Identification of macrolevel factors for EDA companies

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Identification of Macroeconomic Level Factors for the Electronic Design Automation Industry

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Abstract. The Electronic Design Automation industry operates in a complex, dynamic, and unstable environment. During the years companies have been challenged to continuously find ways of survival and competitiveness. For years the USA has been the leading country in this sector. Most of the talents, knowledge, and innovations have come from organizations operating in this part of the world. Nowadays, due to technological war between countries, and changes in the political arena, other countries have started to invest in their workforces and to challenge the current market balance. This paper aims to identify the macroeconomic level factors that impact the firms that operate in this industry. PESTEL framework is used to give a structured view of the macroeconomic factors impacting the growth and the success of this industry. A comparison between China and the USA is presented.

Keywords: Electronic Design Automation Industry, PESTEL analysis, Macroeconomic factors.

1 Introduction

EDA stands for Electronic Design Automation and includes all activities related to the design of electronics and supportive technologies. This industry is strongly connected with the semiconductor industry, the production of chips, and at the same time in close relation with the electronic trends and innovations. The beginning of this industry can be traced back to 1967. Since then, it has been in a continuous war to differ itself from the other industries in the semiconductor supply chain, but at the same time, its existence can be understood, only in strong cooperation with its partners and competitors. Despite the dynamics during the years, since its establishment as an oligopoly market, covered by 95% by US companies, or foreign companies operating in the US, or to put it simply being led by the USA, things haven't changed much, at a macroeconomic level [1]. Few research studies are done in this industry to present the dynamic environment, challenges, and difficulties that face these companies and suggestions on how to help high-tech companies make decisions and survive in the continuously changing EDA market. These industries are known to be very knowledge-

intensive [2]. Technological advancements are a continuous pressure to innovate and improve their products in a short time with complex features. Trends of founded and Merged & Acquired of these companies during the years have shown that their lifespan is short, and few manage to survive [3]. The USA government has been a cornerstone, with its support in Research and Development policies, trade and international cooperation, and high level of education [4].

In the last years, a lack of interest has been shown by the USA government in this sector and at the same time, the trade war with China in the electronics sector, and the COVID-19 chip shortage might bring great changes shaking the market stability. The Chinese government has put this industry on its priority list, investing, and taking initiatives to attract as many as possible necessary resources to establish a sustainable ground for new companies and industry growth in the country. EU on the other side, doing the same thing, threatening the USA leader position. All these changes might reflect on USA economic growth, national and military security. Despite China's efforts, some experts say that it is still early to predict the success of China in this industry due to EDA's characteristics as a very high intense knowledge industry and other specific characteristics presented in these papers [1][4][5][6][7].

This study focuses on the outer part of the environment. The aim is to give an overview of the macroeconomic factors that are key and can contribute to the growth of this industry. Since these companies require a lot of support from outside of the company's environment, it is necessary to make a presentation of the factors that are indirectly impacting the flow of operation within the industry. Political, Social, Economic, Technological, and Legal macrolevel factors are identified, categorized, and presented in the PESTEL framework. PESTEL framework is a tool well-known for decision-makers. They can improve their choice of the strategy to be implemented by scanning the macrolevel factors that impact their business environment [8]. To make it more visible the USA and China are two main case studies used to give a clear and concrete picture of the situation.

2 Methodology

As mentioned above the main aim of this paper is to identify the macroeconomic factors that impact the EDA industry. A literature review was conducted to find previous research done in this field and only two papers were found. One of them focused on the DEMATEL method and Porter's diamond model and the other gave a general view on the EDA. Google Scholar, ScienceDirect, IEEE, and EBSCO, were the main databases searched for scientific papers in this field.

The information in this study is collected by a continuous search and analysis of different public reports written on the challenges of these companies and the characteristics of the industry. Data on the tables and figures are taken from the World Development Indicator Database, OECD.stat database, American Association for the Advancement of Science, and other local databases. Since there is no similar study done before, PESTEL can be a good representation of the current macro-level environment

and factors of the industry. PESTEL stands for Political, Economic, Social, Technological, Environmental, and Legal factors that might contribute to the outbound environment of the companies. Macrolevel factors include the factors that come from the outside of the company, cannot be managed by the company, and have an impact on the company's metrics of success, profitability, and performance. USA and China are the main countries taken into the study to present the situation.

3 PESTEL analysis for the Electronic Design Automation Industry

Political factors. There are 4 main regions or unions where EDA companies are distributed, operate, and have a significant part in the market share. According to SEMI-report, America has been the main region of EDA providers and a leading region in the market. Followed by EMEA (Europe, the Middle East, and Africa), Japan, and APAC (Asia pacific) [9]. All these regions are specialized in different aspects and due to market segmentation and policies from the governments, new companies are trying to enter the market overcoming the barriers. The USA has been the leading state of this specific industry. All three companies that have led the market (Synopsys, Mentor Graphics, and Cadence) were established in the USA. In 2017, Siemens acquired Mentor Graphics but did not move the firm to Germany. Siemens EDA, as now the Mentor Graphics is called still operates from the USA [10].
Since EDA and semiconductors are knowledge-intense industries, their growth, success, and competition depend on knowledge assets, resources, and activities. Companies in this industry should invest continuously in R&D to keep up to date with the latest trends. The market is dynamic, the product lifecycle is short, and the production of new technologies requires many efforts in a long time. Most of the companies cannot exist in this dynamic environment and this leads to oligopoly markets, where the big ones cover most of the needs [1]. The USA government during the years has been a support to the continuous ICT research and development activities [11]. The support of the government is not all the time linked directly to the companies. Government can impact indirectly through investing in academia and R&D centers in universities to prepare experts for the field and at the same time to support new R&D activities in a specific firm within universities.

Private-public cooperation has always been an example especially, for the electronic industry [7]. This support is seen in tax reduction policies, favorable tax treatments, and supporting the process of preparing skilled personnel (case of Taiwan and China [4]). The following figure shows the support of the USA, EU, and China governments to the R&D activities of private companies by their tax policy. Data in Figure 1 are taken from the OECD.stat indicator database.

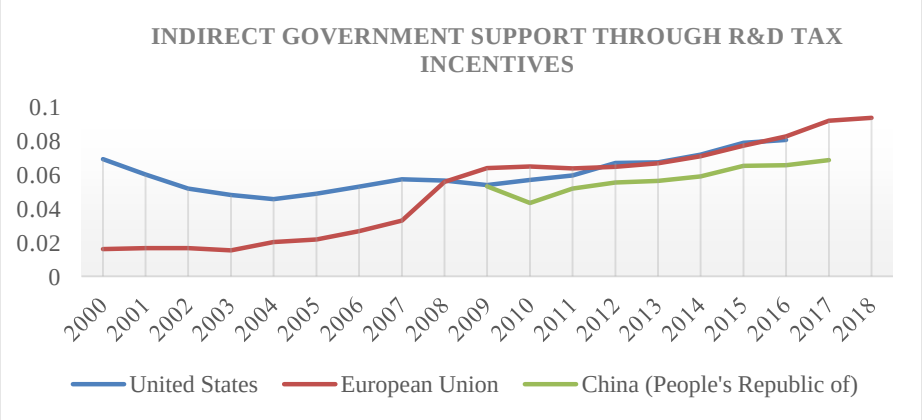

Fig. 1: Indirect government support through R&D TAX Incentives

Political systems might be another factor impacting the success of companies and industries. Americans hold the role of an individual in its highest places while China is a more community-oriented system. In contrast to the USA, China has a different approach to innovation and individual freedom. Despite the initiatives to boost the innovation ecosystem in China through initiatives and policies, the communist root can be easily seen. The government requires that in companies, especially tech-oriented companies, with more than 50 employers a representative of a communist party is required to be part and to give information to the government [12]. Since EDA is a sensitive industry especially due to its impact on the defense and security sector, this controlling element might suppress individual creativity.

The trade and technological war, between China and the USA and especially the Huawei ban, exposed some weaknesses to the world chip development ecosystem, and this forced companies operating in the east and coming from China to invest to create their own EDA resources and be more independent from U.S companies which control most of the market [13]. Lack of political stability and cooperation can bring changes to the sensitive EDA and semiconductor market. Another interesting event was the chip shortage that happened due to COVID-19 restrictions and long quarantines. Developed countries started to put efforts to change their dependence on the main chip design and chip production companies and countries. Investing in Research and Development programs in the electronics sector was one of the policies EU countries, China and Japan implemented to attract foreign direct investments hoping to establish an independent electronic development business ecosystem [4]. AMD announced its investments in a semiconductor plant in Dresden [14]. 16 major initiatives sponsored and led by the government to support this industry are identified by a US National Research Council report [4]. USA leading state in the semiconductor and EDA industry faces many challenges since the foreign supportive and attractive policies and market demands are the production is being shifted offshore. The USA is

losing ground in electronic and computer market share [15]. Data in Figure 2 are taken from the OECD.stat indicator database.

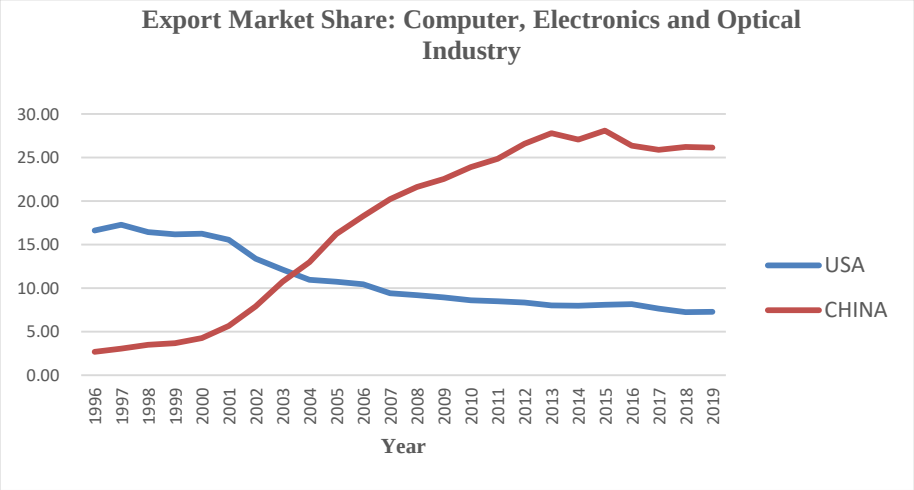

Fig. 2: Export Market Share: Computer, Electronics and Optical Industry

This might reflect the US economic growth and national and military security. When it comes to electronics it is not just a matter of consumer electronics, it is a matter of state defense. EDA is in the USA, but the other part of the chip production is in China and Asia [16]. Chip production companies and Electronic Design companies should cooperate continuously during the process, especially with the complex demands of nowadays electronic chips. The USA is trying to focus more on the other manufacturing process, while China which is a leader in the manufacturing processes is trying to be independent of the USA in the electronic design sector. Their efforts contribute to establishing in China necessary resources to develop its own EDA companies. The Chinese government is the driver behind the current increased interest in the EDA sector in China. And apart from foreign attraction, cooperation between government and universities and research science is seen as a priority, while in the USA there has been a decrease of interest in this field [15]. Another way to support the growth of the EDA industry is the encouragement that Government can do to SME-s. Government policies and support should boost entrepreneurial activities and at the same time should ease the procedures and regulations for public-private partnership in this field [7].

As mentioned above, EDA is a knowledge intense industry, where research and development activities are quite important and at the same time require a lot of financial support, human resources, and a lot of support from government.

Economic factors. The EDA market is highly fragmented, and at the same time very limited. Consumers' demand, trade market, and stock exchange regulations are very important. EDA industry operates in developed countries with high levels of high-tech exports. Consumer demands, as Porter has stated and as found in a specific paper on EDA [7], local demand and local market size seem too important for this sensitive

industry that serves directly to the Chip production ecosystem. On the other side, knowledge-intensive industries require a huge number of financial investments and can be offered only by countries that pose those investments. Figure 3 shows a comparison of R&D in the GDP for the USA, China, Japan, and England for the last 10 years. Data in Figure 3 were taken from World Development Indicators.

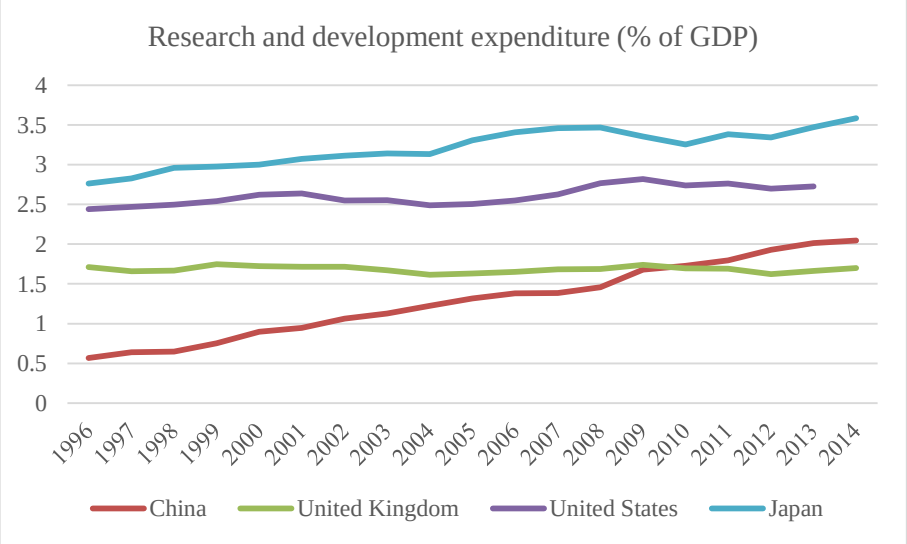

Fig. 3: Research and Development expenditures

As it can be seen from the figure, the interest of China has been increased compared to the stable and slow increase of Japan, the United States, and the United Kingdom.

Another important factor is the support towards new innovative start-ups and unicorns, new businesses in the ICT environment, and especially in the electronics sector. The friendly and supportive entrepreneurial ecosystem is an important element in the EDA. The beginning of EDA in the USA is an example to be followed. China, Germany, and Japan are doing the same. Boosting entrepreneurial activities in the ICT field and attracting an investor. There is an increase in the EDA start-up companies in Japan and the interesting part is the involvement of EDA veterans and experts (experts that used to work at Synopsys or Cadence) [17]. There is an increase in local software tools in China and Japan that has attracted EDA experts to invest and work in these startups [17]. This might threaten the current industry status since new emerging technologies and innovative tools might be developed and threaten the stability of the leading companies in the industry. Experts state that developing from scratch a new EDA tool that might be competitive to the current tools might be a difficult task, on the other side current tools are built in a way that drastically changes might not be possible, and the development of a new tool might open the possibility to design sophisticated and advanced tools that might lead to disruption. For EDA companies to bring growth to the economy of a state, international trade policies,

good cooperation between industries and states is required, proper tax system and policies for international trade.

As it can be seen from Table 1 the proper policies to encourage entrepreneurial activities from China have resulted in big changes in data. China's interest in entrepreneurial businesses has been increased and surpassed the USA's. Data were taken from World Development Indicators.

Table 1: Entrepreneurial Indicators, the USA vs. China

Indicator-% 18-64 pop.	Perceived Capabilities		Perceived Opportunities		Entrepreneurial Intention		Entrepreneurship as Desirable Career Choice		Total early-stage Entrepreneurial Activity	
Year	China	USA	China	USA	China	USA	China	USA	China	USA
2018	24.15	55.62	35.07	69.83	5.28	12.15	60.82	62.66	10.39	15.59
2019	67.35	65.51	74.86	67.24	1.42	13.68	79.32	67.87	8.66	17.42

Social factors. EDA businesses require high levels of educated people and talents and very specialized employees. The level of advanced knowledge and expertise the field requires is not possible to be filled by the education systems and by the level of education provided by all countries. The importance STEM sector for the young professionals in a country's mentality is very important to produce experts and workforce EDA requires. On the other hand, despite the forced labor found in developing countries and underdeveloped countries, the lack of proper education EDA specialists must have blocked the possibilities of companies to develop business in these countries. That is the reason why EDA companies collaborate closely with partners from universities and research centers and attract the best talents due to expertise requirements and R&D level of importance for the companies. From an engineering perspective, the design of electronics is becoming complex, and this is pushing design teams to become global to optimize costs and better use of the resources [18]. China is working on talent attraction and strong cooperation with universities [19].

Technological factors. Advancements in technology and the latest trend have a direct impact on EDA companies and pressuring them to adapt to continuous changes. The new semiconductor markets are driven by Artificial Intelligence and the Internet of Things, like automotive, defense, aviation, are requiring more and more advanced devices demanding from EDA companies new services and capabilities to ease the complexity of the designs [20]. Moore's law, system integration law are also very important factors leading the technological dimension of EDA companies, where the lifecycle of innovation is getting shorter [20] [21].

The internet of everything is expanding the market opportunities for companies operating in the chip production and design sector. EDA companies are trying to innovate their tools through the latest technologies, Mentor's R&D staff has been adding machine learning and artificial intelligence into their own EDA tools [22].

The automotive sector has become an interesting area of chip production and the increased complexity, and sophistication of the tools have led to interesting dynamics

within the industry. There is an increase in M&A activity as an exit strategy for companies that find it difficult to continue [3] and at the same time, experts within the industry have seen a convergence between different industries (mechanical and electronic design) to support the production and development of advanced tools [23].

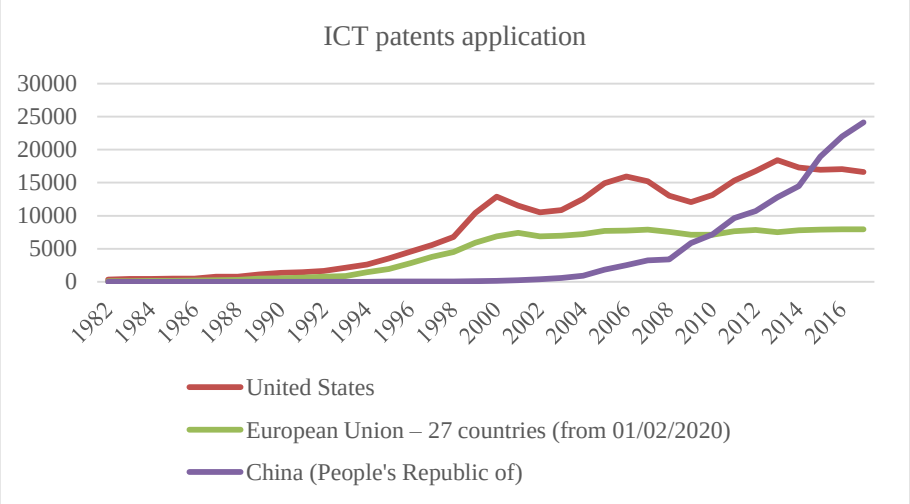

Fig. 4: ICT patents application

The level of innovation required in this industry from companies is too high and the readiness of companies to adapt to these demands as soon as possible is vital. Companies in this industry suffer from the technology pressure and the high R&D investments to keep up the good work of innovating and bringing up-to-date products. We believe that to be one of the reasons, that the market is quite fragmented, requires a lot of tech and R&D investments, and not all companies and new entries can deal with these technological factors characterizing the EDA industry. Figure 4 speaks on the R&D products in ICT in the United States, EU, and China. As it can be seen China is growing faster in this sector with a high level of products that might reflect in EDA. Data in the figure 4 are taken from OECD.stat indicator database

It seems like ***Environmental factors*** might not impact direct the software industry of EDA. But EDA cooperates and is very affected by other industries, like the semiconductor, consumers electronic products, automotive, manufacturing, etc. All these industries and sectors are somehow affected by environmental regulations, and all these businesses operating in these industries focus to produce products that are environmentally friendly with different characteristics. EDA needs to be up to date and adapt to the market demands. Technologies related to the environment come with specifications that might be regulated by dedicated regulations and initiatives. All these details should be reflected in the products and company's policies.

Legal factors. EDA vendors mainly capture value through different licensing revenue models. A new business model that has emerged in EDA is the Intellectual Prop-

erty (IP) business model. Since the time to market is very short and the specifics of the products are too complex, competitors collaborate to exchange knowledge and expertise in the form of IP products. This knowledge is presented in the form of sources of codes and lines that are designed for specific products and tasks. The exchange of knowledge requires a strong legal environment to protect the knowledge through patents, IPs laws, trademarks. Consumer protection laws and privacy laws are essential in this phase. The IP sector and regulations are quite unorganized in most of the countries and especially in underdevelopment and developing countries. While building strategies on products and how to capture value all these legal factors need to be considered. China is struggling in this sector, while the USA has better experience and has a better-established foundation to boost this type of business model. In a survey found in [24], the USA is ranked in 14th place while China is in the 40th when it comes to intellectual property protection and table 2 shows the ranking of China and the USA for the IP protection indicators according to World Bank data. Intellectual property rights and the failure to protect those rights impact the Chinese ability to innovate.

Table 2: USA and China RANK for the IP protection indicator, Source: TCdata360, World Bank.

	2012	**2013**	**2014**	**2015**	**2016**
China	47	51	53	53	63
USA	28	29	25	20	15

To sum up the abovementioned analysis, in table 3, a list of factors we propose to be taken into consideration when scanning the macroeconomic environment of EDA companies is presented.

Table 3: PESTEL factors for EDA industry

PESTEL Factors	
	Political systems
POLITICAL FACTORS	Tax policies
	Security priority and defense expenditures
	Support for Creation of new scientific and technological knowledge
	Government involvement in trade unions and agreements
	R&D Expenditures to private and public organizations
	Public R&D support for private R&D
ECONOMIC FACTORS	Contextual indicators, GDP, Market orientation, corruption levels (Performance and structure of the economy)
	Sales Impact
	High-Tech exports

	Price and structural competitiveness
	Business and Entrepreneurship ecosystem.
SOCIAL FACTORS	Customer's preferences (Demographic factors)
	R&D Human resources (Education level)
TECHNOLOGICAL FACTORS	R&D activity and level of innovation
	Technological awareness
	Infrastructure and diffusion of the new ICT
ENVIRONMENTAL FACTORS	Environment-related technologies
LEGAL FACTORS	Employment laws
	Copyright and patent laws
	Migration policies
	Consumer protection laws
	Data protection laws
	Education laws
	Industry Regulation
	Licenses & Permits

Conclusions

The EDA industry is a complex and very knowledge-intensive industry. It requires continuous efforts for research activities, the attraction of expertise, knowledge talents, and experts. Most of the companies do not resist long in the industry. EDA industry is a support for the semiconductor industry. The higher the demand for semiconductors the higher the chances for EDA to grow and be developed. The role of the government is very important to the development of this industry. The policies, vision, and national priorities can boost entrepreneurial and research activities. Technology on the other side is a driver for this industry. Continuous change and improvement to the products and services are required. There are two ways how most companies deal with this pressure; they invest in their research and development resources, and they buy knowledge from other competitors or partners. R&D resources cost a lot to companies, but the lack of knowledge coming from the universities, and low education level can be a huge problem for the continuity of the company. For this reason, the government in China and the USA are trying to attract as many as possible experts and talents, because they know them to be the key to the industry. An important thing to be done is to build regulation and to offer legal protection for the knowledge and exchange of knowledge.

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