AN INVESTIGATION OF GERMAN HIGH-TECHNOLOGY INDUSTRIES

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Abstract

The global success of Germany's high-technology industries is intriguing. This study explored factors which sets Germany apart from other locations and whether its high-technology industries benefit from these unique assets. Utilizing the Porter's Diamond Model, we analyzed the competitive advantages of selected high-technology industries in Germany. The German Stock Market was scanned for outstanding subcategories within the high-technology sector based on factors such as total revenues and economic impacts. As a result we chose three subcategories for our study: IT industry, mechanical engineering industry and construction industry. The result showed that their success can be traced back to many of Germany's location-specific factors. In addition, future study to apply additional frameworks besides Porter's Diamond Model was proposed in order to further investigate the key success factors of Germany's leading industries.

Keywords: Germany, Porter's Diamond Model, German Stock Market, High-Technology Industry, Key Success Factors

1. INTRODUCTION

Germany companies are well known for their success in several high-technology industries such as Siemens and Bosch from in mechanical engineering, Daimler and BMW the automobile industry and SAP in the IT industry. In the case of SAP for example, it generated revenue of 16.223 billion € with a 2.833 billion € net profit (SAP, 2012). SAP's name is even used as a synonym for ERP software because of its domination in the market (Panorama Consulting, 2012). As for the automobile industry, the top 10 most valuable brands for cars in 2010 featured five German brands with BMW ranking first with a brand value of $21.816 billion (Brown, 2010). The goal of our work is to analyze these industries and evaluate their key success factors in order to find out what competitive advantages are setting Germany apart from other locations. In addition, we want to find out if the revealed competitive advantages are attainable for the international competition. Specifically we are interested in external factors shared by the German's companies. In this study, we conducted the Porter's Diamond Analysis for German IT industry, mechanical engineering industry, and construction

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industry. We chose these industries because of their significant roles in the global market and because they are among the top industries in Germany in terms of export volume and revenues (Statistisches Bundesamt, 2013).

2. METHODOLOGY

Firstly, we scanned the German Stock Market to identify the high potential industries in German high-technology sector. The German Stock Market consists of two segments. The *prime standard* represents the highest standard with the strictest rules regarding publication, transparency and financial reports for German leading firms, while the *general standard* has less regulatory for relatively smaller firms. The basic admission and transparency standards in the regulated marked are based on European Union Law. Furthermore there is the open market which is in contrast to the prime standard not regulated by the EU. The prime standard includes four different indices: The *DAX* (deutscher Aktienindex) lists the 30 biggest German companies according to their turnover. The *TecDax* lists 30 of the 35 largest technology companies in terms of the market capitalization and order book sales. The *MDax* is for companies in classical branches which are too small to be listed in the DAX. These companies are called Midcaps. Finally, the *SDax* represents smaller companies (Smallcaps) not generating enough turnover and marked capitalization to be listed in the MDax.

For our research we categorized the companies listed on the stock market into eight different subcategories which are: the communication, mechanical engineering, IT, medical, semiconductors, bio-technology, automobile and construction industries. Since the automobile industry is already well researched, we focus on the other subcategories. We chose the subcategories with high impact on Germany's global business activities which are the mechanical engineering, IT and construction industries. We want to find out what it is that enables companies from those subcategories to succeed over the international competition. The only similarity between them is their utilization of high technology. However, they operate in very different fields with different requirements.

To investigate whether the competitive advantages could be traced back to the location-specific factors that Germany offers, we utilized the Porter's Diamond Model. This framework investigates why some nations are more competitive than the others.

This model focuses on the immediate environmental factors on which an industry's success is based and factors that enable it to continually create competitive advantages. The model describes a mutually influencing system of factors, which are Demand Condition, Factor Conditions, Firm Strategy/Structure/Rivalry, and Related and Supporting Industries (Lejpras & Eickelpasch, 2011).

The **Demand Condition** in the home country influences a company's competitiveness through three mechanics: There is an advantage if the market segment in the home country is larger than in foreign countries because they have better possibilities to develop strength before penetrating international markets. Also customer's needs at home may be more sophisticated, and therefore, the demand puts higher pressure on companies.

This helps to innovate and improve the products and services significantly. Finally, the demands of domestic buyers help to anticipate the needs of customers in other countries. Additionally **Factor Conditions** are especially important for knowledge-intensive industries which we encounter in this case. Skilled human resources or technological and scientific infrastructure play an important role with their available quantities and costs. As a source of competitive advantage they are very hard to imitate or acquire by foreign competition. Furthermore, if the **Firm strategy, structure and rivalry** are very strong and competitive on the home market it puts pressure on each firm to keep improving its products, customer service, offer competitive prices, and therefore, prepares them very well to compete internationally. In addition to these factors, there are the **supporting industries** such as capable suppliers or partners in relative industries. With the opportunity to form clusters and collaborations, these supporting industries affect the value chain effectiveness and efficiency. Due to sharing new methods and implementing technologies to improve business processes companies within this cluster enhance their processes between manufacturers and raw material suppliers. Lastly, Porter takes into account that **chance** with unpredictable influences such as political instability or natural disasters as well as the **government** supports such as providing the needed infrastructure, tax incentive, or subsidies can create major competitive advantages of a nation (Porter, 1990).

For each of the chosen German high-technology industries, we analyzed them based on Porter's framework. We obtained the relevant data for the industry analysis mostly from official publications such as the Federal Ministry of Economy and public annual financial statements of the companies. Furthermore, we strongly rely on the statistics database of the German Federal Statistical Office.

3. INDUSTRY ANALYSIS

3.1 IT Industry

3.1.1 Overview and current situation

In modern societies the exchange of information is a major concern for private people. However, it is even more important for companies operating within highly competitive markets and trying to reach maximum profits. The way of operating is changing drastically with modern developments in the ways of handling information. Within this structural change the Information and Communication Industry takes a major place and

because its products and services fuel product- and process innovation they are a major reason for overall growth (Rüter, Schröder, Göldner, & Niebuhr, 2010).

With China's dominating position on the global market, it is no surprise that they are the most important business partner of the German IT Industry. However in terms of exports the neighbouring countries within in the European Union are still biggest source of demand for the industry's products and services. None of the European partners has a comparable dominating position within Europe as Germany does (Statistisches Bundesamt, 2013). In 2010 about 75,000 companies with nearly 926,000 employees made up the German IT Industry. They generated revenues of 281.5 billion € which equals a 5.4% increase compared to 2009. With 690,000 employees the IT services provide 72.3% of the jobs which is the biggest share by far compared to 13% of employment in Trade or 15% in Hardware (Statistisches Bundesamt, 2013).

3.1.2 Supporting industries and Factor conditions

The first research and business activity took place in one specific region of Germany during 1960 with founded institutions such as the European Computing Centre in Frankfurt a. M. and the IBM Computing Centre in Sindelfingen. Over the centuries this area developed itself to a hot spot of IT business and research. With 80,000 people being employed and 42 billion € turnover being generated the so called "software cluster" plays a major role in the world wide IT Industry and is able to compete with the famous Silicon Valley in the USA

The software cluster expands around the software development centres Darmstadt, Kaiserslautern, Karlsruhe, Saarbrücken and Walldorf in south-west Germany. It includes four different federal states: Hessen, Baden-Württemberg, Rheinland-Pfalz and Saarland. Each of them has their own considerable smaller IT clusters but networks don't stop at political borders. The connecting similarity is the competence in software, especially software for businesses. Concentrated within the region there are innovative companies as well as universities with renowned IT faculties and research institutions (Software Cluster, 2013)The cluster region includes universities, universities of applied sciences, Max Plank Institutes, Fraunhofer Institutes and two institutions of the German Centre for Research on Artificial Intelligence (DFKI) and the research provides local companies with superior technology and methodology. Founders of Europe's biggest IT Company SAP AG are all graduates from universities within the cluster region. The same is true for Germany's second biggest IT Company the Software AG. Besides the strong competitive advantage in human resources and scientific infrastructure there is the extraordinarily important supply industry of semi-conductors. With Infineon Technologies and Siltronic AG Germany offers two global

players in the nearby environment and additionally there are many more smaller-sized companies producing semi-conductors.

3.1.3 Demand

The IT industry and especially the Software Industry met a very strong demand since the industry's beginning 40 years ago because around 1970 the German economy relied strongly on manufacturing and the big companies correctly saw great potential in upcoming developments such as material resource planning systems. Therefore they wanted to benefit from the enhanced control of material and information flow which resulted in a very high demand for computer systems and the corresponding software. There was another rise in demand during the 1990's. With the spreading of personal computers the industry strongly benefitted from the purchasing power of German households. Until today the demand from domestic buyers is characterized by high standards for quality as well as brand image. Additionally the German customers are very willing to spend time gathering information about the desired product online and to purchase it online from international suppliers if they have the better offer as seen by the rise of e-commerce demonstrated in figure 5 (Handelsverband Deutschland, 2013). Therefore the German companies were well prepared to meet the needs of international customers when they started to expand their businesses internationally.

3.1.4 Government

How the German government values the IT Industry can be seen by a quote from the Minister of Economy and Technology:

"…The digitally networking by information and communication technology drive our economy. Without it our location would be cut off from the future. … We need impulses from this technological branch and a strong IT industry. … Therefore the German government decided to adopt a comprehensive strategy to ensure the digital future of Germany."

- Rainer Brüderle, Minister for Economy and Technology (Bundesministerium für Wirtschaft und Technologie, 2010).

The industry benefitted from the first day on from programs by the government. Between 1967 and 1979 there was the "DV-Förderung" which can be translated as "support for the branch of data processing". Table 1 provides detailed information about the support (Leimbach, 2010). The payments were originally in DM (Deutsche Mark) and were calculated as Euro with a rate of 1€ equal to 1.95583DM and rounded on the second decimal.

Table 1: Funding of the IT industry 1967 - 1979

	1st Program 1967 - 1970		2nd Program 1971 - 1975		3rd Program 1976 - 1979		Accumulated Volume	
	€	%	€	%	€	%	€	%
Higher Education and Aprenticeships	3.27	12.9	199	21.4	130.74	18.9	316.75	19.6
Industrial Research and Development	125.22	67.7	366.75	39.4	273.13	39.4	765.1	42.3
Data processing application	15.39	8.3	291.18	31.3	214.9	31.0	521.47	28.8
Others	2.56	11.1	73.52	7.9	73.78	10.7	167.75	9.3
Total		100	**1,819.8**	100	**1,354.5**	100	**3,535.9**	100

Table 2: Goals from Germany Digitally 2015

Goals for growth and new jobs due to digitalising	
Small and young companies →	Create 30,000 jobs until 2015. Increase amount of new founding. Support implementation of IT technology in companies.
Goals for digital networks of the future	
Policy of frequencies →	Covering the demand for mobile data networks including incentives to use frequencies efficiently.
Goals for trust and security	
Customer protection →	Improve the protection of customers against hidden costs or hidden subscriptions.
Intellectual property rights →	Guarantee a high protection of intellectual property and an effective application of copyrights. Create a Europe-wide legislation for such cases.
Goals for Research and Development	
Internet of services →	Developing and testing of base technology for the future “internet of services”. Efficient exploitation of the knowledge on the web

	through newly offered services
Internet of things →	Usage of location competencies in the technology branches which are relevant to the "internet of things".

Today's supportive and development program is called "Germany Digitally 2015". This is the strategy of goals and actions Rainer Brüderle mentioned in the quote earlier (Germany Digitally, 2015). It provides a specific strategy for what the government wants to reach and how they are going to proceed in terms of developing the IT industry (Bundesministerium für Wirtschaft und Technologie, 2010).

The program is divided in goals and actions for different topics. The topics for example cover "trust and security". For each of these topics it is further divided in fields in which the goals and actions are planned.

3.2 Mechanical Engineering Industry

3.2.1 Overview and current situation

The Mechanical Engineering branch generally deals with the Construction and Production of machinery. As an industrial branch it was developed from the metalworking of blacksmiths. Nowadays mechanical engineering contains different subcategories for instance combining the mechanical machinery with electrical and electronic components (mechatronics), measurement technology, control technology and many more. It is based on subjects like mathematics, physics, thermodynamics and chemistry. Mechanical engineering is one of Germany's biggest and most important branches with approximately 950,000 employees. It is characterized by individual production of small series. A survey conducted by the Fraunhofer Institute showed that about 58 percent of the mechanical engineering companies focus on this kind of production (Kinkel & Som, 2007). Approximately 85 percent of Germany's Mechanical Engineering companies employ less than 250 people and many small and middle size companies are world leaders in their special field (VDMA, 2013).

With a revenue of 250 billion € Germany ranks number four in the world when it comes to the revenue of the mechanical engineering sector. The Mechanical Engineering Industry is characterized by its strong orientation towards customer requests. The survey by the Fraunhofer Institute mentioned before also pointed out that one fifth of the interviewed companies consider the ability of individually adapting their products to customer requests as the main factor for competitive success. A differentiation on the product price appeared to be not as important as in other industrial branches (Kinkel & Som, 2007).

3.2.2. Factor conditions

According to the Association of German engineers (VDI) the branch of Mechanical Engineering is the most innovative branch. The number of companies that imposed an innovation within the last three years reached a level of 76 percent. An innovation could therefore be a newly developed or improved product or alternatively new or improved processes and ways of producing. Even 28 percent of the companies introduced a new product or product improvement as the first supplier in their relevant market (ZEW, 2013). The main resource the companies access is the outstanding skill of their engineers when it comes to developing new ideas, creating innovation or improvement of existing structures. Furthermore the non-academic workers, who mostly have at least a three year apprenticeship, receive incentives for making suggestions for improvement. These incentives can reach a high amount of money since they are often linked to the costs the company is able to save by imposing the suggestion. Due to their profound understanding of the product skilled workers often have a better sense of where problems are likely to occur during production. (Berufsgenossenschaft für Gesundheitsdienst und Wohlfahrtspflege - BGW, 2008).

Another reason for the excellent competitiveness of the industry is its ability to create customer specific solutions out of innovative technologies to fulfill the customers' demands in terms of quality, precision and flexibility (Kinkel & Som, 2007). All departments of the company have to work close together which requires excellent communications skills of all persons involved. A factor which has led to the success of this branch is that most of the companies within this sector offer apprentices where students can work in the factory and study at a university at the same time. With this approach companies can form excellent junior staff to get access to new and fresh ideas which lead to the innovations that are the key factors for their success (Stifterverband deutsche Wissenschaft, 2011).

3.2.3 Demand

Since Germany is a highly developed industrial nation and gains a lot of money from producing goods and exporting them there has always been a huge demand for high quality machines because the producing companies are highly dependent on their machines. Since all kind of products have to be improved, changed or adapted to the customers' needs and wishes during their lifecycle there is almost always a need for new innovations and improvements within the mechanical engineering sector to guarantee that the manufacturers can produce according to the requirements of customers (Slnn, 2013).

3.2.4 Rivalry

In addition to subsidies and taxes benefits the governments provides strict copyright laws to protect new inventions and innovations from being copied by competitors

(Bundesministerium für Bildung und Forschung, 2006). That leads to a strong competition among the companies when it comes to creating new individual ideas. This competition results in a high amount of different inventions and many technical solutions for any kind of machines and hence improves the international competiveness of the mechanical engineering sector (Schuh, et al., 2009).

3.2.5 Supporting Industries

The main suppliers of Mechanical Engineering companies are steel producers which belong to the heavy industry sector and often process the steel further. The main region where German steel producers are located is the Ruhr Valley in the northwestern part of Germany. The industry produced approximately 42.7 million tons of steel in 2012 which was the highest number within the European Union. The steel industry has developed from raw material suppliers to the partner of many steel fabricators and suppliers of high-tech products to tailor-made components for the Mechanical Engineering Industry (Wirtschaftsvereinigung Stahl, 2013).

3.2.6 Government

With the founding of the "Europäische Gemeinschaft für Kohle und Stahl" (European Community of Coal and Steel) in 1952 the international control over the Ruhr Valley finally ended. Until that time plants have been partially dismantled by the British in order to receive reparations from the Germans after World War 2. Therefore the founding of the EGKS turned out to be a crucial factor for the growth of the German Steel Industry and the related businesses such the Mechanical Engineering Industry (Reichel, 2004).

3.3 Construction Industry

3.3.1 Overview and current situation

The Construction Industry is a powerful branch, which significantly contributes to the added value and newly created employment on the German market. Through a great number of upstream and downstream areas this branch is the driving force for local economy and generates economic vitality. This is confirmed by the latest data about the German Construction Industry (German Construction Industry, 2013):

- About ten percent of the German Gross Domestic Product (GDP) is used for construction projects. This equals 260 billion euros in 2012.
- The Building sector gains (on the same level as vehicle construction) the highest gross value added in the country.

The Industry is divided in main construction trades (mainly adduces shell construction and engineering service) and finishing trade (primary carries on interior construction and adduces renovation measures). Furthermore we differentiate three categories of construction output which are residential, commercial and public (see figure 7). There are two federations in this

branch. The German Construction Industry Federation (HDB), is the industry's lobby and employees' federation. Interests of construction companies are represented by the Central Association of the German Building Trade (ZDB) (German Construction Industry, 2013).

3.3.2 Demand

During World War II nearly every fourth flat was destroyed, however the allies invested a lot of money into reconstruction of the German infrastructure. Based on this reconstruction the German demand in the construction sector increased rapidly. Over the last twenty years the demand declined only slightly despite the unpleasant overall economic situation. Although the demand is not increasing the quality in German building industry is still rising and has an excellent reputation around the globe. Especially through sub companies and associated companies the German Construction Industry is successful abroad. Between the years 1991 and 2011 the volume of orders increases from 3.6 to more than 26.8 billion Euro annual ("Chart of Orders from Abroad between 1991 and 2011", German Construction Industry, 2013). More and more construction industries of emergent countries and advanced developing countries are able to offers low risk project by themselves. As a result nearly 90 % of Germany's international business handles in industrial countries by finishing large major projects. (German Construction Industry, 2013). Nowadays people become increasingly environmentally aware and it is a very important part in daily life. Especially citizens in Germany try to save money while simultaneously protecting the nature. The main reason for this change of attitude are political parameters and incentives from the government. Here are state wide climate action in close connection with German federal climate change law combining with the global climate agreements created by EU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2012). With the Kyoto-protocol from 1997, the signatories oblige to reduce the output of drastic hazardous greenhouse gases. The benefit for the Construction Industry here is that 15 percent of the CO2 emission is caused by private households. So, the government creates a support plan for new buildings, modernizations and energy related renovations. In collaboration with KfW Bank Group they offer several programs (Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), 2013). For example for *energy-efficient construction*: The program serves low-interest long-term financing of investments for the construction and initial acquisition of KfW Efficiency houses, which has to be confirmed by an expert. Secondly there is a program for *energy-efficient renovation*: In form of ecological construction support, supplementary credits, investment grands and loans those are supported. Furthermore they support *renewable energy*: There are low-interest, long-term financing facilities for the use of renewable energies. Big but also small investments are promoted, for Example large solar collector systems or even a photovoltaic system. Finally they provide *On-Site consultation*: Even discussions are promoted which relate to the comprehensive

structural insulation and heat generation and distribution, including the hot water and the use of renewable energies. So there still are a lot of orders and big turnovers are generated within the industry (KfW Bank Group, 2013).

3.3.3 Government

Another reason for the competiveness of the industry is the influence of federal government. It holds routinely talks with the parties HDB and ZDB. Part of such meetings is collective bargaining for salaries and contracting conditions between employers and employees. Additionally to discussions on the strategic orientation there are five other topics which are coordinated (Federal Ministry of Transport, Building and Urban Development, 2013): firstly building investments and public private partnerships; secondly combating illegal employment in the building trade; thirdly reducing bureaucracy; as a fourth point there is social and labor law; and finally further training in the Construction Industry.

Germany being a major exporting country, it needs an efficient infrastructure. Therefore the government creates the PPP Task Force. Public-Private Partnership (PPP) is a contractual cooperation between public sector and private-law companies. These are examples of modern and efficient actions taken by administrative authorities. They are part of the Federal Government's initiative to promote innovation and are aimed at managing public infrastructure projects more efficiently than in the past. The private partner takes responsibility for the efficiency of the individual economic performance, while public authorities shall take care to ensure compliance with general interest objectives. The economic benefit for the public sector justifies the PPP because it reaches an average of ten to fifteen percent cost savings. Private companies hope to gain from participation in PPP projects in terms of profitable business opportunities with new business partners. PPP is available in a variety of areas. The IT project Hercules of the German armed forces for example is regarded to be the currently largest PPP project in Europe. Another support of the government is the anti-cyclical fiscal policy. It means, when there is a negative economy climate (recession), cutting taxes or increasing spending on subsidies (e.g. investment subsidies) or government purchases for example in public construction are required. Thereby, plans for additional supportive payments and for construction projects will be prepared in time and accurately. Therefore they can be effective immediately if necessary. The resulting security is required particularly for construction projects, which normally have a planning period of 1 to 1 ½ years (Federal Ministry of Transport, Building and Urban Development, 2013).

A study on innovation within the Construction Industry and a further investigation of the innovative actions of the German Construction Industry in international comparison has shown that the Construction Industry is more innovative than generally perceived. The evaluation of patent applications at the European Patent Office (EPO) between the years 2005

and 2012 revealed the following results ("Indicators for measuring innovation activity in construction – an international comparison", Institut for Work and Technology, 2013):

- With a total amount of 5,850 patent applications in the technology area "construction" Germany ranks first
- The areas of technology dealing with climate protection and renewable energies belongs to the fastest growing segment
- On an international comparison Germany has a higher concentration of applicants. Refer to the relevant patents Germany leads in total figures as well: one fifth of the considered patent applications came from Germany

3.3.4 Supporting Industries

Highly qualified architects are key factor for the success of the Construction Industry. German architects have a more pronounced quality requirement than their foreign counterparts ("Architectural quality in international comparison", Forsa-Institut, Federal Chamber of Architects (BAK), 2003). German architectural firms operate globally, for example, with urban projects ("Albert Speer & Partner" in China, "Ingenhoven Architekten" in Ireland). Furthermore it is not uncommon that German offices from abroad realize projects in Germany, often in collaboration with locally based offices. For example designed the Swiss architects "Herzog & de Meuron", the Allianz Arena in Munich or "Zaha Hadid" the "phæno" Science Museum (2005) in Wolfsburg (Kähler, Federal Office for Building and Regional Planning, 2002).

3.3.5 Factor Conditions

Of course the Construction Industry needs highly skilled human resources as well as other technological branches. But like in nearly every German branch the demographic change and as a result of these the shortage of qualified personnel is a difficult issue. It is hard to cover all open apprenticeships, especially in civil engineering. However, the German Construction Industry invests increasing amounts of money in training and development. Furthermore companies provide graduates with a lack of education a chance to make use of refresher to prepare these people for training maturity (Knipper, German Construction Industry, 2011).

4. DISCUSSION OF THE RESULTS

Firstly, the current situation of each subcategory confirms the assumption that they are internationally successful and therefore feature an extraordinary competiveness. Because of this the further investigation, if their competitiveness is rooted back to Germany and its external influence on the companies, is justified. Secondly, examining the results of our analysis we recognize two similarities between the subcategories. For each of the three, the

governmental activity as well as the broadly available supporting industries for each of the subcategories positively impacts the competitiveness of the companies. We came across problems while analyzing the Mechanical Industry. Because of the heterogeneity of the branch and the limitations by the number of samples it is difficult to get a result for the whole subcategory by looking at the samples. Therefore, for further studies we would consider two additions and one major change. Firstly, extend the data set by including more companies into our sample. By doing so we can lessen the impact of a single sample and solve the problem for highly heterogenic subcategories such as the Mechanical Engineering Industry. Secondly, we should consider additional roots of the international success and look for actions. Finally we should look into how the competition could attain the competitive advantages of German companies.

5. CONCLUSION

Based on our Porter's Diamond analysis, we came to the conclusion that a large part of the branches' competitive advantage, in fact, roots back to the location Germany offers. We further recognize that there are additional factors influencing the international competitiveness we did not cover in our research. Although, the location Germany offers positively influences their international competiveness, it is not reasonable to say it is the single root of the companies' success. With the help of the given site-specific factors and the purposive regulations on the part of the government Germany has succeeded in creating an advantageous environment for sophisticated industries over decades. The factors revealed within our analysis are either results of political decisions and economical changes in the past or related to natural conditions. They developed over a long period of time by chance and by the mentioned political decisions. Therefore, they cannot be copied easily by other countries and are very hard to attain for the international competition in short term.

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