



Unlocking value through carve-outs

PwC Deals Study

Part 3 of 3: Carve-out as a Strategic Tool



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PwC Deals Study

Three-part study

Part 1: Market Environment & Strategy Process – Optimism on uncertain grounds

Part 2: Portfolio and Operational Footprint Management – Mastering uncertainty and volatility

Part 3: Carve-out as a Strategic Tool – Unlocking value through carve-outs

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Table of contents

Table of figures.....	4
Study motivation and contacts.....	5
A Study focus	6
B Executive summary	7
C Unlocking value through carve-outs	8
1 The baseline – relevance of carve-outs	8
2 The role of transformation in divestment processes	9
3 Comparison of carve-out approaches and decision criteria.....	12
D Market insights on carve-out success factors	13
1 Our research hypothesis	13
2 Understanding entanglements.....	14
3 TSA scope and duration.....	15
4 Standalone structures.....	16
E Conclusion.....	19
F About the study	20
G Appendix	23
About PwC.....	25
Cooperation partners.....	25

Table of figures

Fig. 1	Divestment deals value for the DACH region	8
Fig. 2	Comparison of the sequential approach and the parallel approach.....	9
Fig. 3	The sequential approach	10
Fig. 4	The parallel approach	11
Fig. 5	Approach determination for an illustrative deal scenario.....	12
Fig. 6	Definition of carve-out success and impact of primary and secondary transformation factors	13
Fig. 7	Has your company implemented a structured and regular assessment of interdependencies and the complexities of these interdependencies between the business units?	14
Fig. 8	Duration of TSAs.....	15
Fig. 9	Proportions of cost allocations to divested entity provided by the seller prior to day 1 that are provided using TSAs after day 1	16
Fig. 10	Implementation of standalone structures in carve-outs and reasons for doing so	16
Fig. 11	Impact of chosen approach on carve-out speed and costs.....	17
Fig. 12	Percentages of functions set up as standalone units prior to day 1	17
Fig. 13	Average number of standalone functions prior to day 1	18
Fig. 14	Measures to improve carve-out success	19
Fig. 15	Survey responses per Carve-Out type.....	20
Fig. 16	Main industry of surveyed companies.....	20
Fig. 17	Country distribution of surveyed companies.....	21
Fig. 18	Annual turnover of surveyed companies	21

Study motivation and contacts

Study motivation

In our daily interactions with our clients, we are constantly looking for ways to improve their competitive positioning and reimagine what is possible, using measures from across the deals spectrum. Naturally, this includes looking into the future and making reasonable assumptions on how corporate environments and markets will develop, which trends and regulations will come up, and how our clients can best contribute to a brighter and more sustainable future. But over the last few years we have found that looking into the future in this way is becoming more and more difficult, complicated by layers of opacity which conceal huge amounts of volatility, uncertainty, complexity and ambiguity (VUCA). It is almost certain that this trend will further intensify, so the ability to rein in and successfully navigate VUCA waters will be a key success factor in future markets. Because of this, we have made VUCA the focus of our study. A wise choice, as the outbreak of the current pandemic – which came shortly before we finalized the study design – showed.

Key focus questions include: what do top executives think of market environments? What are their future prospects? How does the current pandemic impact their market situation and prospects? How are they adapting their portfolio and operational footprint management approaches? Which role do strategic measures such as carve-out play? The design and focus of our study offers unique peer-to-peer insights from top executives to top executives, helping them clarify their understanding of market environments and implement new approaches to strategic and operational management to successfully master VUCA.

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A Study focus

Corporate environments have become increasingly volatile, uncertain, complex and ambiguous (VUCA). The triggers are very diverse. They include new regulations, changing consumer preferences, environmental hazards, political tensions, technological innovations and pandemics, as recent events have shown. This has a severe impact on corporates and top executives, which need to find ways to navigate VUCA waters successfully.

In cooperation with Kantar and the Technical University of Darmstadt, PwC conducted a three-part study with focus on companies in the DACH region (Germany, Austria, Switzerland) with an annual turnover of more than €300m. A total of 157 decision makers (board level, M&A/strategy lead or similar position) participated in the study, and the distribution of participants is representative across countries, industries and company size in scope.

A total of 157 decision makers (board level, M&A/strategy lead or similar position) participated in the study, while 90 participants provided market insights on carve-out project experience, relevant for this study part.

Overview focus areas of the three study parts

Part 1



Market Environment &
Strategy Process
**Optimism on
uncertain grounds**

published in
October 2020

Part 2



Portfolio and Operational
Footprint Management
**Mastering uncertainty
und volatility**

published in
November 2020

Part 3



Carve-out as a
Strategic Tool
**Unlocking value
through carve-outs**

out now

B Executive summary

A carve-out is the divestment of part of a business. A clear perimeter of the part of the business being divested must be identified across various dimensions – such as people and processes – in order to enable the sale and generate value for the seller. To provide valuable insights for sellers, this study includes a detailed assessment of value creation drivers in carve-out situations, specifically highlighting the relevance of transformation prior to day 1 – this is achieved by setting up standalone business functions, free of entanglements. The first chapter of the study highlights the importance of carve-outs, providing the basis for

the research. Next, we outline different approaches to transformation during carve-outs, elaborating on the role of entanglements, transitional service agreements (TSAs) and standalone structures in carve-out processes. Having laid down this theoretical framework, we then identify key success factors based on survey results, and assess correlations between value-generating factors in different approaches to transformation to provide validation of potential impacts of various aspects of transformation on overall carve-out success.

Key findings

- Entanglements are a key driver of carve-out complexity. Regular assessment of entanglements is crucial to meet carve-out expectations of price, speed and cost.
- Purchasers are willing to pay more in return for sellers' commitments to business continuity and allowing sufficient time for transition. To avoid negative impacts on the purchase price, TSAs must be offered for periods of 12 to 18 months. There are also indications that having a larger number of TSAs enables sellers to achieve higher purchase prices.
- As an alternative to extensive and long-running TSAs, the implementation of standalone structures has a positive effect on the speed and the cost of carve-outs.
- Standalone IT functions had a particularly positive effect on carve-out speed and purchase price when undertaking carve-outs from large companies with revenues above €1bn.

Structured, regular assessment of operative entanglements has a positive impact on the success of carve-outs, yet only **27%** of companies perform these assessments.

44% of companies chose a TSA duration which was not optimal for the purchase price obtained.

46% of companies considered and implemented standalone structures in their carve-outs, which positively impacted carve-out speed and costs.

44% of companies set up standalone IT functions. This had a particularly positive effect on speed and purchase price for companies with revenues above €1bn.

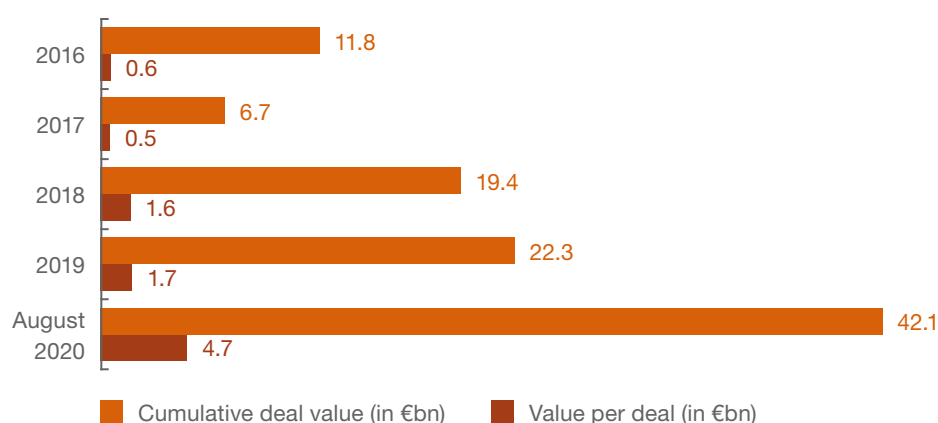
C Unlocking value through carve-outs

1 The baseline – relevance of carve-outs

While market conditions have been particularly favourable for sellers in recent years, companies are facing challenges. These include keeping up with disruptions such as the recent unexpected COVID-19 pandemic, which has hit the entire global economy hard. Ambiguous future prospects and turbulence in global stock markets are exacerbating these challenges, causing uncertainty in valuations.¹

In such uncertain market environments, divestment of assets or business segments from one company to another enables sellers to achieve a variety of strategic goals, such as focusing on core business or increasing cash liquidity. Strategic rationales behind carve-outs also include external factors such as new regulatory requirements or technological disruptions, alongside aspirations of generating value by leveraging the seller's enterprise value or streamlining corporate performance. The CEOs surveyed indicated that the carved-out entity's weak competitive position was the main trigger for divestment (85%). An opportunistic sale (including unsolicited approach by a buyer) was named as the second most important reason (71%), followed by geopolitical or macroeconomic uncertainty (47%) and the need to fund new technological investments (42%).²

Fig. 1 Divestment deals value for the DACH region



Source: Mergermarket.

Increasing overall carve-out³ deal volume and rising deal values demonstrate the relevance of this form of divestment, particularly in uncertain times.⁴ Responses to our survey also reflect the continuing trend towards carve-outs; 69% of participants stated that they expect the relevance of carve-outs for the future to remain constant or increase over the next five years.

¹ See part 2 of this study, Mastering volatility and uncertainty.

² Cf. PwC, CEO Survey 2017.

³ Mergermarket definition: the agreed sale of an asset or assets from one company to another, distinguished from other transactions by the fact that it is the vendor who actually initiates the transaction.

⁴ Divestments completed between 2016 and August 2020. Bayer AH and ABB megadeals have heavily impacted 2020 value (deal volume excluding these two deals: €27bn).

As the macroeconomic business environment becomes ever more complex and dynamic and shareholder expectations increase, dealmakers are coming under pressure to understand what effect particular aspects of a carve-out have on the deal's success. Companies undertaking divestments are also assessing and trying to mitigate potential value leakage, with a variety of aspects needing to be taken into consideration.

One approach to reduce complexity in the seller-buyer relationship and, hence, maximise value for the seller is to reduce entanglements with the non-divested business prior to day 1. These entanglements range from integrated value chains to centralised back-office services. The ultimate aim of this approach is for the divested entity to work as a standalone business on day 1.

The aim of this study is to scientifically analyse the extent to which transformation using standalone solutions creates added value and thus contributes to carve-out success. The study also identifies and examines value-generating factors contributing to the success of carve-outs and standalone solutions. These new insights provide transaction professionals with advice on how to maximise value creation in carve-outs.

2 The role of transformation in divestment processes

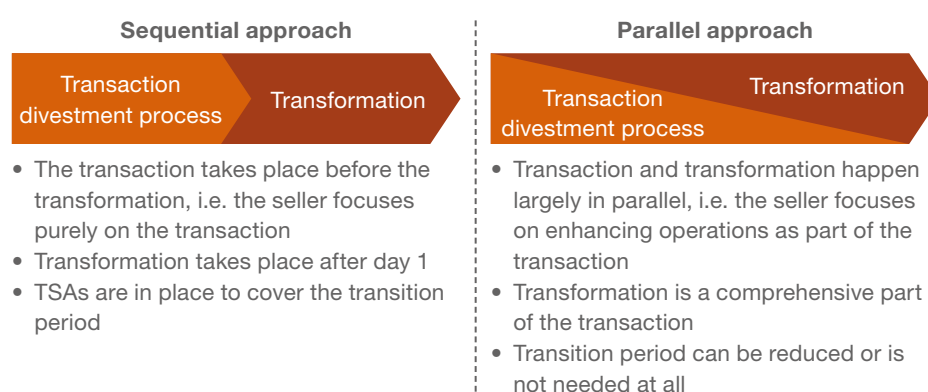
In order to get a business entity into the desired target state, certain transformation activities in business organisation, assets, processes, people and technology may be required to achieve seller-independent (standalone) target operations within the unit to be divested. These transformation activities are undertaken in addition to the transaction-related activities. Target operations may include rightsizing of functions and building new capabilities according to future strategy, as well as simply cutting entanglements with the seller.

In terms of the timing of the transformation at the divested entity, we draw a distinction between two approaches: the sequential approach and the parallel approach.

“Sellers invest in transformation of the business to be divested in order to increase the value generated from the transaction.”

Sebastian Horstbrink

Fig. 2 Comparison of the sequential approach and the parallel approach

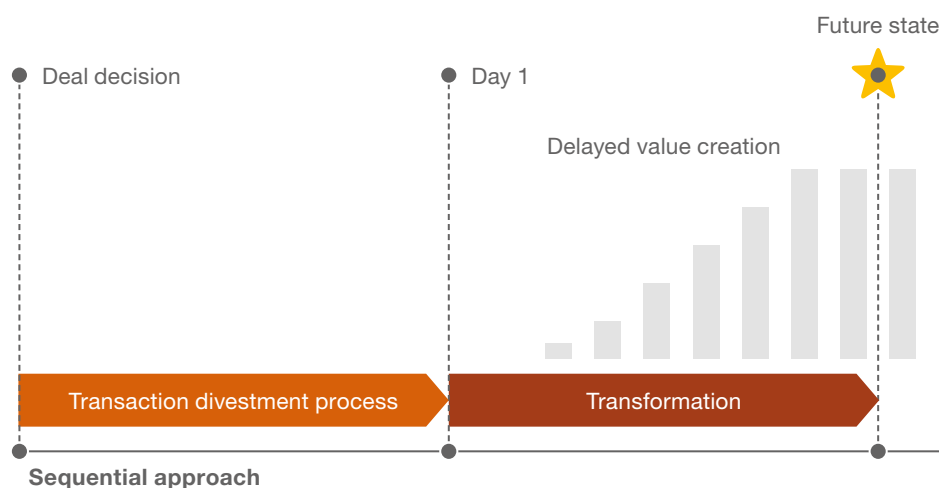


The sequential approach involves the seller focusing purely on preparing the handover of the divested business to the buyer. Any investment in the transformation of the business is left to the purchaser. If necessary, essential services during the transition period after day 1 are provided through TSAs.

The parallel approach, on the other hand, involves transformation activities at the divested business being launched prior to day 1, in parallel to the transaction activities. This means that the seller invests in preparing the handover and enhancing the business to increase value. In a best-case scenario, the seller can leverage synergies between the two activities.

Sequential approach

Fig. 3 The sequential approach



In the sequential approach, the transaction is centred around core assets and the transformation does not start prior to day 1. This means that value is only generated by the purchaser after day 1.

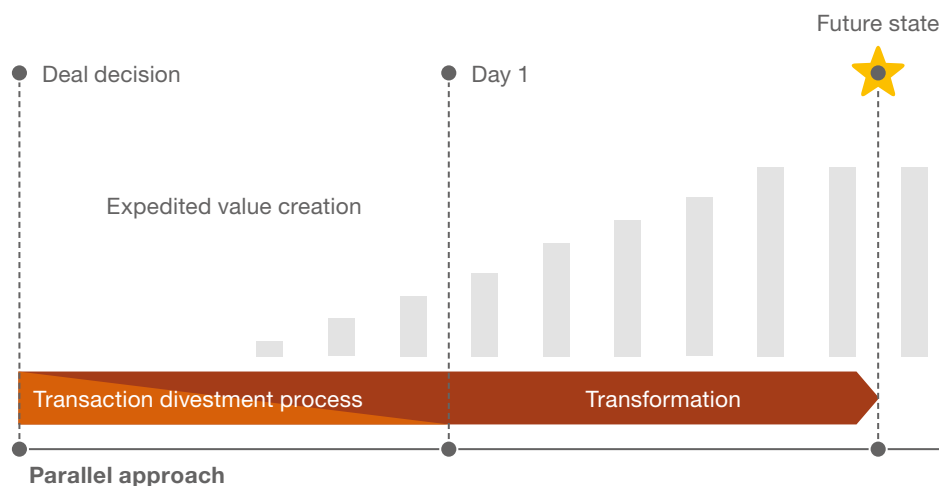
In this scenario, a large number of transitional TSAs are necessary. Support from the seller during the transition period is especially vital if the divested business is required to be operational soon after divestment. Given the short period of time between the announcement and the conclusion of the divestment in some transactions, the buyer is not always able to take over all services and adapt rapidly enough, even if they have the necessary skills and resources. As a result, the seller provides this support in the form of services outlined in TSAs during the transition phase. To ensure efficient use of TSAs and overall success of the carve-out, the key elements of the TSA must be thoroughly defined; these comprise the scope of services, the duration of the support, and the accounting of costs incurred.

In an environment where strategic decisions are needed quickly and where companies face regulatory burdens and financial dependencies, sellers regularly divest to focus resources and attention on their core business activities. From the seller's perspective, a TSA can conflict with this goal and become an inconvenience. A TSA therefore poses the risk that the seller will not be able to focus entirely on their core business activities for at least some time after the carve-out.

It is difficult to estimate in advance the cost of providing the services agreed in a TSA. Therefore, there is a risk that the seller may underestimate these costs. Confidentiality of internal information, which must be accessible to the seller, is also difficult to include in a TSA. Moreover, sellers often do not have the resources for providing the required services externally. Consequently, sellers generally lack the necessary tools and processes to monitor service quality and to govern service arrangements with unaffiliated customers.

Parallel approach

Fig. 4 The parallel approach



The sequential approach, by its very nature, involves initiating the transformation after the transaction process has been completed. By contrast, the parallel approach aims to maximise value by optimising the critical areas of the divested unit while keeping the associated carve-out costs low. The challenge for the seller is to find the right degree of investment in business transformation prior to day 1, considering that different purchasers may have different integration strategies – these can range from complete integration into an existing company to standalone operation of the business. To mitigate this, sellers will look into options to fill gaps with flexible outsourcing solutions rather than hiring resources. However, the benefit of a reduced need for TSAs can be achieved independently of this purchaser-specific consideration.

This approach thus allows for more flexibility on the part of the buyer and allows the newly acquired business to be developed without restrictions created by TSAs in terms of changes and scalability. Transformation and limited use of costly TSAs also allow the operating expenses of the divested business to be kept to a minimum, which has a positive effect on the net profit of the transaction.

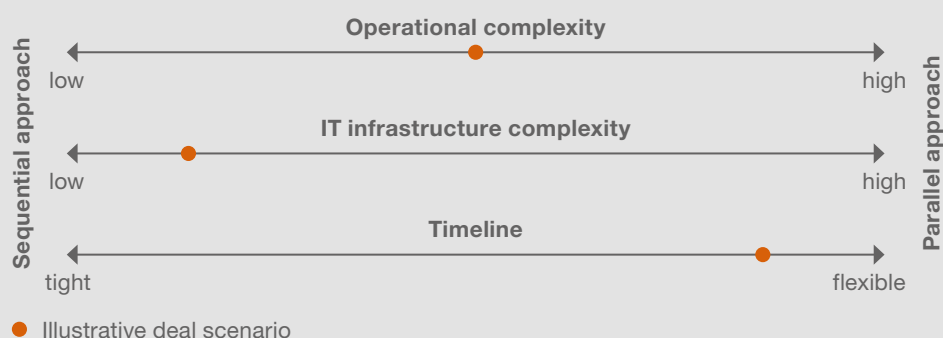
The business to be divested can either be set up as a standalone business at an early stage and subsequently operated within the seller group for a period of time, or this can be delayed until the transaction is concluded.

3 Comparison of carve-out approaches and decision criteria

The parallel approach aims to build a fit-for-purpose entity ready for the transaction by leveraging standardised outsourcing solutions to fill gaps in the administrative backbone of the standalone divested entity. Where necessary, custom solutions are used to support critical business processes. As a result, this approach is suitable for very complex scenarios where the benefit of mitigating entanglements is greater. The potential increase in profitability brought about by this approach may be relevant when selling less well-performing entities. On the other hand, costs of preparation for day 1 may be higher due to the additional transformation activities required.

In the traditional sequential approach, the transaction is centred around the core assets. In many cases, only a legal and logical separation of the businesses is possible on day 1, and entanglements in aspects such as IT remain at this time. This approach can be quicker, as the lack of transformation prior to divestment means that fewer activities are required prior to day 1. However, transitional services mean that the seller will be involved in the divested business for a period after day 1.

Fig. 5 Approach determination for an illustrative deal scenario



“The selection of the best carve-out approach depends on the specific parameters of a transaction. Key decision criteria include operational complexity, IT complexity and available time to close the transaction.”

Jens Weber

D Market insights on carve-out success factors

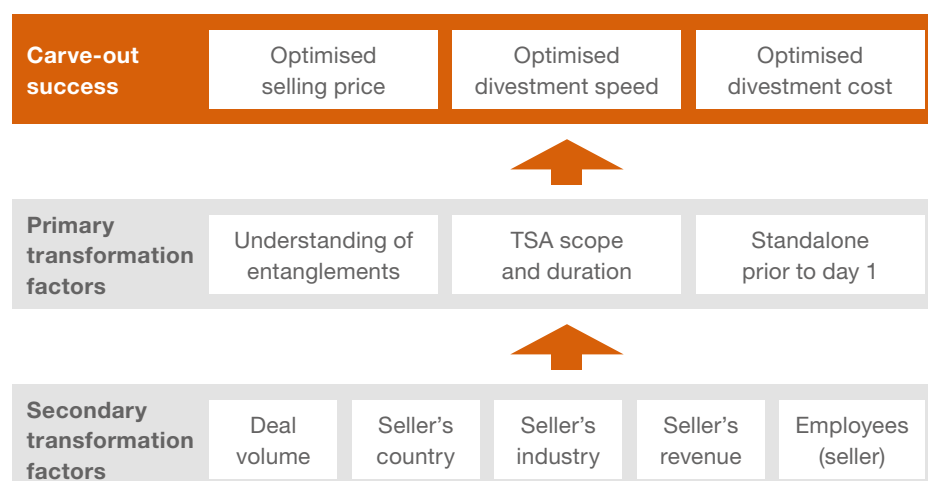
1 Our research hypothesis

In order to assess the impact of transformation activities on carve-out success, we need to define success. Our definition of success is based on three factors from the seller's perspective: firstly, the selling price achieved, where the seller strives to achieve the highest price possible for the entity to be divested; secondly, the speed of divestment, where the seller usually aims to achieve a sale as quickly as possible; and thirdly, the costs generated, where the seller works to optimise (i.e. reduce) divestment costs as far as possible.

Carve-out success, in turn, is impacted by primary transformation factors; as explained above, the direct impact of these factors on carve-out success is the main focus of this study. Our research examined our participants' transformation activities in terms of how regular entanglements were assessed prior to the carve-out, whether the carved-out entity was working as a standalone business prior to day 1, and how the scope of TSAs was defined.

To find additional insights, we also identified a number of secondary transformation factors which may have indirect impacts on the success of a carve-out by affecting the primary factors. The secondary factors analysed in this study are deal volume, the seller's country, the seller's industry, the seller's revenue, and the number of people employed by the seller.

Fig. 6 Definition of carve-out success and impact of primary and secondary transformation factors



2 Understanding entanglements

Our results show that failure to assess operational linkages and complexity of interdependence of business areas will have a negative effect on the speed, the price obtained, and the costs incurred during a carve-out. It will therefore reduce the overall success of the carve-out. This is mainly due to the fact that entanglements need to be identified and addressed early enough in order to take countermeasures where required and avoid unpleasant surprises later. If these interdependencies are only identified at a late stage, dealing with these issues may significantly reduce the speed of the carve-out.

Our results show that failure to assess operational interdependence will also have a negative impact on the selling price – a fact which seems obvious against the backdrop of complex organisational setups, supply chains and operations. In order to identify the perimeter of the entity to be carved out and fully divest it, it is essential to understand the entanglements involved. This enables the company to detect potential pitfalls and issues at an early stage and take appropriate countermeasures to facilitate the carve-out process.

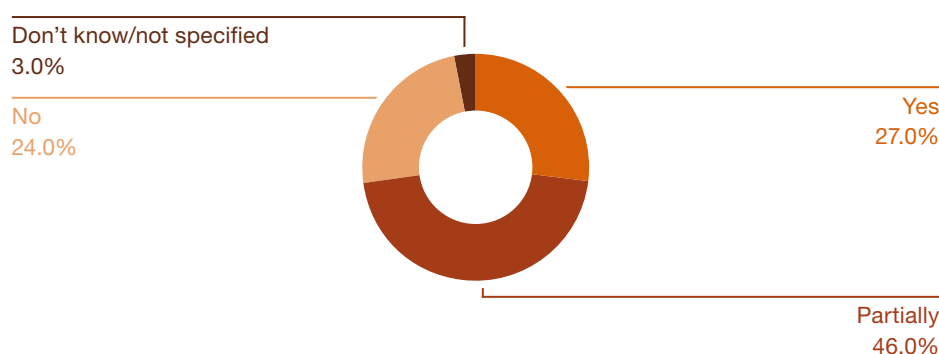
As stated above, failure to assess operational linkages and complexity of interdependence involving the divested business will also have a negative effect on the costs incurred in a carve-out and thus on its success, particularly for deals below €50m. Potential entanglements should be considered at an early stage when planning a carve-out to avoid costly changes of approach and plan later on.

Among the companies we surveyed, only 27% perform structured and regular assessments of operational entanglements and interdependence of entities in their business operations – even though the results of these assessments could impact business cases and, consequently, decisions on divestments.

“Entanglements – especially in the value chain – are the key driver for time and cost of a carve-out. Lack of transparency on these often leads to less value being generated from the carve-out.”

Christian Moldt

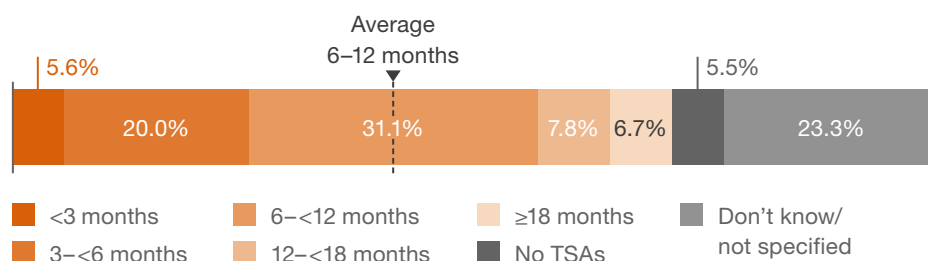
Fig. 7 Has your company implemented a structured and regular assessment of interdependencies and the complexities of these interdependencies between the business units?



3 TSA scope and duration

Alongside information on standalone structures as described above, we also asked participants about the duration of TSAs after day 1 to assess their approaches to transitions. On average, the responses indicated that TSAs last between six and twelve months.

Fig. 8 Duration of TSAs



Finding just the right duration of a TSA can have a significant impact on carve-out success. Our findings demonstrate that TSAs which are either too short or too long have a negative impact on the price obtained; specifically, the results show that TSAs lasting between six and twelve months, or over 18 months, have adverse effects on the achieved price. During too-short transition periods, it may not be possible to set up dedicated functions and processes at the divested entity quickly enough to replace the TSA. This creates the risk for the buyer of not being able to prepare for business continuity after the end of the transition period, and this risk might therefore generate downward pressure on the selling price. With transition periods of 18 months or more, this pressure is usually caused by significant complexity of entanglements between the divested business and the seller. This complexity, whether direct or indirect, is a downside to the transaction from the buyer's perspective due to limited flexibility for the transition period as explained above. As a result, too-long transition periods can also generate downward pressure on the selling price.

Our results additionally show that having a higher number of TSAs can increase the purchase price. This suggests that buyers are willing to reflect the seller's efforts to ensure business continuity in the purchase price.

However, while determining the right duration of TSAs has proven critical to the selling price, it does not have any effect on the speed of the carve-out. Interestingly, the duration of TSAs has no impact on carve-out costs either.

Consequently, determining the right duration for a TSA is a balancing act between ensuring that there is enough time to set up dedicated functions and processes on the one hand, and limiting the involvement of the seller on the other.

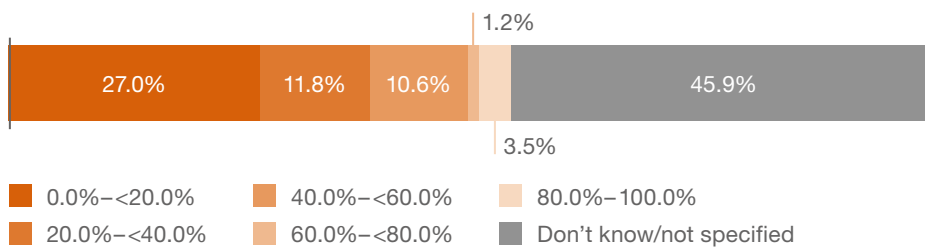
We also investigated the ratio of cost allocations provided by the seller to the divested business prior to day 1 versus the services provided by the seller as transitional services to the buyer after day 1.

“Purchasers are willing to reflect assured business continuity – supported by a broad range of TSAs and a reasonable transition period of 12 to 18 months – in the purchase price. However, this means sellers would still be heavily involved in the transaction for more than a year after closing, which may impact their ability to implement other strategic initiatives.”

Jens Weber

Our findings suggest that using TSAs after day 1 to maintain 80% to 100% of provided services from before day 1 has a positive impact on the selling price. This again supports the argument that purchasers are willing to reflect sellers' efforts to ensure business continuity in the purchase price.

Fig. 9 Proportions of cost allocations to divested entity provided by the seller prior to day 1 that are provided using TSAs after day 1



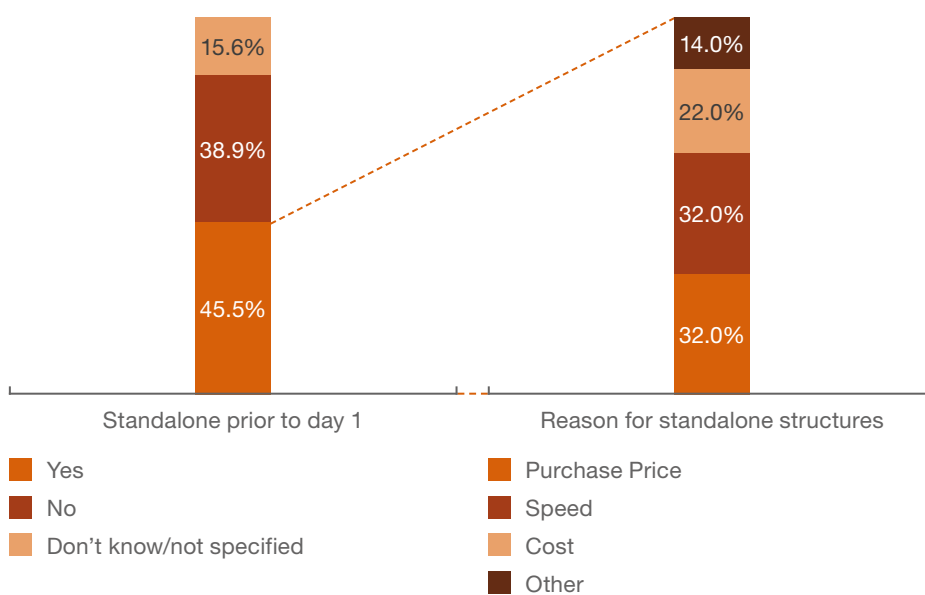
4 Standalone structures

One goal of our survey was to identify the importance of standalone structures in carve-outs.

We therefore asked our respondents exactly when they had implemented standalone structures. 46% said that they had set up standalone structures prior to day 1 (parallel approach), while 39% stated that this did not occur until after day 1 (sequential approach).

When asked why they had set up standalone structures, respondents gave the purchase price (32%), the speed of the transaction (32%) and the cost of the transaction (22%) as the main reasons.

Fig. 10 Implementation of standalone structures in carve-outs and reasons for doing so

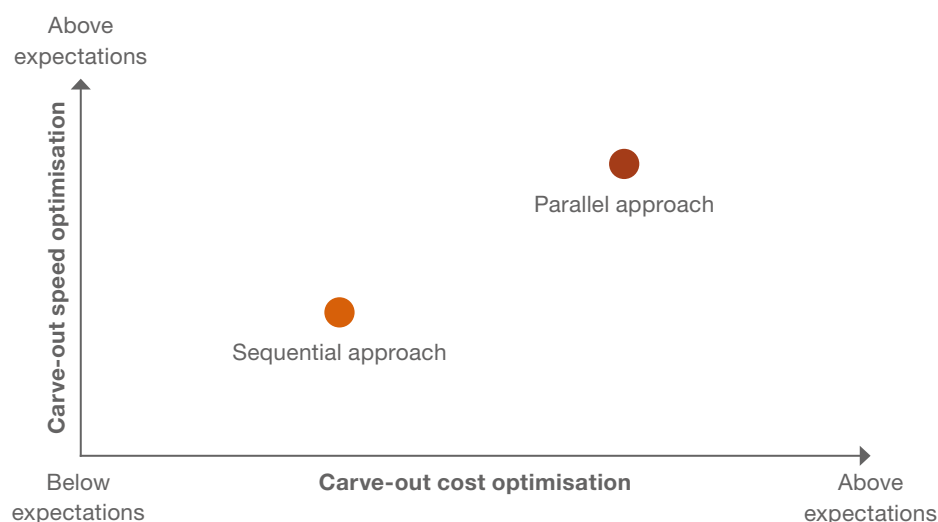


“Not transferring IT complexity and costs of large companies to a target increases the value of that target. Creating a standalone IT function has a positive effect on speed and purchase price for divestments by companies with revenues above €1bn.”

Sebastian Horstbrink

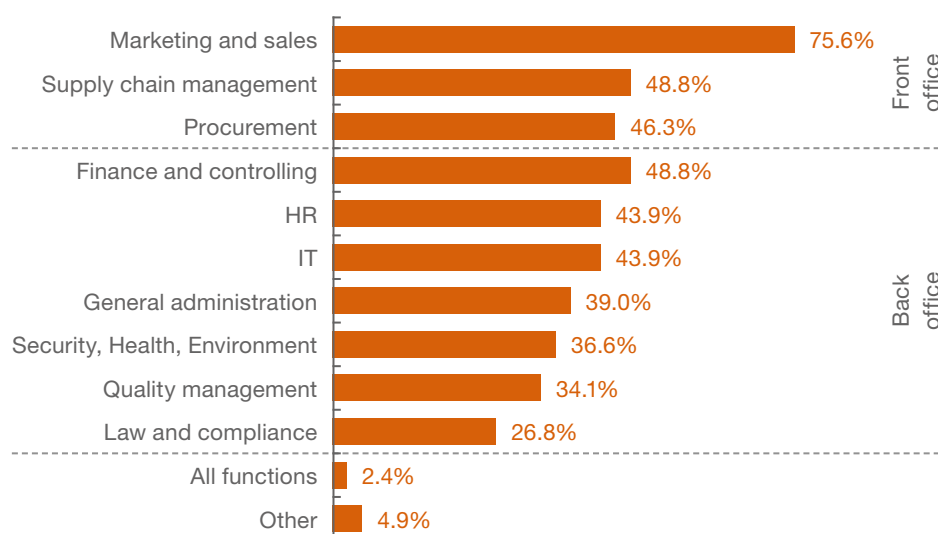
Analysis of the two approaches to carve-outs in terms of the success factors reveals that expectations of carve-out speed and costs are frequently exceeded when the parallel approach is used. Carve-out speed in particular fell short of expectations when the sequential approach was used, i.e. when standalone structures had not been established prior to day 1. Our interpretation of this result is that the purchaser's influence is usually higher when the sequential approach is used, impacting the seller's ability to manage carve-out speed and costs.

Fig. 11 Impact of chosen approach on carve-out speed and costs



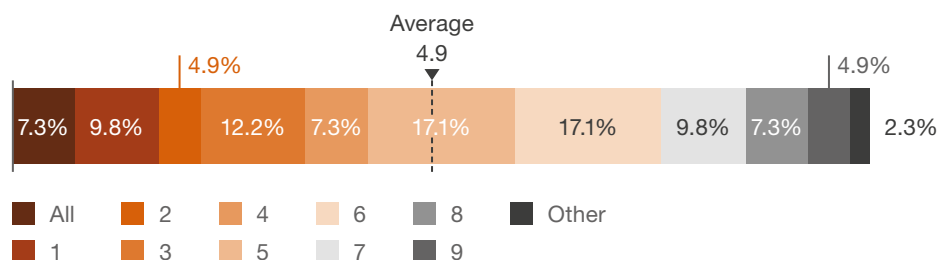
In order to assess the impact of implementing standalone structures on carve-out success, we asked for information on which functions were set up as standalone functions prior to day 1. Nearly half of our participants focused on front-office activities such as marketing and sales or supply chain management, along with finance and controlling.

Fig. 12 Percentages of functions set up as standalone units prior to day 1



The market insights provided by our participants also reveal that, on average, around five business functions are converted to standalone units prior to day 1. Only 7% of participants executed a carve-out with a fully standalone approach, setting up all business functions as standalone functions.

Fig. 13 Average number of standalone functions prior to day 1



From a functional point of view, creating a standalone IT function is particularly beneficial to the transaction. This stems from the fact that a standalone IT function helps reduce complexity at the perimeter of the carve-out, and can therefore facilitate or even accelerate the transaction process. Standalone IT functions in companies with more than €1bn revenue or more than 5,000 employees – which often use more complex IT environments – are particularly beneficial to the carve-out price obtained, demonstrating the importance of reducing complexity.

Academic view

“Effort pays! – Sellers who are able to guarantee cost transparency and ensure business continuity for their carved-out units profit in the form of speed and purchase price.”

Prof. Dr. Dirk Schiereck, TU Darmstadt, academic study director

E Conclusion

Our study has revealed invaluable insights into factors which influence the success of carve-outs. Based on our respondents' experiences, we have identified a number of key findings.

Firstly, determining the right duration of TSAs will not only affect the transaction process but also the purchase price. TSAs should have a duration of 12 to 18 months to generate a positive effect on the selling price. Furthermore, buyers are willing to accept a higher purchase price in return for a larger number of TSAs covering particular activities at the carve-out perimeter to ensure business continuity after day 1. The downside of this is that the seller will still be involved at the carve-out perimeter after day 1, at least to a certain extent, due to the critical role of TSAs for a successful carve-out. As a result, sellers need to carefully evaluate their specific situations.

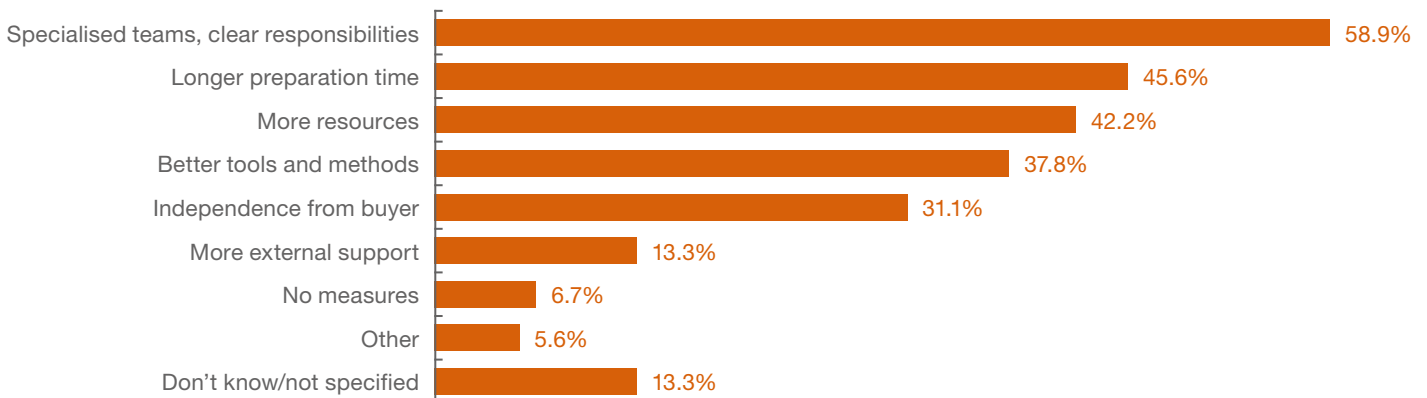
Secondly, implementing standalone structures has a positive impact on carve-out success. This stems from the fact that a standalone approach allows the seller to perform separation independently from the seller. Standalone structures have proven particularly beneficial for IT functions, where they allow complexity to be reduced. A standalone IT function will also facilitate subsequent transformation of other functions. A smooth separation process is, in turn, reflected in greater carve-out speed and lower-than-expected costs.

Thirdly, a thorough and continuous understanding of entanglements between parent companies and their subsidiaries and potential entities for carve-outs has a major effect on carve-out success. Regular assessments of interdependence between parent companies and potential entities for carve-outs are an important tool for drawing the right conclusions on purchase price, carve-out speed and carve-out costs early on in the process.

As an additional insight, we asked participants for proposals of how to improve carve-out success. The results can be grouped into two main areas: resources and approach. In terms of resources, more than half of the respondents (59%) felt that having a larger number of specialised teams would facilitate carve-out success, followed by more resources (42%). This suggests that respondents believe that they have the necessary skill set to perform carve-outs, but acknowledge the need to structure their resources more efficiently. In terms of approach, respondents believe that better (i.e. longer) preparation time (46%) and applying more efficient tools and methodologies (38%) would have a positive impact on carve-out success. Besides this, 31% of respondents stated that separating the entity for carve-out independent of the buyer – i.e. performing an internal carve-out – would increase carve-out success by giving the seller better control of the separation process. This is in line with the benefits of standalone structures identified above.

Fig. 14 Measures to improve carve-out success

Respondents were allowed to choose multiple answers.



F About the study

To understand the factors influencing the success of carve-outs, we surveyed 90 senior-level executives from a range of different industries in the DACH deals market. All of these executives undertook a carve-out between 2015 and 2019.⁵

The following diagrams show the carve-out types, industries, countries and deal volumes covered by our survey.

Fig. 15 Survey responses per Carve-Out type

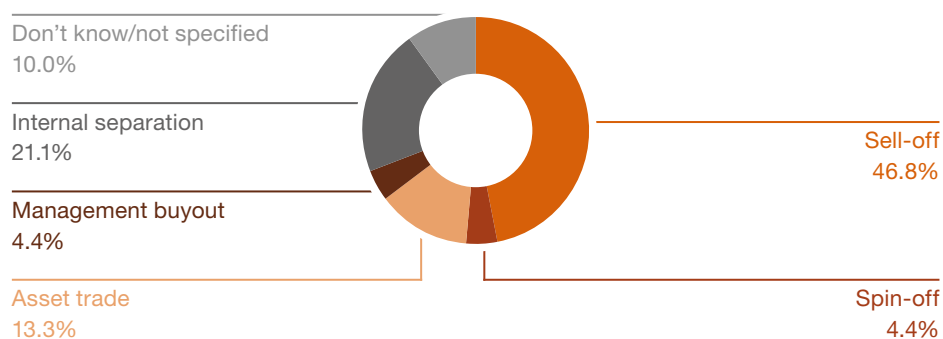
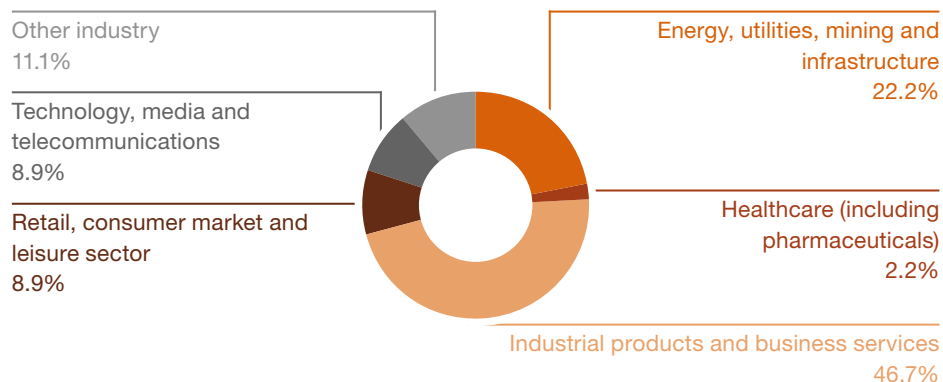
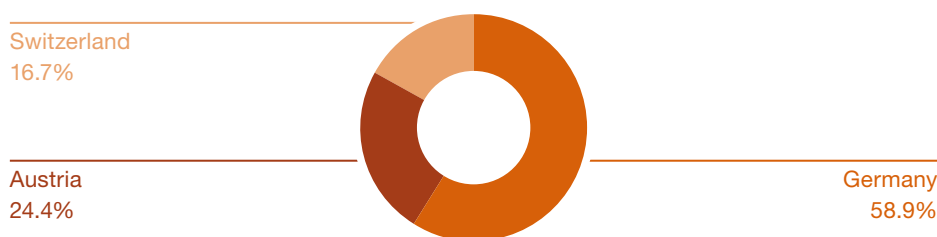
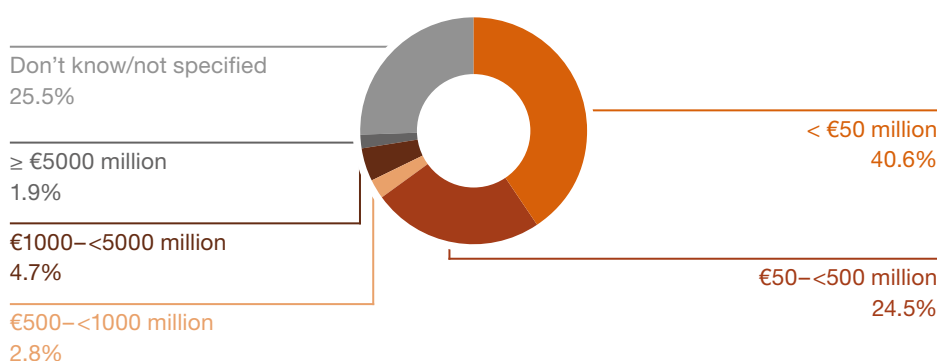


Fig. 16 Main industry of surveyed companies



⁵ Survey responses stating no past carve-out experience have been removed from the data set.

Fig. 17 Country distribution of surveyed companies**Fig. 18 Annual turnover of surveyed companies**

In particular, we asked our respondents about their experience with value creation through carve-outs and implementing standalone solutions. The survey included a combination of qualitative and quantitative questions. All responses were anonymised and presented as aggregate data. In this study, the success of a carve-out was measured based on three key success factors:

- Purchase price for the carved-out entity
- Meeting project budget
- Number of days between signing and closing the deal

Based on the results of the survey, we analysed the relationship between the success of a carve-out and the implementation of a standalone solution using quantitative models. Logistic regression models were used to determine the influence of the explanatory variables “TSA Duration⁶”, “Standalone⁷”, “Standalone Unit⁸”, “Operative Entanglements⁹” and “Allocations¹⁰” on carve-out success, measured by three success variables: “Purchase Price”, “Speed” and “Costs”.

⁶ Implementation period of TSAs after closing/day 1.

⁷ Dummy variable: standalone structures before the buyer is determined.

⁸ Functions most likely to be converted/most consistently converted to standalone functions (dummy variable for each function).

⁹ Assessment of the complexity of operational interdependencies. Process follows clearly defined and standardised criteria.

¹⁰ Share of cost allocations and other contributions made available after closing/day 1.

We also split our sample according to the variables “deal volume”, “industry”, “country”, “revenue” and “number of employees” to create subsamples. We then used logistic regression models for each subsample to determine the influence of the explanatory variables “TSA Duration”, “Standalone”, “Standalone Unit”, “Operative Entanglements” and “Cost Allocations” on the success variables.

Explanatory variables

1. Operative Entanglements
2. TSA Duration
3. Cost Allocations
4. Standalone
5. Standalone Unit



Success variables

1. Purchase Price
2. Speed
3. Costs



These figures were regressed against measures of the degree of implementation of standalone solutions to quantify a potential correlation between standalone solutions and carve-out success. Data for this regression was collected from an online survey and from expert interviews. This data output was then further presented, analysed and interpreted, not only with regard to the potential correlation described above but also with regard to other value-generation effects for carve-outs, such as the seller’s experience with carve-outs. The new insights that this produced suggest potential value generation opportunities for corporations. Based on these insights, the study also presents recommendations for selecting carve-out strategies to enhance carve-out success.

G Appendix

Quantitative model

Linear regression models are used to analyse the relationship between two variables x and y , where x is called the explanatory variable and y the explained variable. Relationships which can be analysed using linear regression models include the effect of years spent in education (x) on the hourly wage of young professionals (y) and the effect of the number of police officers (x) on the crime rate in a certain area (y).

A simple linear regression model is given by the following equation:

$$y = \beta_0 + \beta_1 x + u$$

As well as x and y which were introduced above, the equation also includes β_0 , β_1 and u . In this context u is defined as the error term. This means that u represents factors other than x which influence y . β_0 is a constant which indicates the value of y when x is zero. β_1 is the slope, which defines the effect of x on y . Therefore, β_1 is interpreted as follows: if x increases by one unit, y will increase or decrease by β_1 units.

To analyse the effect of various explanatory variables on one explained variable, the multiple linear regression model is used as an extension of the simple linear regression model. This model is structured as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k + u$$

As the formula above indicates, there are multiple explanatory variables (x_1, x_2, \dots, x_k) and multiple slopes $\beta_1, \beta_2, \dots, \beta_k$. As before, the error term u represents factors other than x_1, x_2, \dots, x_k which affect y . β_0 is, again, a constant which indicates the value of y when x_1, x_2, \dots, x_k are zero. Once again, $\beta_1, \beta_2, \dots, \beta_k$ are the slopes, which describe the effect of x_1, x_2, \dots, x_k on y .

In order to check the linear regression model for statistical significance, the standard t-test and F-test are commonly used in research. The t-test checks whether one coefficient is zero. If this is the case, the coefficient in question has no effect on y . The F-test is used for checking whether the sum of the coefficients is equal to zero. If this is the case, the entire model is not suitable for predicting y .

Ordered logistic regressions are used when the dependent variable has more than two categories and the categories can be ordered sequentially – this means that one value is definitely higher than the previous one.¹¹

¹¹ Credit ratings (e.g. by Moody's) are an example of ordinal scaled data – an 'Aaa' rating is higher than a 'Baa' rating.

The starting point of the ordered logit model is a regression equation for estimating the latent continuous variable y_i^* . In this model, x_i represents a $k \times 1$ matrix including the features of observation i while β describes a $k \times 1$ matrix of the model parameters with the first entry being zero:

$$y_i^* = x_i^T \beta + \varepsilon_i, i=1, \dots, n.$$

The ordinal scaled variable y_i with J possible values is described by y_i^* using $J-1$ thresholds indicated by a_j :

$$y_i = \begin{cases} 1, & \text{if } y_i^* \leq a_1 \\ 2, & \text{if } a_1 < y_i^* \leq a_2 \\ \dots & \\ J, & \text{if } y_i^* \leq a_{J-1} \end{cases}$$

The values for y_i in the range from 1 to J are intended as placeholders for ordinal scaled values in the data set.¹² Using the threshold values, the probability that y_i belongs to the j th class in the range from 1 to J is given as follows:

$$Pr(y_i = j | x_i) = \frac{\exp(x_i^T \beta - a_{j-1})}{1 + \exp(x_i^T \beta - a_{j-1})} - \frac{\exp(x_i^T \beta - a_j)}{1 + \exp(x_i^T \beta - a_j)}, j = 2, \dots, J-1.$$

Values for the parameter vector β and for the thresholds a_1 to a_{J-1} are estimated using the following log likelihood function:

$$\log L = \sum_{i=1}^n \sum_{j=2}^{J-1} d_{ij}^* \log \left(\frac{\exp(x_i^T \beta - a_{j-1})}{1 + \exp(x_i^T \beta - a_{j-1})} - \frac{\exp(x_i^T \beta - a_j)}{1 + \exp(x_i^T \beta - a_j)} \right)$$

In this equation, the dummy variable d_{ij}^* takes the value of 1 if y_i belongs to the j^{th} class, and 0 in other cases.

In this study, we mainly used ordered logit models, with the success factors as dependent variables.

¹² In the example of Moody's credit ratings, the placeholders from 1 to J might represent ratings from 'Aaa' to 'NR'.

About PwC



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About Technical University of Darmstadt

TU Darmstadt is one of the leading technical universities in Germany with high international visibility and reputation. According to recently published rankings of the magazine WirtschaftsWoche, the business economists of the faculty of law and economics of the Technical University of Darmstadt are among the top 5 in Germany, Austria and Switzerland. With rank 17 (out of more than 2,500 professors) the chair of corporate finance at the Technical University of Darmstadt performs as the best finance chair among the rankings of the management professors with the strongest research capabilities. Prof Dr Schiereck directed the support of TU Darmstadt, supported by Historei Bariz and Carlos Lopez Granada.



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About Kantar

Kantar (formerly Kantar EMNID) is one of the most renowned and long-established survey institutes in Germany. As part of the Kantar Group, the world's leading provider of market research and social research, Kantar offers data and evidence-based insights at the highest level of quality. Kantar has a complete, unique and rounded understanding of people around the world: how they think, feel and act, globally and locally in over 90 markets. Arthur Guzy directed the support of Kantar.

