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Research Results
Резултати от научни изследвания

INTELLECTUAL PROPERTY AND SECURITY IN THE INTEGRATED CIRCUITS INDUSTRY

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Abstract. The production of integrated circuits (IC) is key to the development of the world economy. The system of intellectual property offers different means of protection for the products of the IC industry. Those are mainly the patents for inventions, registration of topologies of ICs, trade secrets, copyright. The economics of the IC industry in the late 20th century moves different processes in different regions of the world. This economic reality provides an opportunity for those companies to invest heavily in R&D, to create valuable intellectual property and to develop a competitive advantage. The historical development of integrated circuit manufacturing, the development of the main companies involved in the sector and the existing supply chains, raise a number of questions that are related to the concentration of innovation and intellectual property, the potential problems for global supply and economic development, as well as the steps towards overcoming those problems.

Keywords: intellectual property; innovation; integrated circuits; semiconductors; chips

1. Introduction

Integrated circuits form an integral part of technology that we use every day. The production of integrated circuits is key to the development of the world economy. In 2022, the IC market is worth 605.1 bn. $, and it is predicted that it will more than double in 10 years[1]. Their widespread use for the functioning of technologies from our daily life and business environment, as well as by the defense sector, make their development, protection, and commercialization relevant for research. They make possible one of the most important features of the internet – the interactiveness via communication (Strijlev 2019).

Intellectual property is essential to the development of the integrated circuit market. This is due to the high investment required by companies for research and development and the creation of innovations in the machines that are used in the

production of integrated circuits, as well as in the development and production of the circuits themselves. The presence of appropriate regulations to protect these investments is a prerequisite for technological progress.

The historical development of integrated circuit manufacturing, the development of the main companies involved in the sector and the existing supply chains, raise a number of questions that are related to the concentration of innovation and intellectual property, the potential problems for global supply and economic development, as well as the steps towards overcoming those problems.

In the present paper the term „integrated circuits" will be used interchangeably with the terms „chips" and „semiconductor". This stems from the adopted term by the Bulgarian Law on the topology of integrated circuits, as well as international documents adopted by Bulgaria, such as the Treaty on trade related aspects of Intellectual Property and the relevant European Union legislation.

INTELLECTUAL PROPERTY AND INTEGRATED CIRCUITS

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Patents for inventions

Patents can be an economic pillar on which companies can rely in their steady development (Aleksandrov 2022). The patent is one of the main instruments for protection of the results of the IC industry. A patent can be granted for semiconductor devices, as well as for the related productions processes. They have a strategic role when seeking protection for „technically complex structural features of semiconductor devices and innovations in semiconductor processing" [2]. The patent system is characterized by a long formal process of examination of the invention conducted by the relevant Patent office, which is contrasted by the short innovation cycles in the IC industry. Despite of that there are significant advantages to this type of protection.

One of them is that the grant of a patent provides its owner with an intellectual property right over the invention which is exclusive in its nature. The right holder has the right to use the patented device or process (production, application, sale, import/export of the product, etc.), to assign the patent (sell it), to license it to an interested party, and to forbid anyone from using the patented invention without prior permission.

The intensive research work being conducted by companies in the IC industry lead to high patent application activity and an ever-growing patent portfolio. In order to avoid infringing to someone's intellectual property right, companies often choose to cross-license their inventions to one another[3]. This formal expression of technology transfer additionally stimulates the further development of the industry.

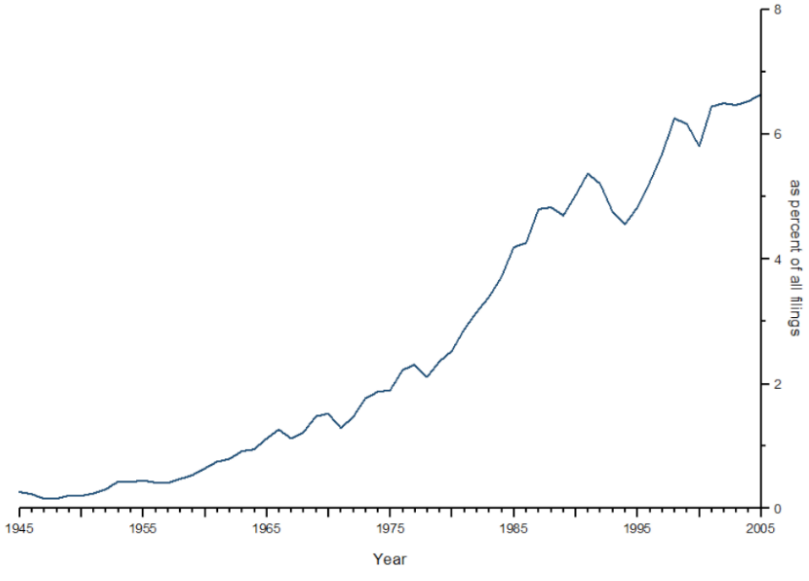

Figure 1. Share of semiconductor patent filings, as percentage of all patent filing, 1945 – 2005
Source: WIPO based on the PATSTAT database

Topology/Layout design of integrated circuits

The protection of the topology of integrated circuits is a legal means of establishing an intellectual property right over the design ICs. In the beginning of the 80s representatives of American companies raise the subject of need to formulate a new kind of right over semiconductors. Their petition is has the following arguments: the nature of ICs makes them easy to copy; the current patent system is ineffective and require a substantial inventive step; the copyright system cannot provide protection for ICs because of the functional aspects of what is being created[4]. The United States adopts the legislation creating this new sui generis legislation in 1984. The European Union follow with the adoption of the Directive on the legal protection of topographies of semiconductor products in 1986. Both documents establish a sui generis right (the formulated protection relies both on characteristics of the patent and copyright systems). They provide protection for the topologies of ICs (not the ICs themselves), give definitions, introduce a formalized registration process to gain protection, establish criteria for this protection, as well as length of the protection – 10 years.

Bulgaria adopts a Law on the topology of integrated circuits in 1999 which contains the already established norms of European legislation. Registration is needed to have protection over the topology. The object of protection is an original topology which is the result of the own intellectual efforts of its creator and is not

known among creators of topologies and produces of integrated circuits during the time of its creation. A topology that combines known elements and connections can also be protected as long as it is the result of intellectual effort and should not be known to creators of topologies and producers of ICs. The length of protection is 10 years from the first commercial use of the topology, if the 2 years after that use it is registered in the Patent office. If the topology wasn‘t commercially used and the approach is to register it directly, the protection starts from the date of the application for registration.

The exclusive right that arises with the registration of the topology of an IC contains the right of the owner to use it (production, sale, import/export of the product), to assign it (sell it), to license it, to forbid third parties from using the protected topology if they do not have prior permission, i.e. activities related to the economic exploitation of the protected object.

On the international level, beyond the supranational level of the European Union, in 1989 during the WIPO conference in Washington the countries sign the Treaty on intellectual property in respect of integrated circuits, which aims to standardize the protection of IC in many countries. The Treaty envisions the creation of a Union (similar to other international treaties the World Intellectual Property Organization administers), it includes definitions, the object of protection, the duration of the protection – 8 years, the possibility for introduction of a formal procedure for the registration of ICs, etc. The Treaty has not yet entered into force but its texts have influenced another international document settling issues on this subject – The Agreement on Trade-Related Aspects of Intellectual Property Rights, signed in 1994 by the members of the World Trade Organization.

It is important to note that the protection for the topology of an integrated circuit doesn’t cover the software that is used for the design of the IC, nor the machines for its production. Also the topology of ICs cannot be protected by patent[5]. Negative aspect of this kind of protection is that what comes under the scope of protection is the layout of the IC, not its functionality, and it is possible to change the design without losing functionality, which means that competitors can reverse engineer the produced chip and produce their own with enough distinction in the design so as to not infring on the registered topology[6].

Trade secrets

Trade secrets refer to commercially valuable information for the company which is known to a small group of people, i.e. it is not considered general knowledge in the industry. For the information to be considered as trade secret the company has to take reasonable steps with regards to protecting the information (ex. Limiting the access to the information, drafting of non-disclosure agreements, etc.)[7].

ICs have strategic importance in the technological development of the modern economy. The use of the latest ICs can secure the competitiveness of whole

industries. In addition to their use in everyday products, integrated circuits have vital importance in the production of fighter jets, missile systems and other component of national defense which makes them an important factor in the geopolitical competition of nation states. The production of this development and production semiconductors requires vast financial resources and specialized human capital.

The companies that create the machines which are used in the production of ICs or those that create the design and produce the ICs themselves often choose to keep their „monopoly" over the knowledge and scientific results that they create by keeping them a secret and take the necessary precautions to prevent dissemination of those results. This cannot be achieved by filing a patent for an invention because the patent system requires of anyone that seeks files an application to divulge to the public what they have invented in order to receive protection.

One of the main impediments with regards to keeping trade secrets a secret is that employees often change companies which despite having them sign non-disclosure agreements creates risks that some of the information that they know will become known to the company which they decide to join[8]. Also it is possible that a representative of a competing company approaches our employee with the goal to receive access to trade secrets. There have been instances where former employees have stolen data which can be used by their new employer[9].

Some research results of the company cannot be protected as trade secrets due to their nature. After a product is released to the market it is a common practice that the main competitors try to reverse engineer the IC to gather as much information as possible about the state of the art of other market players.

Copyright

Creating the layout design of an IC requires specialized software, which falls under the protection of copyright laws which protect computer programs as literary work. This is an established practice in IP legislature which relates the language of computer code to literary texts.

The complexity of modern ICs makes the use of Electronic Design Automation (EDA) necessary – it combines hardware, software, services and processes that help design ICs[10]. The design of the most advanced ICs is only possible with the use of a particular type of software. The global EDA market is valued at 12,9 bn. $ in 2022 and it is estimated to reach 32,9 bn. $ in 2032[11]. The leading three companies in the development of this software are Cadence, Synopsys and Mentor Graphics[12].

The specialized computer programs are used by the leading design companies which create the topology of ICs. Other companies that use them are the foundries which are responsible for the production of ICs. For them the software plays a role as a validation tool for the applicability of the design in the production process. Without the access to EDA the foundries which produce ICs will not be able to execute their operations[13].

The companies which create the design of the ICs provide the foundries with detailed graphic description containing text, software, databases, etc. which are used for the production process and can also be objects of copyright[14].

Characteristics of the integrated circuit industry

The law on the topology of integrated circuit introduces the following definition for the term IC: "a product in finished or intermediate form designated to implement functions for generating, transfer, receiving, processing and/or preservation of information in which the elements and some or all connections are made inseparable in and/or over a common plate"[15]. ICs can perform many functions that provide the functionality of the devices of which they are a part.

ICs have their beginning in the 1950s when the researchers Robert Noyce, working for Fairchild files an application for a patent for a semiconductor device, and separately from him Jack Kilby, working for Texas Instruments, develops a monolith IC[16].

As it was mentioned, the global market of ICs in 2022 is valued at 605.1 bn. $, while in 1976 it was almost 3 bn. $[17]. The quick development of the industry is due to the vast application of semiconductors in devices used in various industries such as defense, transport, telecommunications, home and office appliances, etc. Integrated circuits make possible the advancement of artificial intelligence. ICs are a fundamental part of the modern digital economy.

During the first decades of the development of the industry, the companies that produce ICs combine and execute all the processes in-house, i.e. they are vertically integrated. They owned their supply line which is needed for the design, production and/or assembly, and sale of the ICs.

We can group the main processes for the creation of ICs as follows:

1. Design;
2. Production;
3. Assembly;
4. Marketing and sales.

There is a long list of what is necessary for the production of ICs but we can group them as follows:

1. Materials – such as the silicone used to make the wafers that form the basis of ICs and acts as a semiconductor;

2. Software – important component of IC production needed for the creation of the designs of ICs. Their small size and detailed layout makes it impossible to create a design without using specialized software. This types of computer programs are used both by companies that responsible solely for the design as well as companies responsible for the production of the ICs;

3. Machines – here as well the size and detail ICs require the use of specialized technology (ex. photolithographic technology is used to print the topology of the IC on the silicone wafer).

In the end of the 80s and in the 90s we see the adoption of an entirely different business model. The high cost of maintaining a vertically integrated production of ICs combined with the low cost of the work force in Asia lead to the outsourcing of the production and assembly processes to Asia. This is also helped by the transportation costs and the advancements in telecommunications which make the management of such an operation less complex. The leading American companies are left responsible for the design of the topology of the integrated circuit and the sales of the finished product what it is produced, assembled and delivered to them. This restructuring of the IC industry leads to less of a need for capital investments from the previously vertically integrated model. Companies can put more of a focus on R&D and creation of innovations in the market. In 1990 the US accounted for 37% of the global production of ICs, while in 2022 only for 12 %18. That the result from the change of the production model.

The economic reality and the increased development of the IC industry lead to a globalized division of the different processes that can be summarized as follows:

1. Companies which create the design of the ICs and subsequently market and sell them to the end user or for the purposes of different industries. The leaders in the industry are based in the US – Nvidia, Intel, etc.;

2. Companies which produce the machines which are necessary for the production of ICs. They are based in Netherlands and Japan but the only company which produces machines for the most advanced ICs is ASML, Netherlands;

3. Companies (called foundries), which provide production and/or assembly services. They are based mainly in Taiwan and China. The global leader in production is Taiwan Semiconductor Manufacturing Company, Taiwan.

As we can see the economics of the industry in the late 20th century moves different processes in different regions of the world. This economic reality provides an opportunity for those companies to invest heavily in R&D, to create valuable intellectual property and to develop competitive advantage.

Despite the improved specialization, the generated intellectual property and the advancement of the IC industry, the geographical aspect of IC creation has fundamental problems which stem from the wide use of ICs among different industries. Those problems need to be addressed to avoid potential economic slowdown caused by crisis. In order to observe the problem, we will present as an example two leading companies from the industry – one focused on the creation of the machines for IC production and one focused on the production of ICs.

The leader in the production of equipment for integrated circuits

ASML is a company based Veldhoven, Netherland, created in 1984 as a subsidiary of Philips which subsequently sells the company. ASML is specialized in the production of photolithographic machines which are used to produce ICs. Photolithography is the method for printing the detailed design of ICs onto the silicone semiconductor wafers. The leading producers of ICs are clients of the company, such as TSMC, Samsung и Intel.

Although the company has competition such as Nikon and Canon, they only produce DUV (deep ultraviolet) machines – the previous generation equipment for IC production. ASML is the only company in the world that produces EUV (extreme ultraviolet) technology used to produce the most advanced ICs. The machines are developed by the company, and they own the intellectual property which means that they have an economic monopoly over their use. Due to their large size the machines are comprised of different modules that are produced in different locations around the world and then assembled by the company in the Netherlands19. ASML invested 6 bn. $ for R&D to create its product[20]. The company owns a vast IP portfolio consisting of over 15 000 patents and over 29 000 filed patent applications[21].

Year	Market Cap (bln. $)	Revenue (bln. $)	R&D (bln. $)	Earning (bln. $)	Patent Applications	Patents
2017	74.6	10.23	1.42	2.77	1560	609
2018	66.06	12.93	1.86	3.47	1834	757
2019	124	13.24	2.21	3.11	1942	875
2020	205.12	15.97	2.51	4.76	1756	949
2021	325.23	22.02	3.01	7.58	745	1011
2022	220.27	22.31	3.43	6.78	88	634

Figure 3. Economic data of ASML
Source: https://insights.greyb.com/taiwan-semiconductor-manufacturing-company/

ASML (which is a publicly traded company) has more than doubled its revenue and its R&D and has significantly increased its earnings in a period of 5 years which proves the ever increasing role of the company in the IC industry.

The leader in the production of integrated circuits

In 1987 Morris Chang, a specialist in the field ICs that has worked for Texas Instruments, creates Taiwan Semiconductor Manufacturing Company (TSMC) in

Taiwan. The main purpose of the company is to fit the new business model of the IC industry of outsourcing production to Asia. TSMC is a foundry which produces ICs without engaging in the design or sales to the end user.

All Taiwanese companies comprise 68% of the global production of ICs[22] and 92% of the market of the most advanced IC which have a size smaller than 10 nm[23].

TSMC is the leading company in the production of ICs. In the third quarter of 2023 its market share is 57.9%[24] and it produces around 90% of the most advanced ICs[25]. The company provides its services as a foundry to clients such as Apple, Qualcomm, AMD, Nvidia, etc. has filed more than 75 000 patent applications and owns more than 52 000 patents[26]. It is visible from its market share and patent activity that the TSMC has a key role in the IC industry.

Year	Market Cap (bln. $)	Revenue (bln. $)	R&D (bln. $)	Earning (bln. $)	Patent Applications	Patents
2017	199.41	32.98	2.72	13.35	5011	3373
2018	191.19	33.69	2.81	13.01	5612	3577
2019	286.57	35.77	3.06	12.96	7185	1247
2020	488.12	47.69	3.90	20.83	7197	3133
2021	575.93	57.23	4.50	23.97	6128	1860
2022	386.31	73.67	5.31	37.33	1116	1201

Figure 2. Economic data of TSMC
Source: https://insights.greyb.com/taiwan-semiconductor-manufacturing-company/

Its rapid development and market position allow it to make considerable investments in R&D and the generation of objects of intellectual property which sustain its dominant position. The company From the financial data of the company we can conclude that it has more than doubled its revenue, it has doubled its R&D, and tripled its Earnings in a period of 5 years.

Identified risks for the industry and the adopted response

The geographical aspect of the IC industry that we have presented above raises several potential and some realized risks for technological development as a whole and for the global economy. That is due to the vast application of ICs in many different industries. We can see a concentration of a few large companies with significant market share, distanced from each other geographically, engaged in specific processes of IC creation. These concentrations have the following risks:

– Political conflicts/War – ex. Taiwan has a longstanding conflict with the People's Republic of China related to its sovereignty. Considering the

immense importance of Taiwan for global semiconductor supply, a more serious conflict could disrupt many different industries;

– Natural disasters – ex. The production of ICs requires vast quantities of water without which it becomes impossible. Potential droughts can disrupt global supplies[27]. Other natural disasters such as cyclones and earthquakes are a frequent occurrence in the region where Taiwan is located[28].

– Pandemics – COVID-19 created a global IC shortage due to lockdowns introduced by local governments. This showed the sizable deficiencies of globalization[29];

– Intellectual property protection – infringement of IP rights is a common practice that has existed ever since the introduction of the system. The protection of ICs is affected on the one side by the long and protracted processes of examination that the patent system is characterized by and which contrasts short innovation cycles of ICs. There are also difficulties in proving infringement with regards to rights over ICs due to their complex nature[30]. Because of the economic importance of semiconductors for both companies and nation states, and the high cost of R&D and production in the industry, we often see cases industrial espionage, leaks of trade secrets, etc.[31].

Due to the negative aspects of the abovementioned concentration that we experienced during the Covid-19 pandemic – global production of automobiles, which relies on the use of ICs, decreased by 26% in 2021[32] – national and supranational governments (such as the EU) began to adopt strategies and law, and to provide funding for the development of the local IC industry, the effects of which we are yet to see. Several examples of this response are:

– The USA adopted a Chips Act that is supported by an investment of 52.7 bn. $ for the production, research and development of human capital in the IC industry[33];

– The European Union adopted a law for chip and plans to invest 43 bn. $ to boost the development of ICs in the Union[34];

– The People's Republic of China plans to invest 40 bn. $ for the development of its IC industry[35];

– The Republic of Korea adopted amendments to their tax law in order to stimulate investments and the production of ICs locally[36];

The adopted response show the key role that ICs have for the economy and an understanding of the importance of having the different processes closer to the country and the consumers that needs to use the end product.

Conclusion

The use of ICs is of immense importance for the development of the world economy. This is visible from the effect that the disruption of global supplies had on economic activity. The IC industry is characterized with the division

of the separate activities of design, production, assembly in different regions of the world which makes supply chains complex and susceptible to crisis.

We can draw the following conclusions with regards to the IC industry:

– There is high specialization in a particular IC creation process of a small number of companies;

– The execution of the different IC creation processes is geographically distanced;

– The leading design and sales companies are based in the USA;

– The leading production company is based in Taiwan;

– The leading machine production company is based in the Netherlands and is the only company that provides machines for the production of the most advanced ICs;

– There is a link between the investment in R&D and the high patent filing activity;

– Although that the initial change in the business model of IC production was characterized by outsourcing based on cheap work force and transportation, we can conclude that the model has continues today because of the developed high specialization of those companies and their innovativeness based on intellectual property.

The identified risks in the development of the IC industry stimulate the formulation of a response from nation states consisting of high investments for the development of a local IC industry. This aims to limit the risks associated with the current status quo. We are yet to see whether the response as it will bring change to the global production of ICs.

NOTES

1. For more information: https://datahorizzonresearch.com/semiconductor-market-2206.
2. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.22.
3. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.26.
4. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.27.
5. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.22.
6. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.31.
7. For more information: https://www.wipo.int/tradesecrets/en/.

8. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.24.
9. For more information: https://www.lexology.com/library/detail.aspx?g=58197902-54b1-432f-a8b5-8a1101116175
10. For more information: https://www.arm.com/glossary/electronic-design-automation.
11. For more information: https://www.gminsights.com/industry-analysis/electronic-design-automation-eda-market.
12. For more information: https://www.technologyreview.com/2022/08/18/1058116/eda-software-us-china-chip-war/.
13. For more information: https://www.granitefirm.com/blog/us/2023/06/14/eda-synopsys-cadence-mentor/.
14. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.32.
15. For more information: https://www.wipo.int/wipolex/en/text/577944.
16. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.9.
17. For more information: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf p.5.
18. For more information: https://www.cfr.org/blog/us-investment-semiconductor-manufacturing-building-talent-pipeline.
19. For more information: https://www.cnbc.com/2022/03/23/inside-asml-the-company-advanced-chipmakers-use-for-euv-lithography.html.
20. For more information: https://www.asml.com/en/products/euv-lithography-systems.
21. For more information: https://insights.greyb.com/asml-holding-patents/.
22. For more information: https://www.cfr.org/blog/will-chinas-reliance-taiwanese-chips-prevent-war.
23. For more information: https://www.forbes.com/sites/katharinabuchholz/2023/01/13/advanced-microchip-production-relies-on-taiwan/?sh=6d5e9cd2371d.
24. For more information: https://focustaiwan.tw/business/202312090011.
25. For more information: https://www.cfr.org/blog/will-chinas-reliance-taiwanese-chips-prevent-war.
26. For more information: https://esg.tsmc.com/en/update/innovationAndService/caseStudy/45/index.html.
27. For more information: https://www.npr.org/sections/goatsandsoda/2023/04/19/1170425349/epic-drought-in-taiwan-pits-farmers-against-high-tech-factories-for-water.
28. For more information: https://nspp.mofa.gov.tw/nsppe/news.ph

p?post=235468&unit=410&unitname=Stories&postname=Hard-Earned-Knowledge:-Taiwan%E2%80%99s-Typhoon-and-Earthquake-Response-Experience.

29. For more information: https://www.techrepublic.com/article/global-chip-shortage-cheat-sheet/.
30. For more information: https://www.lexology.com/library/detail.aspx?g=dacad9be-9e97-4cd9-9d82-0b6fe99c0285.
31. For more information: https://www.bloomberg.com/news/articles/2023-02-15/asml-says-ex-employee-in-china-misappropriated-chip-data.
32. For more information: https://www.jpmorgan.com/insights/global-research/supply-chain/chip-shortage.
33. For more information: https://www.reuters.com/technology/us-reports-big-interest-52-billion-semiconductor-chips-funding-2023-08-09/.
34. For more information: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en.
35. For more information: https://www.reuters.com/technology/china-launch-new-40-bln-state-fund-boost-chip-industry-sources-say-2023-09-05/.
36. For more information: https://www.jdsupra.com/legalnews/the-south-korean-k-chips-act-and-its-8892812/.

REFERENCES

ALEKSANDROV, A., 2022. The role of patents for economic growth on a micro- and macro level. *Journal of Economic and Social Alternatives*, no. 3, pp. 43 – 59. ISSN:1314-6556.

ASML Holding Patents – Key Insights and Stats, Insights by Greyb, available at: https://insights.greyb.com/asml-holding-patents/.

BUCHHOLZ, K., 2023. Advanced Microchip Production Relies On Taiwan, Forbes, available at: https://www.forbes.com/sites/katharinabuchholz/2023/01/13/advanced-microchip-production-relies-on-taiwan/?sh=6d5e9cd2371d.

Bulgarian Law on Topography of Integrated Circuits (SG No. 81/1999, as amended up to October 27, 2020).

BUTTS, D., 2023. Employee of chip equipment giant ASML accused of stealing company secrets went to Huawei: report, South China Morning Post, available at: https://www.scmp.com/tech/tech-war/article/3239008/employee-chip-equipment-giant-asml-accused-stealing-company-secrets-went-huawei-report.

CHEN, B.; WEI, A., 2022. TSMC was Honored with the Highest Level of TIPS AAA Certification, TSMC. Available at: https://esg.tsmc.com/

en/update/innovationAndService/caseStudy/45/index.html.
CHIEN-CHUNG, C.; HUANG, F., 2023. TSMC cements global lead as market share rises to 57.9% in Q3, Focus Taiwan, available at: https://focustaiwan.tw/business/202312090011.
Electronic Design Automation (EDA) Market Report, Global Market Insights, 2023, available at: https://www.gminsights.com/industry-analysis/electronic-design-automation-eda-market.
FENG, E., 2023. Epic drought in Taiwan pits farmers against high-tech factories for water, NPR, Available at: https://www.npr.org/sections/goatsandsoda/2023/04/19/1170425349/epic-drought-in-taiwan-pits-farmers-against-high-tech-factories-for-water.
Hard-Earned Knowledge: Taiwan's Typhoon and Earthquake Response Experience, Ministry of Foreign Affairs Republic of China (Taiwan), available at: https://nspp.mofa.gov.tw/nsppe/news.php?post=235468&unit=410&unitname=Stories&postname=Hard-Earned-Knowledge:-Taiwan%E2%80%99s-Typhoon-and-Earthquake-Response-Experience.
HINES, D., L., MCCAMMON, J. K., 2019. Drafting and Enforcing Semiconductor Patents, Lexology, available at: https://www.lexology.com/library/detail.aspx?g=dacad9be-9e97-4cd9-9d82-0b6fe99c0285.
KOC, C.; WU, D., 2023. ASML Says Ex-Employee in China Stole Chip Data, Bloomberg, available at: https://www.bloomberg.com/news/articles/2023-02-15/asml-says-ex-employee-in-china-misappropriated-chip-data.
LIN, A., 2023.Three EDA oligopoly vendors: Synopsys, Cadence, and Mentor Graphics, Andy Lin's blog, available at: https://www.granite-firm.com/blog/us/2023/06/14/eda-synopsys-cadence-mentor/.
Official website of Arm Holdings plc.
Official website of ASML.
Official website of European Commission.
Official website of WIPO.
PAN, C.; WU, S., 2023. The South Korean K-Chips Act and Its Impact on International Companies and Investors, JD Supra, available at: https://www.jdsupra.com/legalnews/the-south-korean-k-chips-act-and-its-8892812/ .
SACKS, D., 2023.Will China's Reliance on Taiwanese Chips Prevent a War?, Council on Foreign Relations. Available at: https://www.cfr.org/blog/will-chinas-reliance-taiwanese-chips-prevent-war.
Semiconductor & Electronics Market Research Report, Data Horizzon 2023, available at: https://datahorizzonresearch.com/semiconductor-market-2206.

SHANE, E., 2023. Global Chip Shortage: Everything You Need to Know, TechRepublic, available at: https://www.techrepublic.com/article/global-chip-shortage-cheat-sheet/.

SHEPARDSON, D., 2023. US reports big interest in $52 billion semiconductor chips funding, Reuters, available at: https://www.reuters.com/technology/us-reports-big-interest-52-billion-semiconductor-chips-funding-2023-08-09/

STRIJLEV, H., 2019. New business models for radio industry product distribution through digital technologies. *Journal of Economic and Social Alternatives*, vol. 1, pp. 32 – 39, ISSN 1314 – 6556.

Supply chain issues and autos: When will the chip shortage end? Global Research, J.P. Morgan, 2023, available at: https://www.jpmorgan.com/insights/global-research/supply-chain/chip-shortage

TARASOV, K., 2022. ASML is the only company making the $200 million machines needed to print every advanced microchip. Here's an inside look, CNBC, available at: https://www.cnbc.com/2022/03/23/inside-asml-the-company-advanced-chipmakers-use-for-euv-lithography.html.

VAN SLOAN, S., 2023. U.S. Investment in Semiconductor Manufacturing: Building the Talent Pipeline, Council on Foreign Relations, available at: https://www.cfr.org/blog/us-investment-semiconductor-manufacturing-building-talent-pipeline.

YANG, Z., 2022. Inside the software that will become the next battle front in US-China chip war. *Technology Review*, available at: https://www.technologyreview.com/2022/08/18/1058116/eda-software-us-china-chip-war/.

WIPO, 2015. Economic Research Working Paper No. 27. available at: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_27.pdf.

ZHU, J.; HUANG, K.; MO, Y.; LIU, R., 2023. Exclusive: China to launch $40 billion state fund to boost chip industry, Reuters, available at: https://www.reuters.com/technology/china-launch-new-40-bln-state-fund-boost-chip-industry-sources-say-2023-09-05/.

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