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Is a Knowledge-intensive European Recovery possible without European Public Corporations?

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Daniele Archibugi
Vitantonio Mariella

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È possibile una ripresa europea basata sulla conoscenza senza imprese pubbliche europee?

Daniele Archibugi, Vitantonio Mariella
2021, p. 16 IRPPS Working papers 126/2021

Sommario: Le nuove tecnologie associate alle TIC e al software sono dominate da una manciata di imprese oligopolistiche basate negli Stati Uniti. Gli sfidanti non sono più imprese europee, ma imprese giapponesi o cinesi. Le azioni intraprese dall'UE per colmare questa lacuna tecnologica, compresi i vari Programmi Quadro della CE, sono utili ma ancora insufficienti per le risorse impegnate. Questo articolo sostiene che l'UE ha urgentemente bisogno di aggiungere un altro strumento di politica economica per sfidare le imprese dominanti, ossia creare alcune grandi società nelle aree di maggiori opportunità scientifiche e tecnologiche, con un forte sostegno pubblico. Ciò dovrebbe essere complementare alle politiche di innovazione su specifiche missioni già in corso. Pur essendo consapevoli delle difficoltà politiche ed economiche di attuare una tale strategia, ricordiamo l'avventura pionieristica di Airbus, fondata più di 50 anni fa e che, nonostante le numerose controversie economiche e politiche, è riuscita a sfidare i produttori di aeroplani civili statunitensi. È possibile replicare il tentativo per le tecnologie verdi, i servizi sanitari, le TIC e l'intelligenza artificiale?

Parole chiave: Imprese pubbliche, Politica industriale, Opportunità tecnologiche, Tecnologie abilitanti, Airbus, European Battery Alliance

JEL Codes: L32, L52, 031, 038

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Abstract: Pervasive new technologies associated with ICTs and software are dominated by a restricted oligopoly of US-based corporations. The challengers are not any longer European firms, but rather Japanese or Chinese companies. The actions taken by the EU to fill this technology gap, including the EC Framework Programmes, are beneficial but still insufficient in terms of the resources committed. This article argues that the EU urgently needs to add another economic policy instrument to defy these incumbent firms, namely to create a few publicly supported large corporations in the areas of greater scientific and technological opportunities. This will be complementary to the already ongoing mission-oriented innovation policies. While we are aware of the political and economic difficulties to implement such a strategy, we recall the pioneering venture of Airbus, established more than 50 years ago and which, despite several economic and political controversies, has successfully managed to challenge the dominant US-based passengers' aircraft producers. Could similar attempts be replicated for Green technologies, Healthcare services, ICTs, and Artificial Intelligence?

Keywords: State-owned companies, Industrial policy, Technological opportunities, Enabling technologies, Airbus, European Battery Alliance

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* Dirigente IRPPS – Consiglio Nazionale delle Ricerche, Professor, Birkbeck, University of London. Email: daniele.archibugi@cnr.it
** Assegnista, IRPPS – Consiglio Nazionale delle Ricerche. Email: vitantonio.mariella@irpps.cnr.it

Redazione: Sveva Avveduto, Massimiliano Crisci, Mario Paolucci, Fabrizio Pecoraro, Tiziana Tesauro e Sandro Turcio.

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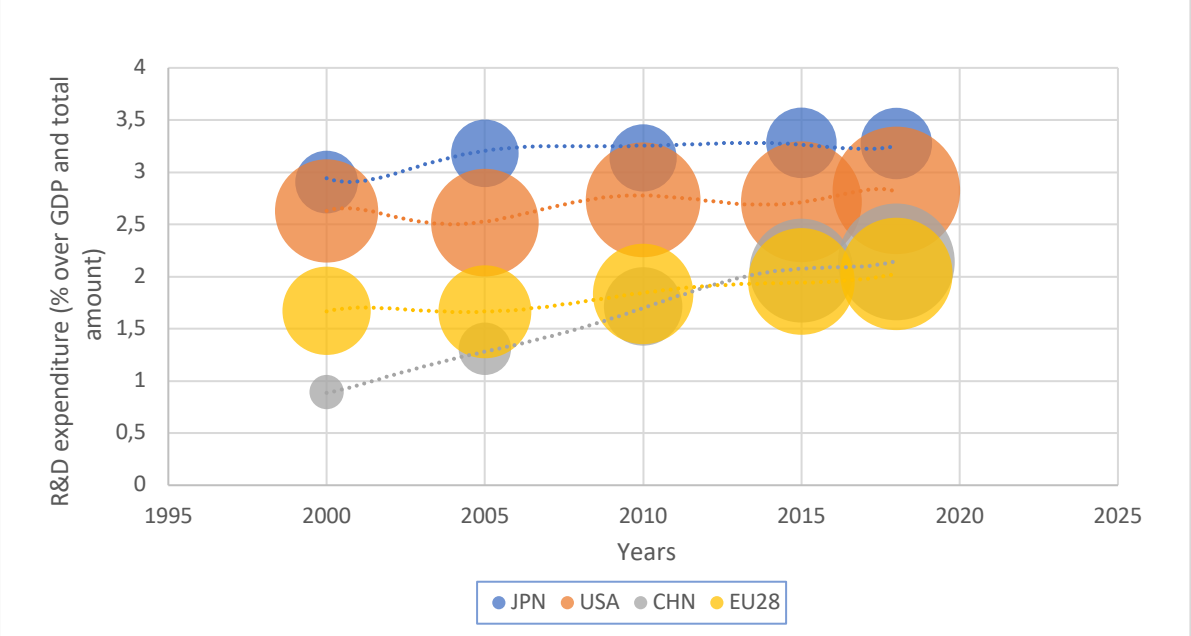
1. Can the European economic recovery be knowledge-intensive?

There is a consensus that Europe will start a solid recovery after the Covid-19 crisis only if supported by remarkable direct government intervention. The existing policy instruments at the national and the European levels, and most notably those made available with the Recovery Fund, have the aim to support and boost economic, technological, social, and cultural development.

One of the key priorities aimed at enhancing the European economy is that of bridging the scientific and technological gap of the EU vis-à-vis the United States and Japan, also because these competencies are needed to sustain rising industries. We know that the EU is composed of very heterogeneous countries and while some of them are very R&D intensive, others are lagging. Overall, the EU has a lower R&D to GDP intensity than those of the USA and Japan and it is now challenged by emerging countries such as China (see Figure 1)[1].

Figure 1. R&D intensity and Gross Domestic Expenditure of China, Japan, EU28 and the United States (% to GDP and total amount [size of the circles])



Source: Elaboration on OECD, Main Science and Technology Indicators.

For several decades, the EU has carried out a battery of actions to enhance education, science, technology, and innovation. Specifically, the EU Framework Programmes (FPs) started in 1984 tried to foster European capabilities in promising technological areas. Among them, a crucial role has been devoted to supporting ICT clusters, perhaps because it was considered an enabling technology on which the overall economic prosperity depended. Unfortunately, the gap with the USA is still substantial. The EU FPs have played a crucial role in creating capabilities across the old continent, also allowing integration and intra-European collaboration among firms, universities, but they have not managed to close the gap, nor they could have achieved alone such a demanding task.

[1] The corresponding values are collected in the Appendix, table A.1.

The overall economic consequences of the 2008 financial crisis also affected science and technology. The EU level of investment – one of the main carriers of innovation – was still below its 2008 level when the Covid-19 crisis broke out. In many EU member countries, public investment, rather than acting anti-cyclically, decreased even more than the business investment. The EU tried to sustain the total level of investment with the European Fund for Strategic Investments (EFSI), but this also proved to be insufficient (Archibugi et al., 2020).

The current and post-Covid-19 instruments, including the European Recovery Fund, will eventually provide massive resources to support public investment plans and a substantial part will be devoted to R&D and innovation. But the bulk of these resources will be managed by national authorities under a European Commission supervision and not, like the FPs, directly by the European Commission.

This article asks the question: can the EU fill the technology gap through public investments and incentives to R&D and innovation without also attempting to create enterprises in high-tech industries? We doubt it. Our view is that the interventions aimed to finance and support the activities of the existing institutions and firms are certainly useful, yet this may not be enough. We suggest that a cluster of new firms able to contribute to the generation of technological opportunities and, above all, the capacity to transform them into viable commercial products, processes, and services may be needed.

To prove our point, a comparison with China is certainly instructive. China has substantially increased the resources devoted to education, R&D, and innovation, but to exploit this investment economically, it is bolstering new companies able to compete with the Big Tech American corporations, especially in the new strategic industries. In comparison, the EU response is much feebler.

In the following section, we briefly outline the Eu strategies and efforts aimed to enhance technological capabilities. Next, we explore the possibilities for Europe to set up large public corporations in enabling technologies, briefly describing two past experiences: the Concorde and the Airbus case. We later explain how the most promising emerging sectors could be identified, with a special focus on the European battery Alliance. In Section 7, we discuss the possibility to exploit new technological opportunities through the creation of start-ups and Section 8 provides concluding remarks.

2. The EU regional dimension in scientific and technological capabilities

The problem of the EU is that it is a highly heterogeneous area. Differently from the United States or China, it has not the powerful governance devices, which characterize nation-states yet. The various FPs were forced to balance two opposite objectives. On the one hand, their goal was to enhance scientific and technological competencies of the core areas to support European industry's competitiveness against foreign countries. On the other hand, they aimed to foster the development of competencies in the catching-up areas.

Regional imbalances in technological capabilities in the EU are very severe. Whereas some timid signs of convergence have occurred because of the FPs, regions' contributions to the overall generation of new knowledge are very asymmetric (Archibugi et al., 2021). Eastern European countries, despite their attempt to better integrate into the overall EU scientific and technological communities, have registered small signs of progress in enhancing their innovative capacity. This indicates that the transition from a planned to a market economy has been harder than expected, especially concerning technological developments. Southern

European regions continue to be far away from the Northern Europeans and have accumulated increased delays in the aftermath of the 2008 crisis.

Furthermore, it has been demonstrated that having a strong, influential network position in collaborative EU research greatly affects participation in Horizon 2020 projects (Enger, 2018). The presence of these "closed clubs" has often been at the expense of the less influential Higher Education Institutions prevalently located in the periphery of Europe, leading to a vicious spiral in which established institutions have acquired more funds and reinforced their position.

Therefore, the EU has to face a strenuous mission. On the one hand, it should foster EU scientific excellence and technological capabilities vis-à-vis a fiercer global competition with established countries like the United States and Japan and emerging countries like China and India. On the other hand, it should also increase EU cohesion by reducing technological disparities across its regions and industries. The two objectives are somehow in conflict with each other. On the one hand, the former may require a further concentration of competencies in the already most emancipated areas to compete with leading technological poles such as Silicon Valley, Route 128, Samsung town, or Shenzhen. On the other hand, the latter nurture capabilities of the least developed regions and sectors.

What are the instruments available at the EU level? One of the most relevant are certainly the FPs and it is very likely that the coming Horizon Europe (2021-27) will have to ponder two choices:

- To reduce disparities by fostering the distribution of knowledge also in peripheral areas and comparatively weaker sectors;

- To challenge the dominance of the US and China by enhancing the excellence of selected players and areas.

The Horizon 2020 project, just ended, was one of the world's largest public schemes supporting new knowledge development. Despite the massive resources made available by the EU to enhance scientific and technological capabilities, especially in enabling technologies, they corresponded to the yearly equivalent budget of the R&D investment of large corporations such as Amazon, Alphabet, Volkswagen, or Samsung. While the Horizon 2020 yearly budget was about 13.2 billion Euros, large corporations such as Amazon (21.2), Alphabet (18.3), Samsung (14.8 billion euros), Microsoft (14.7), Volkswagen (13.6), or Huawei (12.7) alone spend more or comparable amounts (see Table 1).

While Horizon Europe is an excellent financial instrument to generate and disseminate competencies across the EU, it will not be able single-handed to create a genuine industrial capacity to allow the EU to be a world-leading player in emerging technologies.

Table 1. Top corporations' R&D expenditure in 2018 and Horizon 2020 average budget

Rank	Company	Country	Industry	R&D expenditure (€billion)	Employees (thousand)	Market cap (€billion)
1	AMAZON		General Retailers	21.2	647.5	773.52
2	ALPHABET	US	Software & Computer Services	18.27	98.77	321.57
3	SAMSUNG ELECTRONICS	South Korea	Electronic & Electrical Equipment	14.83	309.63	243.46
4	MICROSOFT	US	Software & Computer Services	14.74	144	752.29
5	VOLKSWAGEN	Germany	Automobiles & Parts	13.64	664.5	40.81
6	**HORIZON 2020**	**EUROPE**		**13.26**		
7	HUAWEI INVESTEMENT & HOLDING CO	China	Technology Hardware & Equipment	12.74	188	
8	APPLE	US	Technology Hardware & Equipment	12.43	132	960.21
9	INTEL	US	Technology Hardware & Equipment	11.83	107.4	19.50
10	ROCHE	Switzerland	Pharmaceuticals & Biotechnology	97.98	944.42	150.05
11	JOHNSON & JOHNSON	US	Pharmaceuticals & Biotechnology	94.10	135.1	315.58

Source: Elaborations on the EU Industrial R&D investment Scoreboard (2019) and EU expenditure and Revenue 2014-2020, available at https://ec.europa.eu/budget/graphs/revenue_expediture.html. For Amazon, we use the data provided by Skillicorn, 2020.

3. Can European Union set up large corporations in enabling technologies?

There is widespread consensus on whether the state should be a vigilant referee of the competitive process through regulations and anti-trust policies. By contrast, there is much more debate on its role as a direct economic player in a market economy. A daring perspective is that European governments should actively participate in the decisions concerning industrial policy strategies, rather than simply act as a regulator (see for example Cimoli et al., 2015, and the other contributors to the *Intereconomics* forum). There are several industrial policies that governments carry out to reinforce the presence in innovative industries (Edler and Fagerberg, 2017). But the EU as a whole, with the support of national governments, should attempt to add another economic policy instrument, namely the generation of new firms in the emerging and enabling technologies.

"National champions", i.e. large corporations able to compete in the global markets, need the support of a proper national government to survive (Strange, 1991), especially if they are associated with complex knowledge infrastructures (Mazzucato, 2013). But fresh national champions would have insufficient strength to compete with the incumbent American and Chinese corporations, also because they may receive political protection by the government of their own country only. European fast-growing companies and start-ups, especially in ICTs and related sectors, could easily be acquired by the biggest companies in terms of market capitalization (market value) and liquid assets (see Rikap and Lundvall, 2020). American Big

Tech have already acquired promising European start-ups, a strategy that is widely used to obtain quick and easy access to new technologies and retain market dominance (Marks, 2017). If new start-ups are acquired by foreign big-tech firms, they will indirectly provide public support for the technological advancement of foreign competitors. As shown in Table 1, none of the R&D largest spenders with gigantic market capitalisation is based in Europe.

The policy implication is quite straightforward: to become a challenger in high-tech, we need new publicly supported corporations at the continental level. Has ever happened that European countries have joined their forces to create companies able to enter new industries competing with the United States? It has happened seldom, but there are two important cases to be reminded of: Concorde, which started as a French – British venture in 1969, and Airbus, which began as a French–German venture also in 1969.

4. Lessons from the past: Concorde and Airbus

Back in the 1960s, the European governments' decision to produce airplanes was finalized to enter as a third player between the two-dominant rivals, the United States and the Soviet Union. The two superpowers developed competitive airplanes because of military purposes and subsequently adopted them to civilian transportation. Since European countries were not any longer military leaders, they lacked this capacity. The vulnerability of the European industry, specifically in aircraft, created the political conditions to build-up new ventures. Many commentators believed that without them, Western Europe would have been marginalized in the international division of labor (see, for instance, the influential book by Servan-Schreiber, 1968).

The launch of the Concorde by Aerospatiale (France) and BAe (UK) - a jet engine passenger aircraft developed during the 1960s and introduced in 1969 - was one of the first-ever collaborations within the European context, even if took place outside the institutions of the European Economic Community (in 1969 the UK was not yet a member of the European Economic Community). Concorde was born because the French and British empires joined their forces to compete with the Soviet Tupolev Tu-144 to produce supersonic transport aircraft. This collaboration is indeed an example of a combination of two existing national trajectories. At the time, France was specialized in jet technology (for military purposes), and the UK had a long record in the passenger market.

While Concorde was a technological success, it ended up being an economic failure. Twenty airplanes only were manufactured, seven of which acquired by British Airways and seven for Air France, the respective flag airline companies. Although the product was well designed and prestigious, it turned to be a commercial fiasco, mainly due to its impressive consumption and maintenance costs.

The second example is the European Airbus consortium, which started developing aircraft in the 1970s. Airbus has been economically successful and, after half a century, has managed to create a European firm dominant in the industry. Set up as a French-German venture in 1969, Airbus rapidly became a transnational consortium involving Aerospatiale and BAe, the German firm DASA and the Spanish firm CASA. Even this venture developed outside the institutions of the European Economic Community. Its success has paved the way for new

European networks, such as Avions de Transport Regional (ATR), and recently Aero International Regional (AIR).[2]

Airbus challenged the American incumbent airplane manufacturers, all subsidized for military purposes (Boeing, Lockheed, and McDonnell Douglas). Similarly, European governments responded with subsidies for R&D, fiscal incentives, and political support to urge airline companies to purchase from Airbus rather than US producers. This led to a fierce Atlantic commercial rivalry between the European Union and the United States, and the governments of each side supported their companies.

Airbus' rivalry with Boeing and McDonnell-Douglas led to intense contentious already in the GATT about the role of public funding in generating 'unfair' competition. These cases were later debated at the WTO, with the USA and the EU representatives each complaining for the public subsidies received by the companies. Specifically, the EU argued that Boeing received government aid under the military procurement provided by the Pentagon, while the USA government argued that Airbus receive R&D and other subsidies from European governments. Eventually, focusing on the civilian component, Airbus managed to generate and maintain cheaper and consumer-friendly airplanes. In 1994 for the first time, Airbus sold more commercial aircraft than Boeing and in 2016 became the first world company in the sector. Without Airbus, currently, the world market in civil airplanes would be a monopoly in the hands of a single US corporation, Boeing.

Aviation has witnessed a rapid acceleration in transnational networks among firms developing high-risk innovations, and other knowledge-intensive industries have followed the same route. The question here is why countries ought to collaborate. From an evolutionary perspective, one expects that countries in cross-border collaborations recombine their national specialization pattern. To the extent that two countries are specialized in different technology/market combinations globally, they can collaborate in two ways. Either they recombine the technology in which they are specialized, with the market in which the other country is specialized or vice versa. The recombination of specialization patterns allows partners to explore new technology/market trajectories collectively.

When Airbus was set off, France had just switched its technological base from jets to turbofans, while the UK was already specialized in passenger aircraft (Frenken, 2000). Hence, previous specialization patterns reflect the techno-economic specialization of the transnational network. However, concerning the other two countries, Germany had lost its expertise in aircraft after the end of WWII and Spain had little experience. For these countries, Airbus provided an opportunity to leave their old specialization pattern and to enter a new market segment using state-of-the-art technology. Airbus's entry into the aircraft passenger market may be conceived respectively as a reshuffle of competencies for some countries and a developing strategy for others. Overall, governments provided the political support, the financial resources, and the expertise, but without a company, it would have been impossible to enter into such a complex and protected market. This demonstrates that when entrepreneurs are not willing to bear risks, the government should intervene directly.

While there was an initial underestimation of the beneficial effects of Airbus's entry into the aviation market (Neven and Seabright, 1995), after half a century it can be considered a vital political and economic choice which produced benefits not only for Europe, but for the whole

[2] In military aircraft, European collaborations date back to Panavia, established in 1969, and extended to Eurofighter and Europatrol. Similarly, European Helicopter Industry (EHI) and Eurocopter have become prominent leaders in the European helicopter industry.

world, USA included. A new venture in a fast-growing industry impeded that the sector ended up in a worldwide monopoly.

5. Choosing the new emerging industries

The current American-dominated oligopoly in ICTs has strong similarities with the situation of commercial aircraft of the 1960s. But ICTs are today much more relevant for current and future economic development. Not only are nations that depend on foreign corporations in strategic areas such as communications, satellites, data, social networks, and artificial intelligence more vulnerable, but they also lose their technological sovereignty (Edler et al., 2020).

It is certainly not easy to identify the crucial sectors which will be indispensable for future economic, social, and political life. One may wonder why shoes and champagne are less relevant than satellites and vaccines, provided that the former is as lucrative as the others. And the fact that the EU has a persistent commercial surplus with the United States, even if none of the Big Tech companies is located in Europe, may dismiss the urgency to enter these high-tech sectors. But some sectors are likely to play a paramount role in future economic competitiveness.

There are many ways in which economists can contribute to identifying the strategic industries of the future. The first is to consider the growth rate of production and productivity. But when statistics show that production starts increasing exponentially, the position of nations in the international division of labor has already been established and it is difficult to revert it. For this reason, one may need to use indicators that anticipate the upcoming scientific and technological opportunities. By looking at the degree of dynamism and the level of the pervasiveness of scientific and technological sectors, it is possible to anticipate which industries will be dominant in the future. The fast-growing classes of academic papers and patents often indicate the most rewarding scientific and technological areas (Meliciani, 2001). The level of pervasiveness - defined by the variety of users across industries – indicates those enabling technologies that will be necessary for the delivery of most products, processes and services (Evangelista et al., 2018). These areas are likely to be those where innovations lead to organizational and social changes to the extent that can be seen as the backbones of a new techno-economic paradigm (Freeman and Louçâ, 2001).

Policymakers do not necessarily wait for experts' recommendations to decide where to invest. It is self-evident that in crucial areas, such as computers and smartphones, the market share of EU corporations is very tiny. EU citizens rely on American social networks, while its institutions have serious difficulties obtaining regulations to protect their data enforced and proper tax paid. While China has succeeded in entering new lucrative fields such as smartphones with Huawei and social networks with Tik Tok, the EU has lost its competitive companies (think about Olivetti for computers or Nokia for cell phones) or not even tried to enter into the market of social networks. Similar problems apply for e-commerce: Amazon dominates the European market without being challenged, while China has maintained at least its internal market through Ali Baba. In new enabling sectors like Artificial Intelligence, the EU investment rate is much below not only that of the USA but also Japan and China, and, above all, it does not seem that there will be an EU company to gain prominence shortly (Zachary et al., 2020).

We are not arguing that generating new continental public corporations should be the only industrial policy response to affirm the EU presence in the world economy. In other cases,

different attempts could be more fruitful to generate successful industrial capacity in emerging areas (for an overview, see Edler and Fagerberg, 2017). A case in point is the timely venture of the European Battery Alliance.

6. Capacity building in an extended industrial network: the case of the European Battery Alliance

"In Europe, within this decade, where it is technologically and economically viable, everything that can be electrified will be electrified, thus making battery technology one of the most important key enablers for the green energy transition facilitating existing and new technologies".[3] It is difficult to disagree with such a statement, especially since the European Commission's target is to achieve a successful transition to a fossil-free society, as contemplated by the Green Deal.

The European Commission launched in 2017 the European Battery Alliance (EBA) in the spirit of one of its Mission-oriented Public Programs (Kattel and Mazzucato, 2018, Mazzucato, 2018, 2019).[4] **Industrial alliances allow to facilitate tighter cooperation and joint action among interested actors,** bringing together a wide array of players in a given industry or value chain, including public and private players and civil society. The battery industry does not necessarily require large producers. The common knowledge-base is applied to very different products and markets that include specialized operators, general-purpose users, and consumers. To catch up, a laggard economic area should carry out a variety of actions, and the EU has used several integrated instruments to develop prominence in this specific industry.

The first EU decision in this area is allowing national governments to provide state aids up to 2.9 billion euros. Like any custom union, EU institutions have the mandate to prevent member states aid that could alter competition. But when state aid is directed towards capacity building, especially in emerging areas in which the EU is lagging behind its competitors, the resources provided by national authorities could be advantageous to all members, and they deserve benevolent consideration.

The second is to promote the widespread collaboration and dissemination of the knowledge generated across a wide range of players across countries. This was carried out by fostering cooperation and also by dedicating targeted resources within the Horizon 2020 scheme "Next-generation batteries" and similar actions contemplated in Horizon Europe. These ventures will, at the same time, contribute to both collaborative research and innovation ventures and dissemination of knowledge across players.

The third is to provide loans at negligible interest rates for the battery value ventures through the European Investment Bank. Since 2010, battery projects financed by the EIB totalled 950 million euros and fostered 4.7 billion euros of overall project costs. The EIB involvement has significantly stepped up the financing of all the battery value chain stages, ranging from R&D, raw materials extraction and processing to battery production, e-charging infrastructure, and recycling.

The combination of grants, collaborative ventures, advantageous loans and regulations, together with the commitment to support the industry for several years, will hopefully be

[3] For further details, see https://ec.europa.eu/energy/topics/technology-and-innovation/batteries-europe/news-articles-and-publications/sra_it.

[4] The other EU mission-oriented public programs are: European Raw Materials Alliance, European Clean Hydrogen Alliance, Circular Plastics Alliance.

successful to make the EU a world leader in batteries. But such a strategy could be less effective when there is the need to affirm a remarkable fresh presence in restricted oligopolistic markets. In such cases, if the EU wishes to enter into the market dominated by the US big tech, a more active role is needed, namely the creation of European public corporations.

7. Do large public firms or the environment conduce to start-ups?

Provided that the European Union is a laggard area in knowledge-driven industries, it may be wondered whether the best strategy is either to use public resources and political power to generating ex-novo fresh companies or to create an environment conducive to facilitating high-tech start-ups, some of which could grow surfing over new technological opportunities. The recent American history indicates that during a technological revolution there is space for the birth of hundreds and hundreds of start-ups, although only a few managed to grow up to the point to become gigantic.

Europeans should certainly meditate on the reasons why the Big Tech companies of our age - Amazon, Apple, Google, Facebook, and Microsoft - are all American-born start-ups while none of them comes from the EU. Research in this area has indicated several reasons: i) the availability of scientific and technological opportunities in the USA, often fostered by public intervention; ii) the presence of a strong entrepreneurial spirit; iii) a capital market willing to finance risky projects in daring ventures. The EU should certainly aim to improve the overall business environment for start-ups, especially those devoted to far-sighted projects.

But at this stage, it is very unlikely that European start-ups will regain the market so resolutely hold by foreign companies. First of all, because large American companies, as already noted, have the financial resources to acquire any potential challenger. Indeed, they regularly scan new ideas and are eager to further enlarging their business range through merging and acquisitions. Second, because a start-up does have some chances to become big once new opportunities are not yet covered, but much less when it has to challenge the incumbent oligopolists. Once new markets assume an oligopolistic structure, it is very difficult to revert it.

This does not mean, of course, that the EU should not also actively encourage small firms in high-tech sectors. Several instruments need to be reinforced, including competition policy preventing small firms to be squeezed, opening credit lines for risky ventures, improving the provision of scientific and technological knowledge through technology transfer strategies. Furthermore, the creation of a few large European high-tech public companies could hopefully help enlarge the productive capacity in the continent ultimately holding beneficial for small firms.

8. Conclusions: the need to add another arrow to the EU economic policy instruments

The exogenous crisis represented by Covid-19 will certainly accelerate the global productive organization. The EU is risking falling behind unless its economic activities will not only be adequately supported by government intervention but also steered towards the emerging sectors. Horizon Europe will continue being a crucial policy instrument both to enhance scientific and technological capabilities and to facilitate their dissemination across a rather heterogeneous economic fabric, going from Lisbon to Tallinn. But Horizon Europe budget is comparable to one of the top high-tech corporations and could not alone change the landscape.

The massive resources made available through the Recovery Fund are needed to sustain the long-term drop of investments in the EU, which has been especially detrimental for the innovative component. These resources will be administered by national authorities under the European Commission's supervision. However, it is less likely that they will lead to large-scale intra-European technological projects.

Other industrial policy instruments are needed, and we have here suggested to launch proper continental public corporations replicating what has been done with Airbus more than half a century ago. It is not difficult to identify those areas where there are greater scientific and technological opportunities and where the EU has either an advantage – such as Green technologies and Healthcare services – or where is lagging behind and it is in need to fill the gap with the incumbent and challenging nations – such as ICTs and Artificial Intelligence. These are the areas where genuine European champions could hopefully sustain a solid continental economic recovery.

Although the endorsement of the European Council is certainly needed, these ventures could be initially pioneered by some governments only, in the hope that with time all EU members will join them. They will require building competencies, patient money, entrepreneurship, and leadership. All resources that are available in the EU and which will need to be channelled in new daring routes.

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9. References

Archibugi, D., Evangelista, R., and Vezzani, A. (2021). *Centripetal and centrifugal forces in technological activities: linking regional innovation performances to EU Science & Technology policies*. Birkbeck College CIMR Research Working Paper Series, Working Paper No. 47.

Archibugi D., Filippetti, A., and Frenz, M. (2020). *Investment in innovation for European recovery: a public policy priority*. Science and Public Policy, 47(1), 92-102.

Cimoli, M., Dosi, G., Mazzucato, M., Stiglitz, J.E., Landesmann, M.A., Pianta, M., Walz, R. and Page, T. (2015). *Which industrial policy does Europe need?*. Intereconomics, 50(3), 120-155.

Edler, J., Blind, K., Frietsch, R., Kimpeler, S., Kroll, H., Lerch, C., Reiss, T., Roth, F., Schubert, T., Schuler, J. and Walz. R. (2020). *Technology sovereignty. From demand to concept*. Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe.

Edler, J. and Fagerberg, J., 2017. *Innovation policy: what, why, and how*. Oxford Review of Economic Policy, 33(1), 2-23.

Enger, S. G. (2018). *Closed clubs: Network centrality and participation in Horizon 2020*. Science and Public Policy, 45(6), 884-896.

Evangelista, R., Meliciani, V., and Vezzani, A. (2018). *Specialisation in key enabling technologies and regional growth in Europe.* Economics of Innovation and New Technology, 27(3), 273-289.

Freeman, C., and Louçâ, F. (2001). *As time goes by: from the industrial revolutions to the information revolution.* Oxford University Press, Oxford.

Frenken, K. (2000). *A complexity approach to innovation networks. The case of the aircraft industry (1909–1997).* Research Policy, 29(2), 257-272.

Kattel, R., and Mazzucato, M. (2018). *Mission-oriented innovation policy and dynamic capabilities in the public sector*. Industrial and Corporate Change, 27(5), 787-801.

Khan, M., and Blankenburg, S. (2009). The political economy of industrial policy in Asia and Latin America. In: Cimoli, M., Dosi, G., and Stiglitz, J. (2009). *Industrial policy and development: The political economy of capabilities accumulation*. Oxford University Press.

Marks, P. (2017). *Where have all the start-ups gone?,* Technologist, at https://www.technologist.eu, 3 April.

Mazzucato, M. (2013), *The entrepreneurial state*. Anthem Press, London.

Mazzucato, M. (2018). *Mission-oriented innovation policies: challenges and opportunities*. Industrial and Corporate Change, 27(5), 803-815.

Mazzucato, M. (2019). *Governing missions in the European Union.* Independent Expert, European Commission, Brussels.

Meliciani, V. (2001). *Technology, trade and growth in OECD countries: does specialisation matter?*. Routledge, London.

Neven, D., and Seabright, P. (1995). *European industrial policy: The Airbus case*. Economic Policy, 10(21), 313-358.

Rikap, C., and Lundvall, B.-Å. (2020). *Big tech, knowledge predation and the implications for development*. Innovation and Development, 1-28.

Servan-Schreiber, J-J. (1968). *The American challenge*. New York: Atheneum.

Skillicorn, N. (2020). *Top 1000 companies that spend the most on Research & Development*, available at https://www.ideatovalue.com/inno/nickskillicorn/2019/08/top-1000-companies-that-spend-the-most-on-research-development-charts-and-analysis/

Zachary, A., Rahkovsky, I. and Huang, T. (2020). *Tracking AI Investment. Initial findings from the private markets*, Center for Security and Emerging Technology, Georgetown University, September.

10. Appendix

Table A.1. Data on R&D (% of GDP and absolute values)

R&D_gdp JPN	R&D JPN	R&D_gdp2 USA	R&D3 USA	R&D_gdp4 CHN	R&D5 CHN	R&D_gdp6 EU28	R&D7 EU28
2.91	133294.53	2.63	361468.89	0.89	39902.10	1.67	264518.01
2.97		2.65		0.94		1.69	
3.01		2.56		1.06		1.70	
3.04		2.56		1.12		1.69	
3.03		2.50		1.21		1.66	
3.18	154745.78	2.52	393047.99	1.31	93244.50	1.66	292954.12
3.28		2.56		1.37		1.68	
3.34		2.63		1.37		1.69	
3.34		2.77		1.45		1.76	
3.23		2.81		1.66		1.83	
3.14	153356.98	2.74	446815.57	1.71	208781.15	1.83	342284.17
3.24		2.77		1.78		1.87	
3.21		2.68		1.91		1.91	
3.31		2.71		2.00		1.92	
3.40		2.72		2.02		1.94	
3.28	168546.12	2.72	495094.00	2.06	366070.88	1.95	386010.31
3.16		2.76		2.10		1.94	
3.21		2.81		2.12		1.98	
3.28	173313.41	2.83	551517.75	2.14	462577.57	2.03	428513.16