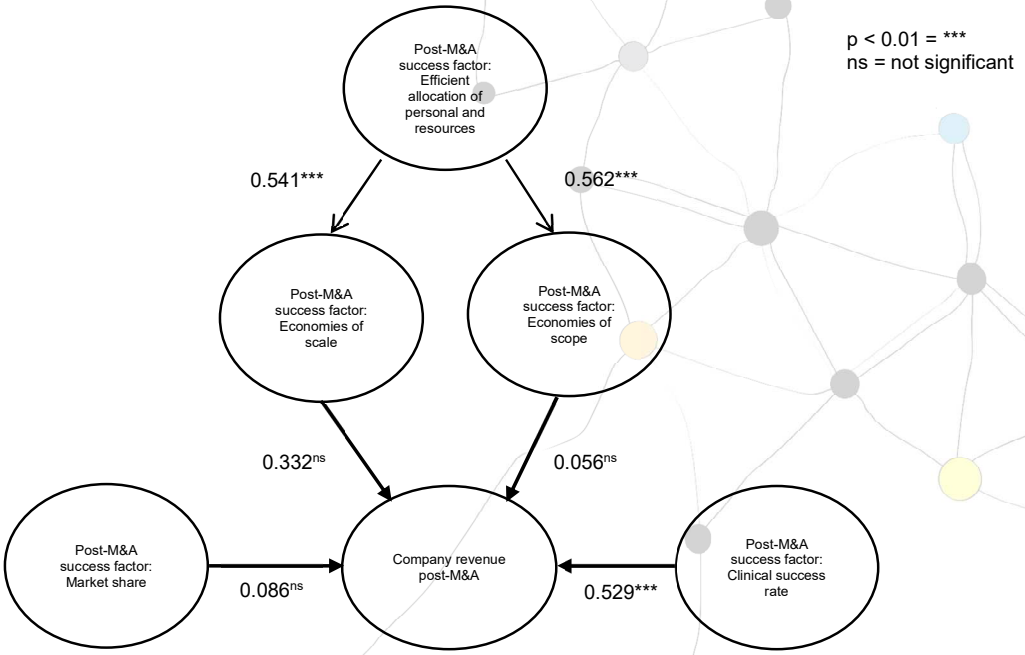

Figure 2. Partial least squares analysis of research framework for merger and acquisition performance

5. Discussion and conclusion

Although, researcher like Sharma & Ho (2002), Danzon et al. (2007) and Cockburn and Henderson (2001) justify M&As by *"Economies of scale"* and *"Economies of scope"*, that argument could not be proved in this research, as both post-M&A metrics show no significant effect on post-M&A revenue. This phenomenon can be explained by the statement that both post-M&A success metrics apply a substantial influence on cost reduction, thereby exerting only an indirect impact on post-M&A revenue. It is crucial to recognize that the primary aim of these strategies is not the direct enhancement of revenue growth; rather, it lies in the attainment of cost efficiencies, with revenue expansion being a potential resultant outcome. Such potential revenue expansion can lead to higher investment in new manufacturing capacities or new technologies, which looking on the long-term perspective led to higher sales and earnings if demand increases. However, this assertion could not be empirically validated in the present study. This discrepancy may stem from several factors, including the possibility that the timeframe chosen for data collection did not adequately capture the anticipated duration of the impact of cost-saving effect on post-M&A revenue. Furthermore, most of the survey participants, 48.6%, were employed at R&D companies, followed by 29.7% of participants employed by companies with R&D and manufacturing sections, meaning that the sample is rather R&D focused. The lack of statistical significance observed in the post-M&A success metric *"Market share"* ($p = 0.664$ and $ß = 0.097$) may potentially be explained through the R&D bias view on research orientate success metrics rather than

a view directed at market shares. However, the study proved that an essential success metric is the *“Efficient allocation of persons or resources”*, which notably supports *“Economies of scale”* with an impact size of $f^2 = 0.414$ and *“Economies of scope”* with an effect size of $f^2 = 0.461$. The results support the claims of Danzon *et al.* (2007) and LaMattina (2011), which state that the effective sharing of persons or resources following an M&A decreases expenses in R&D departments and, as a result, save costs. It will also increase production and R&D capacities, thus making it possible to further enhance the *"Economies of scale"* and *"Economies of scope"* factors. The results further support the argumentation of Schweizer (2005, 2009), who argues that knowledge, know-how, resources and technologies must be integrated as well as possible post-M&A to further develop and market the product or technology of the merged company. The significant result ($p < 0.01$ and $ß = 0.525$) between post-M&A success metric *"Clinical success rate”* and post-M&A revenue with an effect size of $f^2 = 0.431$ can be explained by the fact that passing a specific clinical testing phase or receiving marketing approval for a specific drug candidate increases the value of a company. Following a M&A of this company increase the probability for the acquiring entity to generate comparable revenue in subsequent periods through the sale of new drug products. This is consistent with the claims of DiMasi (2001), Pavlou and Reichert (2004), who argue that acquired NCEs of biopharmaceutical corporations have a greater clinical success rate and that, following the successful approval of such products, sales will grow, and a positive turnover will be achieved. The results of the study reinforce the approach that biopharmaceutical companies, which are on a buying tour, should focus companies that have successful clinical drug candidates in their pipeline, as product innovations are the most valuable assets of a (acquired) company. However, it is essential not to overlook the arguments advocating for the augmentation of post-M&A revenue, facilitated indirectly through cost-saving measures, albeit requiring a prolonged period to manifest effectively.

In the realm of M&A assessment, conventional metrics such as short-term financial indicators, accounting-based evaluations, and long-term financial analyses have long prevailed. However, the utilization of the multivariate analysis PLS-SEM introduces a novel strategy by integrating financial metrics with perception-derived performance indicators. This innovative approach provides managers with an integrated evaluative framework for post-M&A performance evaluation. The findings affirm that various quality criteria, alongside reliability and validity assessments of both the reflective measurement model and the structural model, were meticulously evaluated and met all predetermined thresholds. This underscores the justified application of this unique model within management contexts and fulfils the requirements of researchers like Schweizer (2012), Haleblian *et al.* (2009) and Brouthers *et al.* (1998), requesting a holistic view on the evaluation on M&As performance measure. Although the research results are limited to the biopharmaceutical industry in Germany, PLS-SEM is an excellent tool to evaluate post-M&A success metrics in M&As, not only in terms of financial but also perception-based performance measures.

6. Limitations and future directions

Despite the fact that this study was conducted with extreme care, there are some limitations that should give rise to future research.

First, this study is limited only to the country of Germany and to the associated industry sector of small and medium-sized biopharmaceutical companies. It is expected that the evaluation of worldwide M&A involving big biopharmaceuticals companies would yield other results, which highlights the importance of future research. Second, due to the small sample size, the SEM-PLS model could only incorporate a restricted number of latent variables. In order to improve the number of latent variables in the model and the overall knowledge of the influence of post-M&A success metrics on post-M&A revenue, the number of survey participants must be increased. Third, a number of post-M&A success variables have been discovered and analyzed through an extensive literature review. However, there is a lack of literature on M&A involving biopharmaceutical companies, so future research might uncover other success metrics.

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