EUROPEAN URBAN AND REGIONAL STUDIES

European Urban and Regional Studies
1–7

DOI: 10.1177/09697764231165199
journals.sagepub.com/home/eur
SAGE

Euro Commentary – Europe's semiconductor industry at a crossroads: Industrial policy and regional clusters

Andrew Johnston
University of Huddersfield, UK

Robert Huggins
Cardiff University, UK

Abstract

The European Union has agreed to provide significant investment to the semiconductor industry in order to address issues of self-sufficiency and digital sovereignty. This comes on the back of the long-term decline in the competitiveness and size of the industry in Europe. These issues are of considerable significance to urban and regional economic development agendas as the industry is clustered around several European regions. This commentary seeks to examine the extent to which European policy intervention is likely to positively influence Europe's semiconductor industry. It is argued that the European semiconductor industry is at a crossroads. While it has some competitive advantages and is home to several significant clusters, it faces incessant competition from producers in Asia and the United States. It is argued that European policy should not be space neutral and aim to encourage innovation and enterprise within the sector in conjunction with existing European regional economic development policy measures. Within this approach, supporting key existing clusters through triple helix models of development are likely to be the most effective modes of intervention.

Keywords

Clusters, European Union, innovation, regional development, semiconductors

Introduction

As the European Union (EU) continues to evolve its regional innovation policies in a bid to find the magic formula for facilitating specialised industrial competitiveness across Europe's cities and regions (Pontikakis et al., 2022), it is important to consider those industries which are likely to form a key component of these policies. One industry that has garnered significant attention since the COVID pandemic is the manufacture of semiconductors (Miller, 2022a). Semiconductors – or what are more commonly referred to as 'chips'– hit the spotlight due to shortages partly caused by increased demand

Corresponding author:
Andrew Johnston, Department of Management, University of Huddersfield, Queensgate, Huddersfield, HD1 3DH, UK.
Email: a.johnston@hud.ac.uk

for a range of consumer goods during the pandemic. Semiconductors are integral to every electronic device, enabling technologies from smartphones to computers and cars to satellites, to function.

Following the pandemic, semiconductors have remained high on the agenda of both the media and public policymakers, especially due to geopolitical tensions and the increasingly strained relationships between the United States and China. The United States is seeking to improve its self-sufficiency in chip manufacture through the introduction of a so-called 'Chips Act' (US Department of State, 2022). The Act will lead to significant public investment in the industry in the United States. In 2022, the EU introduced its own Chips Act, which similarly seeks to address issues of self-sufficiency and digital sovereignty (European Commission, 2022). This comes on the back of the long-term decline in the competitiveness and size of the industry in Europe (Dornbusch, 2018), which in many ways has now reached a crossroads in terms of whether it can rejuvenate itself or whether its long-term decline will continue.

These issues are of considerable significance to European urban and regional economic development agendas and policies as the industry is clustered around multiple city and regional locations in Europe. A key question, therefore, is how should regional clusters look in the future and how can they be most effectively configured to ensure that the industry as a whole across Europe improves its competitiveness. To some extent, the bid for digital sovereignty suggests the evolution of these regional clusters into industrial complexes dominated by relatively large-scale plants and high-volume manufacturing (Gordon and McCann, 2000). However, the networked nature of technological innovation suggests a more open approach which connects actors within and across regions may be a more realistic industrial policy. For example, a triple helix approach that links firms of all sizes with R&D capacity in universities and other research establishments and relevant government and public agencies may be the most appropriate configuration for fostering growth (Leydesdorff, 2000). Furthermore, new path creation in the form of more radical innovation based on embracing new technologies, while associated with higher rates of innovation, is likely to require a high level of networked behaviour (Isaksen and Jakobsen, 2017). Against this backdrop, this Euro Commentary paper seeks to examine the extent to which European policy intervention is likely to be able to positively impact on Europe's semiconductor industry and its clusters.

Europe's semiconductor industry and clusters

The world semiconductor market is extremely valuable, with sales of over US$550Bn in 2021 (SIA, 2022; Yeung, 2022). While European production accounts for around 10% of this total, representing substantial revenues of US$55Bn per year, it is widely accepted that the European semiconductor industry has been in relative decline over the last three decades due to the growth of the industry in North America and Asia (Dornbusch, 2018). Indeed, the scale of this decline is highlighted by the fact that in 1990 European production accounted for approximately one-third of global revenues (Dornbusch, 2018).

In addition, the fact that the most advanced chips are currently manufactured in Asia, specifically Taiwan, China, and South Korea means that Europe imports nearly two-thirds of its electronics components (Meyers, 2022; Tech Monitor, 2022; Yeung, 2022). In terms of semiconductors alone, Chinese chips account for approximately one-third of imports (Meyers, 2022). The result is that the EU has a trade deficit of around €20 billion in the semiconductor industry (European Commission, 2022). The reliance on China also means that current US policies, increasingly seen as attempting to 'throttle' China's ability to produce chips, leaves European industries vulnerable to shortages (Meyers, 2022). Within this context, national governments and the EU have started to reconsider the strategic importance of the semiconductor industry and the sovereignty of its assets, both tangible and intangible (Miller, 2022b).

While the proportion of the semiconductor market accounted for by European firms has declined in the past 30 years, the industry remains well established and still possesses several advantages. The most significant of these are the existence of a number of key clusters, namely Leuven (DSP Valley, Belgium), Dresden (Silicon Saxony, Germany), Eindhoven (Netherlands), and Grenoble (France) (European Commission, 2013; Huggins et al., 2022). The DSP Valley cluster is characterised by activity in life sciences, nanotechnology, mechatronics, smart systems, and cleantech, and is home to several innovative companies and knowledge centres that interact closely.

Silicon Saxony contains a large number of semiconductor, electronic, and micro-electronics firms and is home to Europe's largest and most successful trade association for the micro-electronics sector (Silicon Saxony e.V.) with members including AMD (Globalfoundries), Infineon, Siltronic, ZMD (Zentrum Mikroelektronik Dresden), and AMTC (Advanced Mask Technology Centre Verwaltungs GmbH). This cluster is also the site of significant new investments in manufacturing facilities with Intel, Infineon, and GlobalFoundaries both committing to building new factories in the region (Tech Monitor, 2022).

Eindhoven is a leading technology centre accounting for nearly 25% of total Dutch R&D expenditure and 45% of the R&D expenditure of Dutch based firms (Statistics Netherlands, 2020). Companies in the region are not only more R&D-intensive than those located elsewhere in the country, but also are more likely to focus on high technology components and equipment (Romme, 2022). The Grenoble cluster is heavily focused on research, development and product design for microelectronics, nanotechnologies and related software. It is branded by the French government as one of the nation's 18 'global competitiveness clusters', or 'pôle de compétitivité', which aim to bring together firms, research laboratories and educational establishments in a specific region to develop synergies and cooperative efforts (Assimakopoulos et al., 2022).

The existence of these clusters provides a clear potential advantage for European chip production: (1) these clusters are all characterised by significant levels of inter-firm cooperation, (2) within each cluster connecting knowledge producers such as universities and laboratories and (3) these clusters are not atomistic entities as inter-cluster cooperation has been observed across the sector (European Commission, 2013; Huggins et al., 2022; Silicon Europe, 2022).

In general, Europe's firms are more R&D intensive than their Asian rivals, with 15% of turnover directed towards these activities compared with 11% for Taiwan, 9.1% for South Korea, and 7.6% for China (SIA, 2022). However, this still lags behind US firms which dedicate 18% of turnover to R&D (SIA, 2022). Nevertheless, the structure of the semiconductor industry is favourable to European firms, whose strengths lie in design rather than manufacture. The emergence of so-called 'fabless' firms, those that design chips and then contract out the (fabrication) manufacturing to others, has largely eliminated barriers to entering the industry for chip designers (Balconi and And Fontana, 2011). Consequently, European expansion could be promoted through investment in designing the next generation of semiconductor chips.

Furthermore, a significant advantage for Europe is that the equipment to make semiconductors is made by the Dutch company, ASML, which possesses a near monopoly on the optical imaging technology on which the manufacturing process relies. Therefore, much of the expertise in tooling and equipping the semiconductor industry is in fact of European origin. Given ASML's market strength, US firms such as Intel are keen to cooperate and collaborate in terms of designing the next generation of chips. Indeed, Intel's investments enabled the decade long development of manufacturing techniques that utilise the ultraviolet spectrum of light allowing laser cutting to be even more precise (Miller, 2022a).

These advantages suggest that instead of focusing on 'path extension', which involves utilising proven solutions and established routines, Europe's semiconductor industry can pursue 'path creation'. This involves developing new network partners and new ideas/technologies around the design and manufacture of ever smaller and more efficient chips (Sydow et al., 2012). Furthermore, this path extension could also involve developing new architectures for semiconductors, moving beyond the current 'CMOS' focused designs.[1] Indeed, as future demand for advanced chips is forecast to be in areas related to artificial intelligence and autonomous technology, two areas at the heart of Europe's innovation agenda (Aurik et al., 2021), there appears to be a realistic possibility of achieving this. Furthermore, focussing on path creation can also have positive knock-on effects for other related industries within a region facilitating economic diversification (Mewes and Broekel, 2020).

Yet, in reality, each European semiconductor cluster is too small to compete at the global scale, and if they are to compete globally they need to be even better connected (Huggins et al., 2022). While European clusters are already cooperating and working together at some level, such as in the context of sharing information and intelligence, there is a lack of large-scale pan-European cooperation that will allow them to compete with existing industry groups in the US and Asia. Finally, costs represent a major barrier to reforming the European semiconductor sector, with a new fabrication facility requiring an investment of US$13–20 billion (Huggins et al., 2022).

Considering Europe's policy responses

The EU has set out several initiatives under the banner of its 'Chips Act' to boost its share of production in semiconductors to 20% of the world total by 2030 (European Commission, 2022). The aim is to ensure 'digital sovereignty' (i.e. self sufficiency in semiconductor production) through supporting the development of new production facilities, supporting start-ups, developing skills and building partnerships. In total, the Act will result in €43 billion being invested in the sector, although a significant amount of the investment (c. €28 billion) was already committed to existing programmes at the EU and member state level (European Commission, 2022). The Acts set out a range of measures to boost European production by pooling different countries' resources to complement their individual research strengths and to support the development of new production facilities as a means of securing sovereignty.

The Chips Act's three 'pillars' aim to promote innovation, ensure security of supply, and coordinate interventions across the EU. The Act is also related to the 'Important Project of Common European Interest (IPCEI) on Microelectronics' initiative, which seeks to promote transnational cooperation projects in microelectronics across four European nations: France, Germany, Italy, and the United Kingdom (which has a number of regional clusters facing similar issues to their counterparts in the EU, but are of course outside the remit of the EU Chips Act). The IPCEI permits the use of state aid to encourage R&D investment and the signatories agreed to cooperate and co-invest in semiconductor technologies across the full value chain and focus on the development of new chips to support Europe's high-tech industries (European Commission, 2021).

While the Act would appear to be an intervention that could improve the competitiveness and growth rates of the semiconductor industry in Europe, some have criticised its formulation and consider that digital sovereignty is not a viable or desired route for Europe (Meyers, 2022; Miller, 2022b). Furthermore, questions remain as to whether €43 billion investment is sufficient, particularly given that the Taiwanese semiconductor company TSMC have alone announced plans to invest over €95 billion during the same time period (Tapei Times, 2021). A fundamental question concerning the Act is whether or not a policy focus on the production side is realistic or feasible even if it is considered desirable. Consequently, we question the argument that sovereignty will promote competitiveness. It may deliver production of cheap chips on a larger scale, but it is the development of new innovative chips that will underpin any competitiveness improvements in Europe. Indeed, given the large amount of investment by other nations and firms, coupled with the need for new path creation it can be argued that the EU should largely avoid subsidising production capacity and instead concentrate on inputs and chip design.

The EU's Chips Act is not the only one of its kind, as noted earlier the United States has also passed a similar Chips and Science Act aimed at securing the sovereignty of semiconductor production (US Department of State, 2022). The US Chips Act seeks to establish investments and incentives to support US semiconductor manufacturing, research and development, and supply chain security. The Act has authorised US$50.3 billion over 5 years with a further US$550 million per year between 2023 and 2027 for science lab infrastructure (Peters, 2022). In addition, a second strand of the US strategic plan is the creation of a 'Chip 4 Alliance', designed to create a mega-cluster of chip makers in the US, Japan, South Korea and Taiwan to line up against China. Tellingly, Europe is not part of this plan.

From the perspective of urban and regional development, supporting innovation and entrepreneurship is a key part of the EU Chips Act, but it appears to be rather spatially blind as to how this is to be achieved. Instead, we argue that taking a place-based approach that builds on the strengths of cities and regions is likely to bolster the impact of the Act's interventions given that existing clusters represent the broad ecosystem of semiconductor design and manufacture including firms, research facilities, and universities. This involves introducing interventions through the Chips Act which build on the strengths of each existing regional cluster while addressing their shortcomings rather than following a one-size-fits-all approach.

To achieve this, a joined-up approach is essential, institutionalising a triple helix approach to development that formalises collaboration between industry, government agencies, and universities would ensure that these relationships are embedded in the future development and growth of the sector (Reischauer, 2018). Fundamentally, such development and growth in Europe will only occur through the promotion of entrepreneurship. Within the semiconductor industry, this is likely to lie in spinouts from universities as well as in collaborations between existing firm and universities. Furthermore, such entrepreneurship will require government support, especially given the lack of venture capital for early investment in startups in the European semiconductor industry. Therefore, it is only through a concerted and earnest effort to better connect these actors that significant growth within the industry is likely to emerge.

Conclusion

The European semiconductor industry is clearly at a crossroads. While the industry has some competitive advantages and is home to several significant clusters, it faces incessant competition from producers in Asia and the US. In addition, the current geopolitical tensions between the US and China leaves the European industry caught in the middle. Coupled with the relentless pace of innovation across the industry, this leaves European producers in danger of further decline. The €43 billion of investment promised through the EU's Chips Act has been mostly welcomed to arrest this decline.

On the face of it, this policy intervention represents a significant investment. However, this investment is dwarfed by that proposed in the US Chips Act as well as planned investments by private sector firms such as TSMC. Therefore, it is far from guaranteed that the EU Chips Act will increase the European semiconductor industry's market share. If Europe's industry is to continue to play a meaningful role on the global stage then digital sovereignty should be pursued through a long-term strategy. This should encourage new development paths that allow European producers to not only compete with the US and Asia but where possible to leap-frog some of the existing technological routes upon which the industry is currently based. Without this, the erosion of this high value knowledge-intensive industry is set to continue.

In order to make meaningful interventions, European policy measures should heighten the focus on encouraging innovation and entrepreneurship, which should be pursued in conjunction with existing regional policy measures that aim to support economic development across Europe. However, this requires a truly connected approach that acknowledges the multi-scalar and multi-level challenges being faced. In particular, EU level interventions such as the Chips Act show little awareness of the regional development agenda, while on the other hand regional policy appears to show little connection with the grander policy visions of the EU. Given the geographical structure of the semiconductor industry and its broader economic significance, the industry should act as a test-bed for the establishment of industrial policies that embed these multilevel dimensions.

Such an approach would mean that policy interventions can simultaneously protect *and* develop the industry. Therefore, we advocate policies based on a Triple Helix model that utilises government, industry, and academia to support growth in order to strengthen the entire ecosystem. Finally, the EU Chips Act should not be viewed as the final intervention. It should be the start of a coordinated response to provide long-term support to the semiconductor industry. This will require policymakers to continuously monitor and react to changing global circumstances and demand conditions, and to facilitate more accurate forecasting of future technological needs and trends related to the industry.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Andrew Johnston https://orcid.org/0000-0001-5352-9563

Robert Huggins https://orcid.org/0000-0001-9798-8614

Note

1. CMOS, or Complementary Metal–Oxide–Semiconductor, is the name of the current technology underpinning the construction of semiconductors. Dating from the 1960s, this has been the dominant fabrication process since the 1980s due to the fact that these designs utilise low power consumption, possess an ability to resist electrical interference from other components, and operate at low temperatures. As yet, the industry has not developed a universal technology to replace or move 'beyond' CMOS for the production of future semiconductors.

References

Assimakopoulos D, Lawton-Smith H, Baines N, Romeo S and Tsouri M (2022) Oxford and Grenoble: multiple anchors, strong dyadic relationships and national policy in fostering cluster architectures. *Regional Studies* 56(10): 1618–1632.

Aurik J, Gerdemann D, Hales M, Hertel G, Heinrich A and Hubner D (2021) Europe's urgent need to invest in a leading-edge semiconductor ecosystem. Available at: https://www.kearney.com/documents/291362523/291371424/Europes+urgent+need+to+invest+in+a+leading-edge+semiconductor+ecosystem.pdf/f3ec1e30-b8ff-b367-417c-62cf476342ea?t=1636562554000

Balconi M and Fontana R (2011) Entry and innovation: an analysis of the fabless semiconductor business. *Small Business Economics* 37(1): 87–106.

Dornbusch F (2018) Global competition in microelectronics industry from a European perspective: technology. *Markets and Implications for Industrial Policy*. Available at: https://www.imw.fraunhofer.de/content/dam/moez/de/documents/Working_Paper/180301_021_Microelectronics%20from%20a%20European%20perspective_Dornbusch_%C3%B6ffentlich.pdf

European Commission (2013) *Comparison of European and non-European regional clusters in KETs. The Case of Semiconductors. Final Report: A Study Prepared for the European Commission DG Communications Networks, Content & Technology*. Brussels: European Union.

European Commission (2021) A European initiative on processors and semiconductor technologies. Available at: https://digital-strategy.ec.europa.eu/en/library/joint-declaration-processors-and-semiconductor-technologies

European Commission (2022) European Chips Act. Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en#:~:text=The%20European%20Chips%20Act%20will,technological%20leadership%20in%20the%20field

Gordon IR and McCann P (2000) Industrial clusters: complexes, agglomeration and/or social networks? *Urban Studies* 37(3): 513–532.

Huggins R, Johnston A, Munday M and Xu C (2022) *The Future of Europe's Semiconductor Industry: Innovation, Clusters and Deep Tech*. Available at: https://csconnected.com/media/ezlhpdhz/huggins-johnston-munday-xu-the-future-of-europes-semiconductor-industry.pdf

Isaksen A and Jakobsen SE (2017) New path development between innovation systems and individual actors. *European Planning Studies* 25(3): 335–370.

Leydesdorff L (2000) The triple helix: an evolutionary model of innovations. *Research Policy* 29(2): 243–255.

Mewes L and Broekel T (2020) Subsidized to change? The impact of R&D policy on regional technological diversification. *Annals of Regional Science* 29(3): 221–225.

Meyers Z (2022) *The EU Should Abandon Chip Nationalism*. Centre for European Reform. Available at: https://www.cer.eu/sites/default/files/insight_ZM_eu_chip_20.10.22.pdf

Miller C (2022a) *Chip War: The Fight for the World's Most Critical Technology*. New York: Scribner.

Miller C (2022b) The EU's confused role in the 'Chip War'. *Internationale Politik Quarterly*. Available at: https://www.aei.org/articles/the-eus-confused-role-in-the-chip-war/

Peters MA (2022) Semiconductors, geopolitics and technological rivalry: the US CHIPS & Science Act, 2022. *Educational Philosophy and Theory*. Epub ahead of print 31 August. DOI: 10.1080/00131857.2022.2124914.

Pontikakis D, Gonzalez Vazquez I, Bianchi G, Ranga L, Marques Santos A, Reimeris R, et al. (2022) *Partnerships for Regional Innovation Playbook*. Luxembourg: Publications Office of the European Union.

Reischauer G (2018) Industry 4.0 as policy-driven discourse to institutionalize innovation systems in manufacturing. *Technological Forecasting and Social Change* 132(1): 26–33.

Romme AGL (2022) Against all odds: how Eindhoven emerged as a Deeptech ecosystem. *Systems* 10(4): 119.

SIA (2022) Semiconductor Industry Association 2022 Factbook. Available at: https://www.semiconductors.org/wp-content/uploads/2022/05/SIA-2022-Factbook_May-2022.pdf

Silicon Europe (2022) Position paper on the European Chips Act by the Silicon Europe Alliance. Available at: https://www.silicon-saxony.de/fileadmin/user_upload/silicon-europe/Dokumente/2022-11-15_SiliconEurope_ChipsActStatement.pdf

Statistics Netherlands (2020) Domestic R&D Expenditure over €18 Billion in 2020. Available at: https://www.cbs.nl/en-gb/news/2022/05/domestic-r-d-expenditure-over-18-billion-in-2020

Sydow J, Windeler A and Mollering G (2012) Organizing R&D Consortia for path creation and extension: the case of semiconductor manufacturing technologies. *Organization Studies* 33(2): 907–936.

Tapei Times (2021) TSMC announces US$100bn plan for R&D and expansion. Available at: https://www.taipeitimes.com/News/front/archives/2021/04/02/2003754941

Tech Monitor (2022) The European Chips Act will not restore the continent's semiconductor industry to its former glory. Available at: https://techmonitor.ai/technology/silicon/the-european-chips-act-will-not-restore-the-continents-semiconductor-industry-to-its-former-glory

US Department of State (2022) The CHIPS and science act. Available at: https://science.house.gov/chipsandscienceact

Yeung HWC (2022) *Interconnected Worlds: Global Electronics and Production Networks in East Asia*. Stanford, CA: Stanford University Press.