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Industrial Policy in Europe

A Single Market Perspective

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ABSTRACT: European countries are increasingly turning to industrial policy to address the challenge of geopolitical fragmentation, enhance productivity, and accelerate the green transition. Well-targeted industrial policy has the potential to correct market failures and support production efficiency by exploiting scale effects and internalizing knowledge externalities. But even the most carefully designed unilateral industrial policies risk generating negative production externalities in other countries, and, under certain conditions, may not even be welfare-enhancing for the implementing country. The reason is that negative externalities of unilateral industrial policy can drive European and international production patterns away from underlying comparative advantages, create regional or global over-supply, and result in changes in terms of trade that reduce domestic welfare. This suggests significant benefits from coordination. Structural modeling and case studies show that a coordinated approach within the European Union and with international trading partners on a narrowly defined and carefully designed set of industrial policies could unlock untapped benefits. Closer European integration would facilitate the adjustment of firms and workers to coordinated and well-targeted industrial policies and amplify their benefits.

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* This paper was prepared by a team led by Andrew Hodge and Roberto Piazza and comprised of Fuad Hasanov, Xun Li, Maryam Vaziri, Atticus Weller, and Yu Ching Wong. The authors would like to thank Helge Berger and Manuela Goretti for their guidance, Ahmad Lashkaripour and Volodymyr Lugovskyy for making their code publicly available and for insightful discussions on this project, as well as Ali Abbas, Stephan Danninger and IMF seminar participants for helpful comments. All errors are our own.

WORKING PAPERS

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Contents

Glossary

ABER	Agricultural Block Exemption Regulation
BAe	British Aerospace
CES	Constant Elasticity of Substitution
FDI	Foreign Direct Investments
FIBER	Fishery Block Exemption Regulation
GBER	General Block Exemption Regulation
GDIP	Green Deal Industrial Plan
GTA	Global Trade Alert
IP	Industrial Policy
IPCEI	Important Projects of Common European Interest
KfW	KfW Development Bank
MBB	Messerchmitt-Bolkow-Blohm
NIPO	New Industrial Policy Observatory
PPI	Producer Price Index
PV	Photovoltaics
QuIS	OECD Quantifying Industrial Strategies
R&D	Research and Development
SEA	Single European Act
TCF	Temporary Crisis Framework
TCTF	Temporary Crisis and Transition Framework
TFEU	Treaty on the Functioning of the European Union
TFP	Total Factor Productivity
TRAINS	UNCTAD Trade Analysis Information System
WIOD	World Input-Output Data

I. Introduction

The rising fragmentation in the global economic and security landscape poses a challenge for Europe, as it contends with low growth and limited fiscal space. Following decades of efficiency-driven integration, through the European single market and globally through the WTO, Russia's war in Ukraine has amplified global geopolitical tensions, while heightening concerns about supply-chain resilience and economic security (Gopinath, 2023). This has all occurred against the backdrop of longstanding state support to industry in China (Rotunno and Ruta, 2024) and an expansion of US fiscal support for manufacturing (Inflation Reduction Act and CHIPS Act). The growing fragmentation threat adds to pre-existing European growth challenges from weak productivity, amid skill mismatches and an aging population (IMF2024a). These domestic and global challenges are creating spending pressures at a time of tight fiscal space in many countries, where there is an urgent need to rebuild fiscal buffers in compliance with the new EU fiscal rules (IMF 2024b).

In response to these challenges, European countries are increasingly relying on "industrial policy" to boost growth and secure supply chains.[1] State aid data indicate that industrial policy in the EU has been steadily rising over the past decade. This increase has become particularly pronounced due to the support measures introduced in response to the pandemic and energy shock. Nevertheless, while most of these crises-related measures are now being unwound, industrial policy remains significant in many EU countries, at about 1.5 percent of GDP (as of 2022), compared to around 0.5 percent of GDP a decade ago. Currently, state aid measures are predominantly related to environmental protection and energy efficiency and this trend is likely to grow as the green transition accelerates. At the EU level, key new industrial policy initiatives include the European Green Deal, European CHIPS Act, and the Digital Europe Program.

Well-targeted industrial policy coordinated at the European and international level has the potential to correct market failures and support production efficiency by exploiting scale effects and internalizing knowledge externalities. "Bad" industrial policies, often supported by rent-seeking behavior of interest groups, cause misallocation of resources towards low productivity industries (picking 'losers' rather than 'winners') and generating significant fiscal costs. The focus of this paper is in understanding the possible economic justifications and, most of all, the international spillovers from "good" domestic industrial policies, defined as those aimed at correcting domestic market failures and increasing domestic production efficiency in a given sector. Examples of efficiency- enhancing industrial policies are those narrowly targeted at boosting industries with externalities[2], including scale externalities from agglomeration effects, including knowledge spillovers (i.e., "Marshallian" externalities), where a policy-induced increase in output can improve sectoral productivity (IMF 2024d).

Structural modeling highlights how unilateral industrial policies in Europe can create only some winners and mostly losers within the region, even if aimed at correcting market failures at the national level. Simulating industrial policy in the multi-country, Krugman-style industrial policy model of Lashkaripour and Lugovskyy (2023) shows that policy interventions focused only on domestic efficiency can be detrimental to production efficiency of trading partner countries. Public support that expands production in a high-productivity industry with scale externalities can have a 'production relocation' externality (as per Ossa, 2011) that shrinks this industry in trading partners, as export and import patterns are distorted away from underlying

[1] Industrial policy is defined in this paper as 'sectoral policy intervention to transform the structure of the economy in pursuit of a policy goal.' While there is no standardized definition of industrial policy, the definition we adopt is consistent with the latest literature (see Juhasz, Lane and Rodrik, 2023; Criscuolo and others, 2022, and IMF, 2024c) and encompasses interventions via a wide range of vertical policy instruments including subsidies, tax incentives, subsidized loans and grants.

[2] For example, climate, national or geoeconomic security.

comparative advantages, lowering overall productivity in these economies[3]. Unilateral industrial policy may not even be welfare-enhancing for the implementing country, because of its impact on trade prices. Since industrial policy incentivizes reallocation of labor from the rest of the economy towards subsidized industries, increasing their output, this can depress the implementing country's export prices, if foreign demand elasticities are lower in the subsidized industries.[4]. For smaller countries more open to trade (i.e., where trade is a large share of GDP), like many in the EU, these pricing effects, determined by demand elasticities, can be large enough to cause an overall reduction in domestic welfare. These results suggest that without international policy coordination, individual incentives of countries may not be enough to implement efficient industrial policies and may result in counter- productive initiatives.

Coordinating well-targeted industrial policy is found to be mutually beneficial. This is first and foremost the case when industrial policies are coordinated within the EU (given significant intra-regional trade), but there are benefits also for coordination with non-EU countries. Structural modeling shows that in the presence of production externalities, simultaneous implementation of well-targeted industrial policies avoids distorting patterns of production away from underlying comparative advantages and increases gains from specialization, while mitigating potential domestic effects from adverse changes in the terms of trade. Existing state aid rules in Europe support simultaneous action of this form, acting as guardrails that allow countries to monitor each other's industrial policies and incentivize policies that are well-targeted at market failures, without adverse spillovers across countries. Co-ordinated industrial policies, with transparent monitoring regimes, are also likely to be more cost effective and less prone to governance failures.[5]

Gains from cooperation can be enhanced via greater European integration and cooperation within the EU and other multilateral institutions. Structural modeling suggests that the benefits of coordination on industrial policy can be further increased when accompanied by economic integration that enables full internal mobility of firms and labor[6], allowing deeper adjustment to the incentives offered by industrial policy. In practice, Europe may need a singular decision-making body to facilitate EU-wide coordination on strategic priorities, streamlining the existing range of overlapping programs and coordination instruments. The case study of Airbus provides a concrete example of how coordination allowed European countries to build a high-quality supply chain. While policies must always be well-targeted at overcoming market failures, the use of common EU funds could also simplify coordination and help avoid other potential pitfalls of industrial policy, including that fiscal constraints at the national level prevent the implementation of collectively optimal polices. Harmonizing regulations and streamlining approval processes across the EU is also likely to be more efficient than coordinating between different national policy regimes. At a global level, the model's results support the argument that negotiating on the design and implementation of industrial policy multilaterally, seeking international agreements through the WTO, can be beneficial.[7]

The paper is organized as follows: Section II presents stylized facts on the changes in the size and composition of industrial policy in Europe over the past decade. Section III presents the structural model and simulations. Finally, section IV presents illustrative case studies. Section V concludes.

[3] See also Brandao-Marques and Toprak (2024) for an empirical analysis of how state aid benefits recipient firms but can be detrimental to non-recipient firms in the same industry.

[4] The strength of this effect, and thus its practical relevance for policy making, depends crucially on the price elasticity of foreign demand for a country's exports.

[5] See also IMF (2024c) for a discussion of the trade-offs that industrial policy entails.

[6] See IMF (2024a) 'Box 3 What Is Constraining Europe's Productivity Growth? Evidence from a Firm-Level Study'.

[7] The precise form of multilateral cooperation beyond the EU is beyond the scope of this paper.

II. Industrial Policy in the EU Single Market: The Current State of Play

Closer European integration has fostered greater openness to trade and competition. The Single European Act (SEA), which came into effect in 1987, guarantees the free movement of goods, services, capital, and people among the EU's member states. The EU's State Aid regulations are complementary to the Single Market by prohibiting government assistance that could distort competition by favoring specific companies or industries. In parallel, non-tariff barriers to trade have been lowered through harmonizing standards and regulations across countries.[8] By reducing barriers to trade and ensuring a level-playing field across member countries, the Single Market has fostered intra-EU trade flows, which today account for about 60 percent of European trade, and the development of integrated supply chains.[9] Europe has also continued to look outwards, with exports to non-EU trading partners accounting for the remaining 40 percent of EU trade or over 15 percent of EU GDP (Figure 1). Notably, China's share of EU trade has roughly doubled over the past two decades.

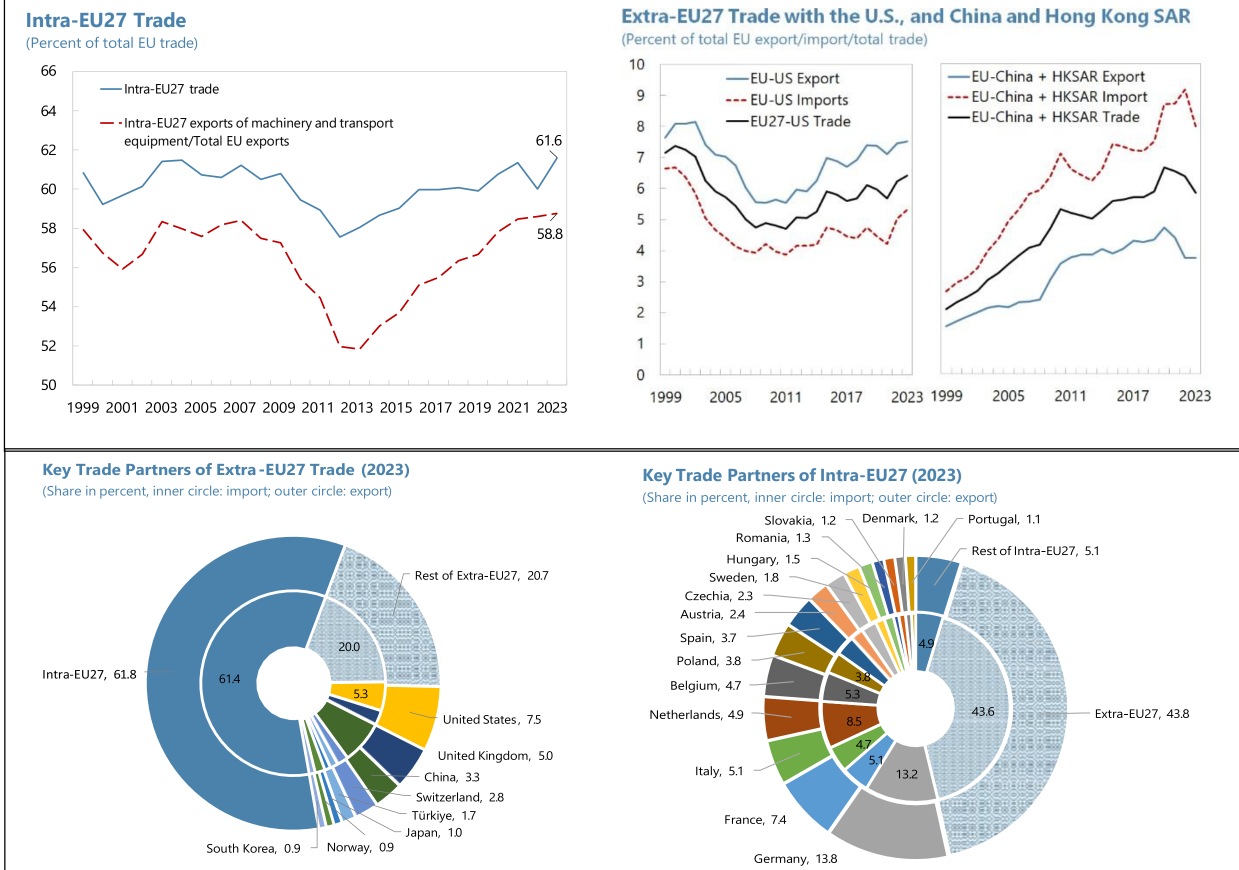
Concerns about supply-chain resilience and economic security following the pandemic and Russia's war in Ukraine have also accelerated industrial policies at the EU level. Industrial policy in Europe has evolved over time from national to more coordinated EU-wide strategies, aimed at enhancing competitiveness, innovation, and sustainability across member states. Earlier examples of coordinated policies include the Lisbon Strategy in 2000, aimed at improving competitiveness, which was followed in 2010 by the Europe 2020 Strategy and in 2016 by the Digitizing European Industry. Against the backdrop of long-standing state support to industry in China (Rotunno and Ruta, 2024), an expansion of US fiscal support for manufacturing (Inflation Reduction Act and CHIPS Act), and rising geopolitical tensions following Russia's war in Ukraine, the EU is pursuing a range of industrial policy initiatives in sectors including AI, batteries, and clean energy.

Notwithstanding new initiatives at the EU level (Box 1), unilateral state aid at each country level remains substantial, resulting in potentially significant fiscal costs and inefficiencies. State aid reached 2.4 percent of GDP as governments mobilized spending in response to the COVID pandemic (Figure 2, left panel). Although most crisis-related measures are being unwound, state aid remains significant in many EU countries at about 1.5 percent of GDP in 2022 (as of the latest 2022 official data in EC State Aid Scoreboard, see Box 2), compared to around 0.5 percent of GDP a decade ago. While the four largest EU member states– Germany, France, Italy, and Spain—account for the bulk of state aid expenditure (70 percent of total), the average EU country spends over 1 percent of GDP on industrial policies. For several smaller EU countries, this figure is significantly higher and reaches in some cases up to 2 percent of GDP (e.g., Hungary) (Figure 2, right panel). This could create important economic inefficiencies and fiscal costs, affecting Europe's ability to keep up with its trading partners and underscoring the need to ensure that money is spent efficiently (see Brandao-Marques and Toprak (2024) on how state aid can benefit recipient firms but have adverse effects on non-recipient firms in the same industry). Direct subsidy grants and interest rate subsidies are the most-used instruments for non-crisis state aid, accounting for 57.8 percent of total expenditure in 2022. Tax incentives, which account for 30.7 percent of total aid, generate further fiscal costs (Figure 3, left panel).

[8] Article 107 of the Treaty on the Functioning of the European Union (TFEU) prohibits aid granted by a member state or through state resources that distorts competition and trade within the EU by favoring certain companies or the production of certain goods. The TFEU, however, leaves room for state aid on selected policy objectives that are considered compatible with the internal market.

[9] Despite progress in lowering barriers to trade, substantial barriers to goods and services flows remain in the EU (see IMF (2024a).

Figure 1. Intra and Extra EU27 Trade



Sources: Eurostat and IMF staff calculations.
Notes: EU27 total exports (imports) totaled €4.0 (€4.1) trillion in 2023. Additional data for intra-EU27's import series (not labeled in the left chart) are Spain: 3.6, Austria: 2.3, Czech Republic: 2.8, Sweden: 1.6, Hungary: 1.7, Romania: 1.0, Slovakia: 1.2, Denmark: 1.1, and Portugal: 0.7. Similarly, extra-EU27's import series (not labeled in the right chart) are United Kingdom: 2.8, China: 7.9, Switzerland: 2.1, Turkey: 1.5, Japan: 1.1, Norway: 1.8, and South Korea: 1.1.

Increased flexibility to pursue these industrial policy initiatives, including to accelerate the green and digital transitions, has been supported through several channels:

- **Green Initiatives.** The Temporary Crisis Framework (TCF) was replaced by the Temporary Crisis and Transition Framework (TCTF)[10] in March 2023 which, in addition to crisis support, allows state aid for the transition to a net-zero economy in line with the Green Deal Industrial Plan. Going forward, state aid for environmental protection is expected to be supported by the extension of TCTF until end- December 2025. Non-crisis state aid is concentrated in the category of 'environmental protection', including energy efficiency measures (Figure 3, right panel).[11]
- **Block Exemptions.** The revision of the General Block Exemption Regulation (GBER) under the State Aid

[10] The TCTF allows member states until end-December 2025 to grant aid for the transition to a net-zero economy. Aid may be given to (i) accelerate the roll-out of renewable energy, storage and renewable heat relevant for REPowerEU and (ii) decarbonize industrial production processes. In addition, aid may be granted to accelerate investments for the manufacturing of strategic equipment, such as batteries, solar panels, wind turbines, and heat-pumps.

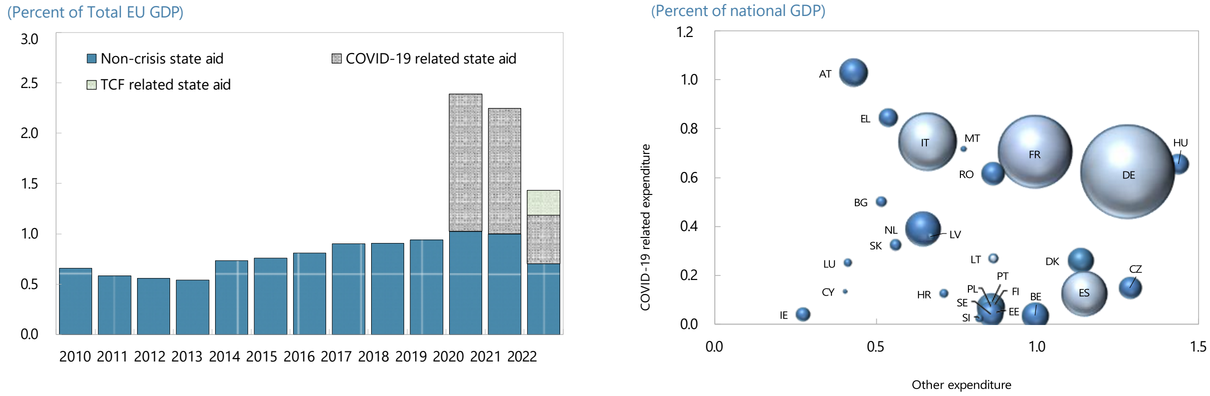
[11] Even before the pandemic, state aid in the 'environmental protection' category grew substantially, driven by German government spending. R&D expenditure picked up in 2021, becoming the second largest category of non-crisis spending, but has declined slightly in 2022. The slight reduction in environmental spending in 2022, which accounted for the reduction in non-crisis state aid, may be explained by the shift of a portion of this spending to the rubric of TCF.

Modernization process in 2014 aimed to reduce the need for prior notification to the EC if certain conditions are fulfilled. State aid measures provided under GBER increased to about two-thirds of all active measures in 2022 from about 40 percent in 2014 (Figure 4, left panel).[12] By expenditure size, the share of notified aid declined to about 70 percent and GBER aid increased to about a quarter of total state aid expenditure in 2022. The Green Deal GBER amendment endorsed in March 2023 further streamlined state aid rules for the green and digital transition. This may lead to an increase in this category of spending in 2023 and beyond, especially if more green projects are classified by the EU as Important Projects of Common European Interest (IPCEI), which are multi-national projects that involve technological or financial risks but may be of benefit to the entire EU.[13]

Figure 2. State Aid Expenditure in EU 27

Total State Aid Expenditure, 2010–22 (Percent of Total EU GDP)

Total State Aid Expenditure by Member State (2022) (Percent of national GDP)

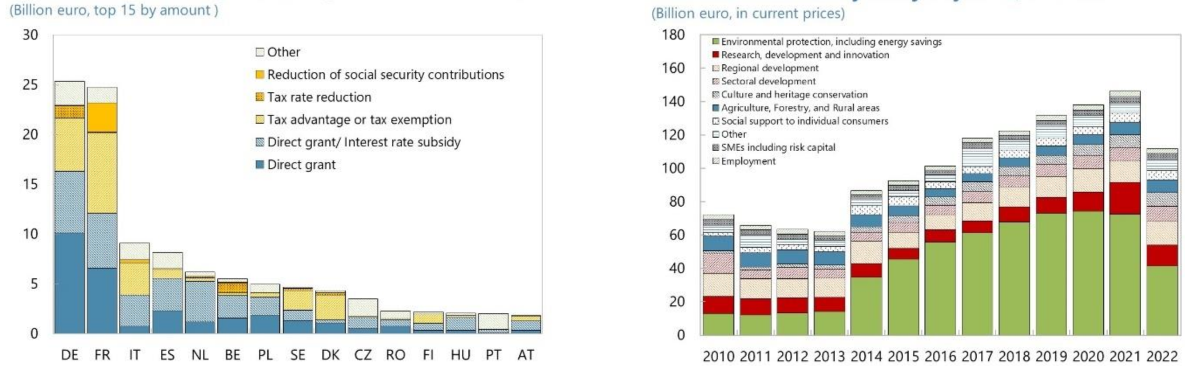


Sources: Eurostat, and IMF staff calculations. Notes:
The Temporary Crisis Framework (TCF) allowed EU member states to support the economy in the context of Russia's war in Ukraine (e.g., aid to compensate for high energy prices). Adopted in March 2022, amended in July 2022 and October 2022. The size of bubbles indicates share of member state's expenditure over total EU expenditure.

Figure 3. State Aid Expenditure by Aid Instrument and by Policy Objective

Non-crisis State Aid Expenditure By Aid Instrument, 2022 (Billion euro, top 15 by amount)

Non-crisis State Aid By Policy Objective, 2010-22 (Billion euro, in current prices)



Sources: Eurostat, and IMF staff calculations.

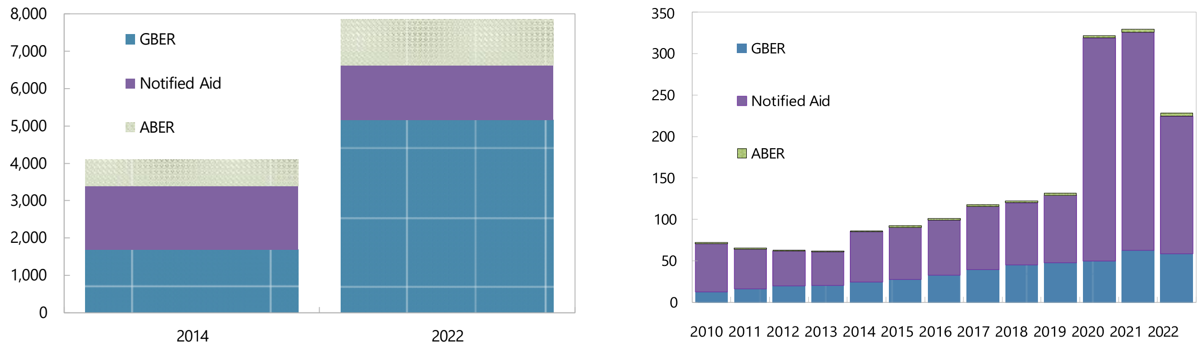
[12] Excluding the crisis measures, the new GBER measures account for 93 percent of total new non-crisis measures in 2022 (European Commission (2024a). The decreasing trend in the number of active notified aid cases since 2014 was only temporarily interrupted by the large increase in 2020 (1,293 cases) and 2021 (1,496 cases), due largely to COVID-19 measures.

[13] European Commission (2024b).

Figure 4. State Aid Expenditure by Type of Procedure

Number of Cases, 2014 versus 2022

State Aid Expenditure, 2010–22
(Billion euro, constant prices)



Sources: State Aid Scoreboard 2023 and IMF staff calculations.

Source: Eurostat.

The State Aid control framework is the key mechanism governing the granting of state aid, but it is not well-suited to steering this aid in a strategic direction. Past reform of the state aid control framework has resulted in a more detailed assessment of market failures by weighing the aid's proportionality and impact on market incentives, as well as by considering the distortions to competition and welfare losses that the public intervention may unintentionally cause.[14] At the same time, modernization efforts aimed at simplifying the approval of state aid have introduced lighter ex ante scrutiny of aid schemes.[15] This increases flexibility but may also reduce incentives for greater coordination across national-level initiatives in line with EU goals and/or consistent with an optimal industrial strategy for the EU as a whole. The IPCEI initiative, as enhanced in 2022, can promote major cross-border innovation and infrastructure projects in strategic areas. Nevertheless, as also discussed in Piechucka et al., (2024), further steps are needed to strengthen coordination and transparency. The recent Draghi and Letta reports on enhancing EU competitiveness have sought to address underlying constraints in EU governance, including by strengthening coordination among member states and expediting decision making on strategic priorities at the EU level. The following sections discuss the benefits for Europe from strengthened ex-ante coordination in efficiency- enhancing industrial policy.

Box 1. EU-wide Initiatives

The European Union's industrial policy strategy is driven by the need to boost economic resilience, increase diversification, and enhance energy security. Key initiatives include:

(i) **the European Chips Act**, which provides funding (similar to the US Chips Act) to bolster the EU's competitiveness and resilience in semiconductor technologies and applications;

(ii) **Foreign Subsidies Regulation**, which creates a new regime aimed at combating distortions of competition on the EU internal market caused by foreign subsidies;

(iii) **Foreign Direct Investment Regulation**, which screens and regulates FDI into EU member states to safeguard critical infrastructure, technologies, and strategic assets of the EU countries from potential risks posed by foreign investors;

[14] See discussion in Piechucka et al. (2024).

[15] The State Aid Modernization process in 2014, while reducing ex ante scrutiny, provided a safeguard through ex-post evaluation for larger cases under the GBER, see Verouden (2015).

Box 1. EU-wide Initiatives (concluded)

(i) **Export Control Regulation**, which monitors exports, deployment of technical assistance, transit and transfer of "dual-use" items; and

(ii) **the Green Deal Industrial Plan (GDIP)** (including through REPowerEU funding), which prioritizes the streamlining of regulations and the promotion of R&D in clean technologies, to facilitate rapid funding, enhance skills, and strengthen supply chains.

The GDIP was proposed in February 2023 as a part of the European Green Deal, a comprehensive set of policy initiatives launched by the European Commission in 2020 with the goal of making the European Union (EU) climate-neutral by 2050 and preserving the competitiveness of the EU as a green investment location. The main components of the GDIP are (i) providing more flexibility on the use of the REPowerEU loans, (ii) the Temporary Crisis and Transition Framework that relaxes state aid rules and allows matching subsidies offered by non-EU countries in clean-tech industries, (iii) the Net Zero Industry Act, which defines industries that benefit from streamlined permitting and financing, and (iv) the Critical Raw Materials Act, which seeks to boost EU production and diversify sourcing of critical resources for the green transition.

Box 2. Databases Covering Industrial Policy

Data constraints make macro-level analysis of European IP challenging because of time lags and aggregation issues. None of the main data sources for industrial policy – EC state aid databases, NIPO and the OECD – are directly comparable in terms of their definitions of state intervention, historical coverage, and degree of detail. And while all have strengths, none provide a complete picture of IP over time.

First, there are **three related data sources based on the EU definition of state aid**:

- The **EC State Aid Scoreboard** provides aggregated data on state aid expenditure by EU member states. This is state aid expenditure for which the EC has either adopted a formal decision or received summary information from the Member States for measures qualifying for exemption under the General Block Exemption Regulation (GBER) or sectoral block exemptions (ABER and FIBER).[16] It is best for monitoring industrial policy developments at the macro level, but the dataset comes with a significant lag of about 16 months.
- The **EC Transparency database** provides access to information on specific state aid awards made by national authorities. However, some EU authorities do not report to this database (e.g., Poland, Romania and Spain) and there are small differences in reporting standards based on differences in countries' legal definitions and/or their administrative capacity.
- The **EC State Aid Case database** offers searchable and detailed information on individual state aid cases notified to or investigated by the EC. It is useful for accessing decisions and compliance with state aid rules but, similar to the EC Transparency database, it is not suitable for aggregation.

Second, the **New Industrial Policy Observatory (NIPO**) dataset compiled by the IMF based on the Global Trade Alert (GTA), provides the timeliest information with monthly releases, though it is a short data series starting only from January 2023. As the NIPO captures distortive IP measures, notably trade and subsidy measures, it is not directly comparable with the EC state aid databases.

Finally, **the OECD Quantifying Industrial Strategy (QuIS)** dataset gathers data on IP expenditure suitable for specific analysis but it is a short data series with limited country coverage and a significant lag.

[16] EU funds managed at EU level are not included as they do not fall within the scope of state aid rules, but they are expected to be in compliance (European Parliament (2018)).

Box 2. Databases Covering Industrial Policy (concluded)

Table 1. Databases Covering Industrial Policy

Database	Purpose	Coverage	Period
EC State Aid Scoreboard	**Expenditure by scheme** An annual overview of state aid provided by EU member states	**Macro** (by country)	Annual 2000 – 2022
EC Transparency Database	**Granting by case** Provide public access to information on individual state aid awards granted by EU member states	**Micro** (by award)	Daily 2016 – current
EC State Aid Case Database	**Budgeting by scheme** A repository of individual state aid cases notified to or investigated by the EC	**Micro** (by case and decision)	Daily 2000 – current
NIPO (IMF)	Global-level (75 jurisdictions) policy intervention associated with IP	**Macro** (by jurisdiction and measure)	Monthly Jan 2023 – current
OECD QuIS Database	Gathers data on IP expenditures by instrument type and eligibility criteria	**Macro** (by country)	Annual 2019-21

III. Modeling the Impact of Industrial Policy in Europe

Industrial policy gives rise to complex interactions and trade-offs, some of which can be analyzed with existing general equilibrium models. Industrial policies can be beneficial by overcoming market failures, including exploiting scale / agglomeration effects and internalizing knowledge spillovers, as well as overcoming coordination failures to build supply chains. Industrial policies can also cause distortions to the domestic economy, particularly if poorly designed policies direct resources to unproductive industries, including because of rent seeking and governance failures. Unilateral industrial policies, whether distortive or not from a domestic perspective, can distort trade patterns, driving them further from what underlying comparative advantage would otherwise suggest. While subsidizing an export-oriented industry can make imported goods cheaper for foreign consumers, it can also create global over-supply, displacing producers in other countries and provoking countervailing measures, such as import tariffs, by other countries.

This section uses a general equilibrium model of international trade that incorporates scope for industrial policies to address the following questions:

- What do well-designed industrial policies with domestic economic benefits look like?
- What are the spillovers to trading partners, inside and outside of the EU, when industrial policies are adopted unilaterally by a country, even if well-designed from a domestic perspective?
- Can cooperation across European countries in setting industrial policy be beneficial given the nature of the Single Market?

The model's simulations are grouped in two parts: those that focus on domestic production efficiency and those that analyze welfare gains across all countries. The discussion of *production efficiency* at the *national level* allows us to characterize well-designed industrial policy. Namely, a policy that increases output in a domestic sector is production efficient if the policy eliminates a market failure and aligns the marginal production cost with the price of sectoral output. This implies that in the absence of market failures, there should be no industrial policy at all. However, if markets fail, for example due to production externalities at the sectoral level, then government intervention may be necessary.[17] These simulations also illustrate the consequences of poorly designed industrial policy that directs resources to low productivity industries. The second set of simulations help clarify that there is an extra layer of complexity, beyond production efficiency, when assessing the *welfare impact* of industrial policies. Policies that increase domestic production efficiency may not necessarily increase welfare for those countries that adopted them. The reason is that, depending on the value of foreign demand elasticities, the increase in production in the industry targeted by industrial policy may prompt too sharp a reduction in export prices. Consequently, the increase in export revenues in the subsidized industry does not outweigh the value of the production foregone in the other industries and stemming from the reallocation of labor towards the subsidized industry. As a result, even when production-efficient policies are adopted simultaneously in all countries and all sectors, changes in international market prices can generate winners and losers.

The Model

The model of Lashkaripour and Lugovskyy (2023) allows for micro-founded structural analysis of industrial policy in an internal context. It is from a strand of literature in which industrial policies are modelled as subsidies that remove distortions arising from imperfect competition and scale externalities at the sectoral level, usually referred to as “Marshallian externalities” (Bartelme et al., 2019; Haaland and Venables, 2016; Harrison and Rodriguez-Clare, 2010). Annex I provides further details. This literature can be viewed as the model-based counterpart to the empirical literature studying the conditions under which industrial policies have been successful in the past (Juhasz et al, 2023). The model of Lashkaripour and Lugovskyy (2023) also allows a discussion of the extent to which import tariffs and export subsidies are effective tools in improving efficiency.

The model shares many features with the Krugman-style, multi-country, multi-industry international trade framework. Labor is in fixed supply and is the sole factor of production in each country. Workers are perfectly mobile across industries within countries but cannot cross international borders. Industries differ by the degree of external scale economies (which can be understood as positive spillovers to sectoral productivity from learning by doing) and by the elasticity of export prices to output . Within industries, differentiated varieties are produced by monopolistically competitive firms and consumers have ‘love of variety’ preferences.[18] Industrial policy in the model takes the form of industry-specific production subsides that restore production efficiency in domestic industries by ensuring that scale economies are fully exploited.[19]

The domestic welfare impact of policies depends on the net benefits from the resulting improvements in production efficiency, production relocation effects, and changes in trade prices.[20]

[17] Scale economy parameters are reported in Table A1 in Annex 1. So, for instance, if an industry has a scale parameter of 0.1 then then a 10 percent subsidy is needed to restore production efficiency in the sector. Notice that we adopt here a relatively broad definition of production efficiency by referring to the marginal production cost in a given sector and country. A narrower definition, tightly linked to Pareto efficiency, would instead refer to the marginal (world- wide) social cost of producing in a given country and sector. The two concepts differ because the latter takes into account, for instance, the externalities that changing the production level in a given country and sector imposes on production in other domestic sectors as well as in all other foreign sectors. The distinction between the two concepts may seem subtle but, as we shall see, it allows our first set of simulations to draw interesting conclusions on the spillovers of “good” domestic industrial policies on production efficiency in other countries.

[18] The simulations presented in this paper are based on the long-run version of the model, where there is “free entry” and firms can transition across industries, after paying a one-off entry cost.

[19] Additional fiscal instruments include trade taxes, in the form of import tariffs and export subsidies. Any tax revenue not required for production subsidies is rebated to consumers via lump-sum transfers. There are no other distortionary fiscal instruments.

[20] Efficiency gains and term of trade channels have been long identified in the theoretical literature as key drivers of countries’ trade policies. See Harrison and Rodriguez-Clare (2010) for a classical treatment of the topic and, more recently, Bown (2023).

- The first effect of industrial policy in the form of Pigouvian incentives is to increase production in sectors with *external* scale externalities, boosting their total factor productivity (at the expense of less productive sectors) and lifting domestic welfare. However, there are additional effects via trade channels.
- Increasing exports in the subsidized industry can shrink other countries' production in that industry, leading to a production relocation externality as per Ossa (2011), which reduces overall productivity in trading partner countries. If this production relocation leads to a deviation from what would be implied by underlying comparative advantages, it may lower the gains from international trade for all countries.
- Further, changing patterns of production and trade will necessarily affect trade prices and thus countries' terms of trade. Industrial policy reallocates labor domestically towards industries with higher scale economies, boosting their output. If foreign demand elasticities are lower in the subsidized industries than in the rest, higher export revenues in the subsidized industry might not make up for the lower production in the other industries, because of a fall in export prices in the subsidized industries.[21] In this case, the country as a whole experiences a deterioration in its terms of trade. According to the calibration of the model, which is based on empirical evidence (see Table A1, Annex 1), there is indeed a negative correlation between scale externalities and the demand elasticities in an industry. Therefore, an industrial policy driven only by production efficiency reasons could reduce domestic welfare. The effect is more marked for countries that are more open to international trade.

The quantitative results presented here rest on specific modeling assumptions as well as parameter calibrations that are subject to significant uncertainty. The net welfare impact of the three channels outlined in the preceding paragraph is an empirical matter, determined by the calibration of the model. However, both the elasticity of foreign demand and the elasticity of scale economies—the key model parameters that determine the size of the three effects—are highly uncertain.[22] To address this point, Annex II presents simulations of a simplified model that, for the case of a small economy, retains the crucial features of Lashkaripour and Lugovskyy (2023). The sensitivity analysis shows how the overall welfare effects of industrial policy depend on the foreign demand elasticity and scale economies elasticity parameters, as well as the degree of openness of the economy. Importantly, the analysis highlights for most countries a tension between using industrial policy as a tool to enhance production efficiency or as a trade policy tool. This tension arises naturally in models where countries produce differentiated goods, so that the foreign demand curve for domestic output varieties is downward sloping (i.e., foreign demand is not perfectly elastic) even for small countries, thus giving rise to terms of trade effects, and in turn, production relocation externalities.[23]

Beyond these channels, it is also important to note that the model is not a complete description of all

[21] For further clarity, consider a hypothetical scenario in which industrial policy is implemented in an industry with unitary demand elasticity. Also assume that, in equilibrium, labor is reallocated to the targeted industry from an industry with perfectly elastic demand (i.e., the industry acts as a price taker in international markets). Furthermore, assume that all the output from both industries is exported. In this situation, after the implementation of the industrial policy, export revenues in the targeted industry remain approximately unchanged—regardless of the magnitude of the productivity increase and the resulting output expansion in that industry. Conversely, export revenues in the second industry will inevitably decrease. Consequently, total export revenues decline, leaving the country worse off. By extension, this conclusion also applies if the demand elasticity in the targeted sector is greater than one (but not excessively high), which is typically the empirically relevant scenario that arises also under the calibration of parameters shown in Table A1 of Annex I. Additionally, these qualitative conclusions hold even when the second industry sells all its output domestically, rendering the elasticity of its foreign demand irrelevant. This outcome corresponds to the one presented in the simplified model discussed in Annex II.

[22] Bartelme et al. (2019) also present a multi-country and multi-industry structural model with calibrations of scale parameters that are alternative to the ones in Table A1 of Annex 1.

[23] From a modeling perspective, the production relocation and the terms of trade effects originate in the international trade literature. They have been put forth as complementary but different explanations for multilateral trade agreements like the GATT/WTO. Terms of trade effects remain a key feature of trade and industrial policy models (Bartelme et al., 2019), but their relevance for policy makers has been criticized (Basu and others, 2020). In fact, models like Ossa (2011) that embed the production relocation externality have been developed exactly to address this critique.

potential benefits and costs of industrial policy. The absence of intermediate goods means that the model cannot fully characterize supply chains, including how industrial policy may support their development, by overcoming coordination failures and onshoring production of critical inputs, which may prove beneficial in times of international crisis. The model also does not capture the potential for rent-seeking behavior and/or moral hazard if industrial policy and trade policy shield firms from competition.[24] Since the model is static, it is also unable speak to the relation between industrial and competition policies—for example, how the endogenous evolution of an industry's market structure provides market-based incentives for firms to internalize learning-by-doing and other externalities (Dasgupta and Stiglitz 1988; Melitz 2005). Also, given the very stylized representation of fiscal policy, the model cannot be used to assess whether large-scale industrial policy is consistent with fiscal sustainability over time. These additional considerations further stress the importance of carefully diagnosing and weighing the costs and benefits of unilateral IP initiatives, even when welfare enhancing from a strict production efficiency perspective.

Unilateral Industrial Policy Creates Spillovers That Affect Production Efficiency in Other Countries

Simulation #1. Unilateral industrial policies that are poorly designed can cause large domestic production inefficiencies and small production efficiency gains in other countries. To illustrate a clearly "bad" industrial policy, we consider subsidies to the services sector, since these exhibit zero economies of scale according to the model's calibration. As an example, Figure 5 illustrates the case of a 20 percent subsidy to services production in Germany. Figure 5 panel (a) shows the impact of this policy on sectoral employment shares and TFP.[25] The employment share of the subsidized sector in Germany increases (by 15 percentage points) and, correspondingly, the employment share of all the other sectors decreases. Since there are no economies of scale in the subsidized sector, TFP in this sector doesn't change as the sector expands, but TFP decreases in all other sectors, which exhibit economies of scale. The final outcome in unambiguous: domestic production efficiency, as measured by aggregate TFP, decreases in Germany, which makes the policy unambiguously production inefficient. Figure 5 panel (b) looks at the spillovers of the German subsidies on France in our illustrative example. The situation is the mirror image of that in Germany, although these second order effects have smaller magnitude. A cross-country production relocation externality occurs and the French services sector contracts, even though output in the service sector is relatively hard to trade internationally, under the model's calibration. The contraction of the French services sector is matched by an expansion of all other French sectors, which exhibit economies of scale, so France experiences a small aggregate TFP increase.

Simulation #2. Unilateral industrial policy that generates production efficiency gains in one country can cause production efficiency losses in others. As an example of "good" industrial policy, we consider production subsidies directed at a manufacturing sector—specifically, Electrical and Optical Equipment—with large external scale economies under the model's calibration. The subsidies correct market failures by incentivizing firms to internalize the external scale effects.[26] We consider the case where the policy is implemented unilaterally only in one country, Germany. Figure 5 panel (c) shows that the unilateral policy leads to a significant increase of around 15 percentage points in the employment share of the subsidized industry in Germany, at the expense of others (see also Brandao-Marques and Toprak (2024) for empirical evidence of state aid benefiting recipient firms, while causing adverse spillovers to non-recipient firms in the same industry). Since Electrical and Optical Equipment exhibit large economies of scale, the expansion of the sector causes its TFP to

[24] Garcia-Macia and Sollaci (2024) study industrial policy in a theoretical model, where there is political favoritism towards particular sectors or random mistakes that cause misallocation across sectors.

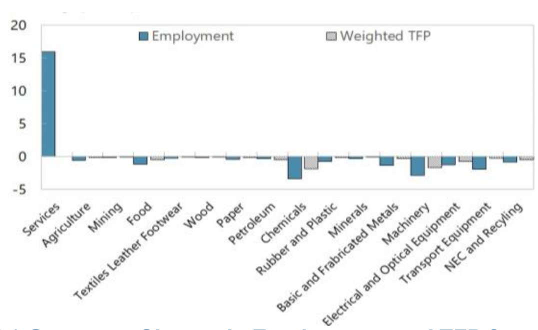
[25] Sectoral TFP is weighted by the sector's initial value-added share of the economy.

[26] Scale economies in electrical and optical equipment manufacturing need a large subsidy to be fully exploited, of 52 percent of production costs, according to the model's evidence-based calibration.

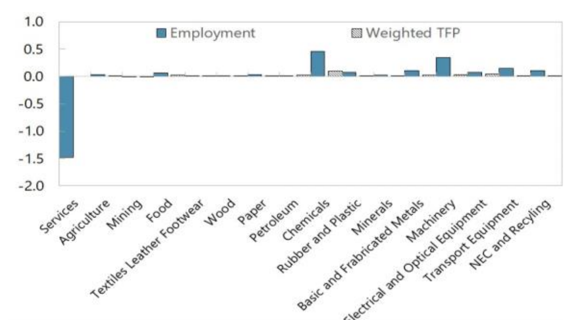
increase by about 5.5 percent, weighted by its share in total output. All other sectors lose employment share in Germany and their TFP decreases, but only by 2.5 percent on a weighted basis, as scale economies in these sectors are smaller.[27] Overall, while weighted average TFP of the German economy rises by 3 percent, this unilateral policy reduces productivity in trading partner countries. Given the productivity increase in the German Electrical and Optical Equipment sector, there is a production relocation externality on trading partner countries which contract their production—Figure 5 panel (d), left panel, illustrates this for the example of France. Unilateral industrial policy in one country (i.e. Germany in this illustrative example) is thereby distorting the international pattern of production away from underlying comparative advantages. Since the production relocation externality in this example occurs in a sector with high economies of scale, weighted-TFP in Electrical and Optical Equipment falls significantly in France and is not compensated by increased TFP in other sectors. On a net basis, the weighted TFP of the French economy falls by 0.4 percent.[28]

Figure 5. Domestic and Spillover Effects from "Good" and "Bad" Policies

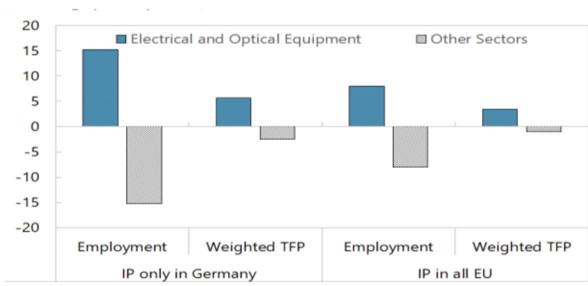
(a) Germany: Change in Employment Share and TFP from IP in Services
(Percentage points; percent)



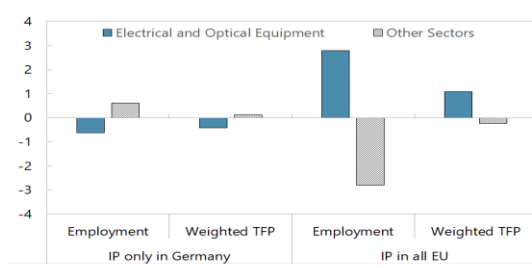
(b) France: Change in Employment Share and TFP from IP in Services
(Percentage points; percent)



(c) Germany: Change in Employment and TFP from IP in Electrical Equipment
(Percentage points; percent)



(d) France: Change in Employment and TFP from IP in Electrical Equipment:
(Percentage points; percent)



[27] The service sector, which alone experiences a 6-percentage-point decrease in employment, is both a sector with a large weight in the economy and has no scale economies.

[28] It is important to realize that the large, subsidized increase inf the size of the German Electrical and Optical Equipment sector is efficient, assuming that there is no other country which intends to put in place "good" IP policies in that sector. In other words, if Germany is the only country capable and willing to subsidize an efficient correction of external economies in its domestic sector, then it is efficient that a large chunk of the European production in that sector move to Germany. In other words, in this model with external economies, sectoral productivities, and thus comparative advantages, are endogenous to policies. Since the productivity of the services sector is unaffected by policies, TFP bars in Figure 5 can also be interpreted as changes in a country's comparative advantage in producing Electrical and Optical Equipment instead of services.

A minimum level of coordination via simultaneous implementation of production subsidies in Europe can raise production efficiency in all countries.[29] As the right part of Figure 5 panel (d) shows, if *all* European countries implement production subsidies in the Electrical and Optical Equipment sector, the employment and TFP of this sector in France will increase too, unlike when the policy was implemented unilaterally in Germany. On a net basis, weighted TFP in France now increases by 0.8 percent. Weighted TFP in Germany still increases on net by 2.4 percent (right part of Figure 5 panel (c)). Simultaneously implementing subsidies that correct market failures avoids the distortion of international production patterns away from underlying comparative advantages, allowing for gains from specialization, given that each country produces different varieties of goods in every industry. This proves to be more efficient for all countries than unilateral subsidies that increase concentration of production in one country. In other words, since in the presence of external economies, sectoral productivities are endogenous to policies, then policies need to be coordinated to fully exploit comparative advantages.[30]

Unilateral Industrial Policy May not be Welfare-Improving Due to Terms of Trade Effects

We now present several scenarios to assess the overall welfare impact of the unilateral and coordinated policies discussed above, taking into account also changes in terms of trade. These simulations use a welfare-based metric that combines the production efficiency changes discussed so far with the distributional effects of changes in relative market prices across countries—that is, the terms of trade. The simulations are performed in a model set-up with 43 countries (including all EU member states), but we also consider the case where all EU countries act as a single country. Unlike the example of subsidizing a single economy-of-scale industry shown above, countries now adopt a package of "good" industrial policies that correct market failures and internalize scale effects in all their domestic sectors. The subsidy per unit of production offered in each sector is proportional to the scale externality in that sector, as shown in Table A1 of Annex 1. Specifically, the model included 15 tradable goods sectors and a services sector. Among the tradables sector, there is agriculture, mining and a range of manufacturing industries of differing levels of technological sophistication, from wood products to electrical and optical equipment.

Simulation #3. Unilateral industrial policy can be welfare-reducing in more open economies, even if narrowly targeted at correcting market failures. If a country unilaterally implements industry-specific production subsidies that eliminate market failures by exploiting scale effects in all sectors, it will improve domestic production efficiency by expanding the share of the most productive sectors, at the expense of others, as shown above, while other countries maintain status quo policies. However, it will also cause a production relocation externality, distorting international patterns of production away from underling comparative advantages, and affecting trade prices. The overall domestic welfare benefit resulting from the improved production efficiency is at least partially offset by a drop in export prices because subsidies are largest in industries where the demand elasticities are smaller. This reflects the empirical relationship across industries between the extent of scale economies and demand elasticities reflected in the model's calibration. Piecewise repetition of this simulation for each of the 43 countries in the sample, while all other countries maintain the status quo in each case, reveals

[29] By our definition, correcting external scale economies only in the Electrical and Optical Equipment is a "good" policy. However, from a domestic perspective, it is not the best policy, which would instead require correcting external economies in all other domestic sectors as well. This point was already highlighted in the discussion above on "broad" and "narrow definition" of industrial policies.

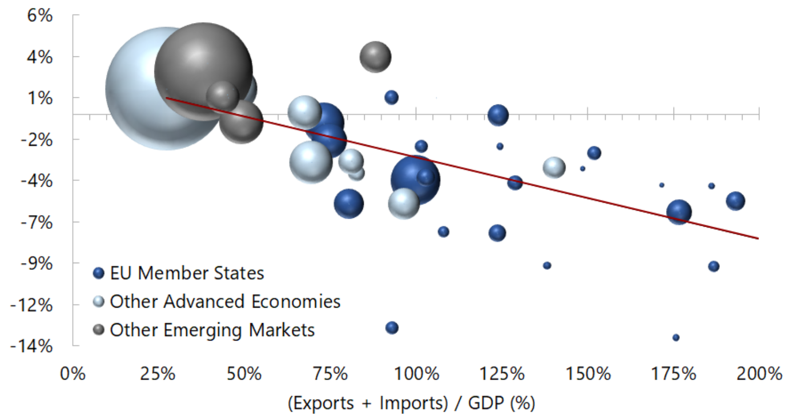
[30] In the model used here there is no cost of moving production factors across sectors. So, in principle, if other EU countries were to put in place their IP sequentially and after Germany has enacted its own IP, then some of the production in the subsidized sector, and that had initially moved to Germany, would then move partly back to the other EU countries, However, in reality, large scale industrial plans suffer from significant irreversibilities. Once production has moved to Germany and Germany's TFP in that sector has increased, then ex-post it could be costly for firms to move elsewhere, even this would have been efficient ex- ante. This provides a critical motivation for countries to coordinate ex-ante their industrial policy plans.

overall net welfare losses for most countries.[31] These losses are particularly large for smaller economies that are more open to trade (in terms of exports and imports as a share of GDP), including most member states of the EU (see Figure 6), since the offsetting losses from lower export prices are more consequential in these economies.

Figure 6. Unilateral Implementation of Industrial Policy

Welfare Impact of Scale-Correcting Production Subsidies

(Relative to Status Quo of Zero Subsidies, percent)



Note: The chart shows the welfare gain (%) when each country unilaterally implements scale-correcting production subsidies, while other countries maintain zero subsidies. The size of the bubbles corresponds to each country's nominal GDP (in USD) for 2023.

Source: Authors' calculations.

Simulation #4. A minimal level of cooperation via simultaneous implementation of well-targeted industrial policy can mitigate overall welfare losses from unilateral policies. To illustrate this, we consider a simulation where all EU countries implement industrial subsidies simultaneously, to correct market failures by internalizing scale effects.[32] As illustrated earlier, simultaneous implementation of subsidies minimizes the production relocation externality and avoids the concentration of production in a country unilaterally implementing subsidies, away from the pattern of production implied by underlying comparative advantages. Furthermore, although subsidies may increase production in industries where foreign demand elasticities are smaller, reducing export prices in that industry, all else equal, trading partners' own subsidies to industries where there are larger scale externalities may lower import prices, overall improving the first country's terms of trade. Aggregating the welfare impact across all EU countries acting simultaneously indicates a *smaller average welfare loss* than in the case where each country acts entirely unilaterally (see bar in Figure 7 labeled ''EU countries acting simultaneously').

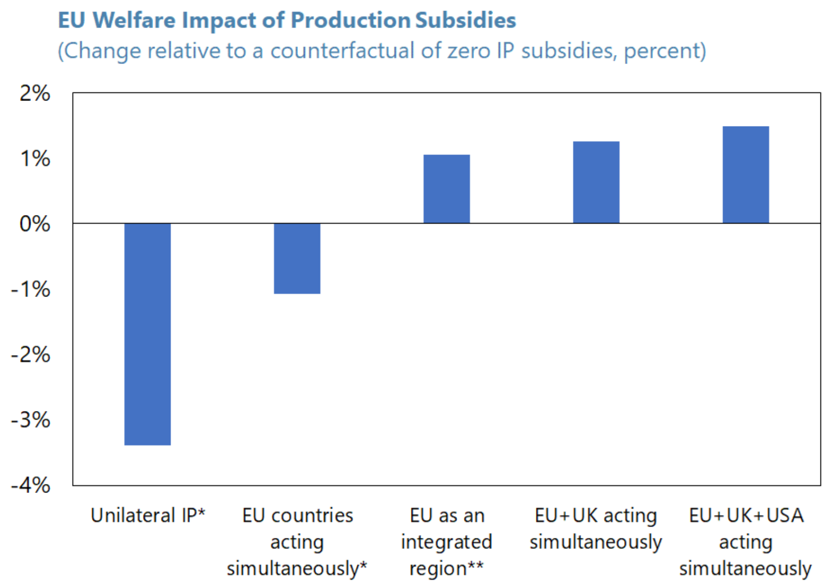
Simulation #5. Further welfare gains are possible from EU integration and global cooperation. The previous simulation assumes that factors of production cannot move within the EU. Although barriers that limit the potential of the single market still exist in practice, this assumption clearly underestimates the current level of EU economic integration. To illustrate the benefits of full factor mobility within a fully integrated single market, at the other extreme of the EU integration spectrum, we re-calibrate the model so that the

[31] Even for European countries found to achieve welfare gains, note that the model captures only a very limited and targeted form of industrial policy, tightly connected to market failures. More expansive industrial policy may not be welfare-enhancing. Furthermore, the model does not capture political economy factors, such as governance failures, that may undermine the effectiveness of industrial policy, nor does the model account for the impact of industrial policy on fiscal sustainability (as discussed later).

[32] Simulation 4 is a single experiment with all countries implementing industrial policy simultaneously, unlike Simulation 3 which determined the impact of only one country implementing industrial subsidies and all others maintaining the status quo, with this exercise repeated sequentially for each country in the sample (see Figure 6 for the results).

27 countries of the EU are treated as a single country. Industrial policy is therefore set at the regional level and both labor and firms are allowed to relocate freely across the EU in response to industrial policy.[33] This maximizes the efficiency gains from implementing subsidies to exploit scale effects. It also minimizes the losses from depressing export prices, since the EU as a whole is less open to trade than many of the individual EU countries, so that the welfare cost of depressing export prices by expanding production in industries where demand elasticities are smaller is less important (see bar in Figure 7 labeled 'EU as an integrated region'). Finally, if the EU as a whole, plus say the UK and USA all implement industrial subsidies simultaneously, this produces further welfare benefits for EU countries, via the same mechanism illustrated in simulation 4 above.

Figure 7. Gains from Coordination

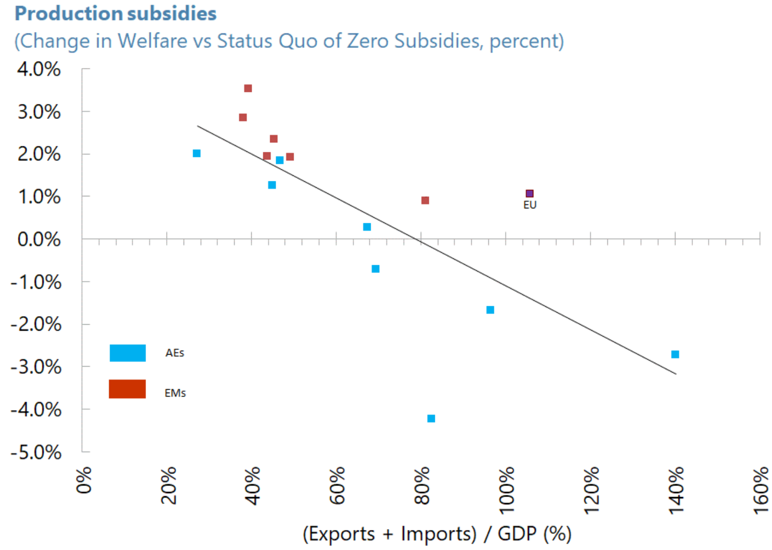


* Weighted average of national welfare losses. ** Welfare change for EU as an integrated region.
Source: Authors' calculations.

Multilateral cooperation on the design and implementation of industrial policy is likely to be worthwhile, even at the global level. Unilateral implementation of industrial policy by large emerging market economies that are less open to trade already implies welfare gains for these countries, as the cost of expanding production in industries with lower demand elasticities is less important and only partially offsets the benefits of exploiting scale effects (Figure 8). More open economies can still suffer welfare losses if they implement industrial policy unilaterally. If all countries in the sample set industrial policy unilaterally to exploit scale effects, but do so simultaneously, then this would avoid some of the production relocation externalities of industrial policy and the reduction in terms of trade from expanding output in industries with low demand elasticities. In this case, the aggregate impact of industrial policy is positive in welfare terms, on a GDP-weighted basis.

[33] While political economy considerations are beyond the scope of this paper's analysis, reallocation of labor and firms across Europe could impact socio-political support for industrial policies, if not accompanied by adequate policies to address skill mismatches and other frictions.

Figure 8. Industrial Policy by Non-EU Countries



Source: Authors' calculations.

The fiscal cost of subsidies that fully exploit scale externalities can be large, especially when unilaterally implemented, illustrating the fiscal risks of industrial policy that need to be carefully managed. In the simulations of the structural model, fiscal costs are limited to production subsidies that fully correct for scale or agglomeration externalities. Since the model is static, the cost of these subsidies cannot be measured over a particular time interval. For illustrative purposes, the fiscal cost of implementing these subsidies can be computed in the model's steady state and interpreted approximately as the cumulative cost of eliminating the market failure, in percent of GDP, that incentivizes enough firms to pay the fixed costs of reallocating to industries with larger scale externalities. For a country implementing these subsidies unilaterally, while all other countries maintain the status quo, the fiscal cost is found to be 13.2 percent of GDP on average across EU countries, on a GDP-weighted basis. This declines to 10.9 percent of GDP if the EU enters the model as a single country, suggesting some degree of cost efficiency under full EU integration, as full labor mobility allows easier reallocation of production across sectors.[34] These estimates raise concerns about fiscal sustainability at a time when fiscal space is limited in many EU countries. The model also does not take into account the potential distortionary effect of taxation needed to fund the subsidies, since taxation is assumed to be lump sum in the model, apart from pre-existing tariffs. While the welfare impact of industrial policy implied by the model is consistent with the estimated costs shown here, in practice any benefit of industrial policy should be weighed against the fiscal risks that the required fiscal spending may entail, given that the static modeling approach is not well-suited to gauging the impact of industrial policy on fiscal sustainability.[35]

[34] The model does not speak to the issue of how fiscal costs may be spread across EU countries, in the case where the EU enters the model as an integrated region.

[35] The Draghi Report estimated that combined public and private investment of 5 percent of GDP per year during 2025–30 would be needed in European industry. This investment would have different aims and scope to that modeled in this paper, so it is not directly comparable.

IV. Overcoming Market Failures with EU Industrial Policy: Evidence from Airbus and the German Solar Industry

The case studies of Airbus and the German solar industry illustrate how industrial policy may be used to correct a broader range of market failures than those captured by structural modeling, while also revealing a wider set of trade-offs and risks. The previous section illustrates a role for well-targeted industrial policy in mitigating market failures, while also showing potential costs, especially for countries acting unilaterally. While the model focused on scale externalities and agglomeration effects, there is a wider range of market failures in reality, including spillovers from innovation and technology diffusion, as well as informational asymmetries. At the same time, industrial policy implementation can pose implementation risks such as rent-seeking by firms requesting public support, high fiscal costs—especially for countries with limited fiscal space—and the potential for retaliatory trade policy by partners. In addition, economic and business conditions constantly change, emphasizing the importance of both the state and firms adapting to changing circumstances. There is also a wide range of instruments that can be used to implement industrial policy, beyond production subsidies, including tax incentives and financing on concessional terms. In this section, two representative cases—the birth of Airbus and the role of the national development bank KfW in Germany's energy transition—illustrate how state support can alleviate market failures, while emphasizing what can go wrong.

A. Airbus: Fostering Cooperation and Competition to Build a Strategic Industry

The case of Airbus offers an example of how industrial policy allowed cross-border coordination challenges to be overcome to build an European commercial jet manufacturer and a pan-European supply chain. In 1970, the governments of France, the UK, and West Germany collaborated to enter the commercial aerospace industry. Airbus remained an intergovernmental consortium before transitioning to a joint-stock venture in 2001. A technical group with industrial know-how from various stages of the supply chain selected supplier firms based on the quality of their technology. For example, the initial allocation of work included French firms for airframes, firms in the UK for cockpits and wings, and German firms for aeronautical segments. As the consortium expanded, the division of work and subcontracting agreements for firms were established through negotiations and consultations, and strategic decisions were made through industrial networks. Airbus eventually built a global supply chain with approximately 30 percent of its operations now located in countries other than the United States and the main EU partners.

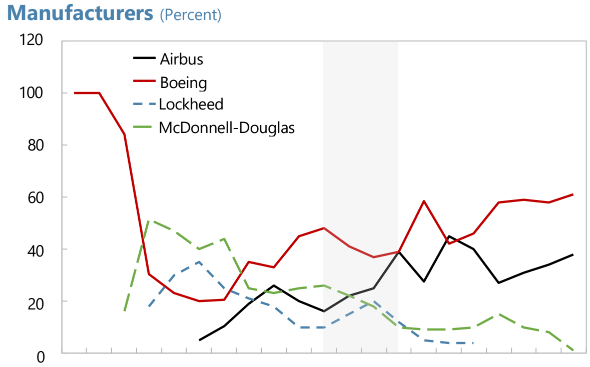
Fiscal support to Airbus was substantial and helped overcome financing constraints to foster start-up investment in innovation and exploit scale economies. Fiscal support took different forms, including equity participation, launch aid, and guarantees against losses from exchange rate fluctuations. The German government also provided guarantees against losses caused by exchange rate fluctuations during the production phase. From 1970 to 1994, the estimated size of accumulated subsidies ranged from 0.2 to 0.35 percent of 1994 GDP of the main Airbus consortium countries (Klepper, 1994). This support was critical during the 20-year period from Airbus launching in 1970 and becoming profitable in the 1990s, during which time Airbus developed various aircraft and slowly gained market share, securing orders from US airlines from 1978 (Figure 9).[36] Without fiscal support, the Airbus consortium would likely have faced higher financing costs, due to the high risk of business failure and delayed profitability. By 1987, Airbus directly employed over 30,000 workers across Western Europe, representing 30 percent of the total workforce of the three main

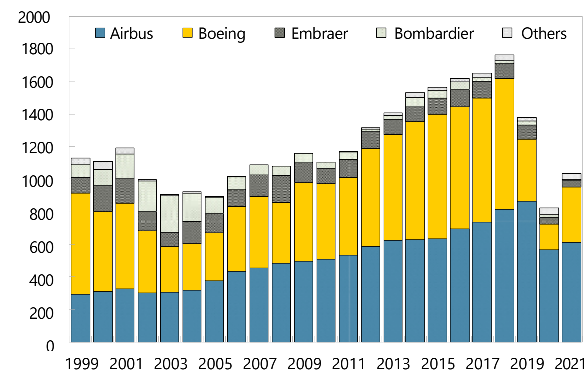
[36] https://www.airbus.com/en/our-history/commercial-aircraft-history/expansion-1991-1992.

industrial partners (Hayward 1987)[37], reaching a scale where it was a major competitor to Boeing, commanding around 40 percent of market share in the wide-body jet market (Figure 9). In the last two decades, EU aerospace industry exports have been about 2 percent of total EU exports, and the aircraft parts sector saw steady growth, particularly within the EU (Figure 10, right). By 2019, total exports of the EU aircraft manufacturing industry reached about 104 billion USD (Figure 10, left).[38]

Public support to Airbus generated knowledge spillovers and facilitated continuous improvement in production techniques and product performance. Although the unit cost for Airbus was approximately 17 percent higher at the same scale of production than that of Boeing (Klepper 1994), efficiency gains from innovation and automation helped offset high labor costs and obstacles to layoffs. This facilitated expansion of European supply chains and supported worker training. A new aircraft was equipped with advanced technologies featuring lower fuel consumption and maintenance costs. This helped Airbus win contracts from airlines across the globe in the late 1970s when less efficient aircraft were being phased out after the global oil crises. Airbus generated a 6 to 11 percent earnings return and created positive knowledge spillovers to other non-consortium member firms (IMF 2024c). Airbus further boosted its R&D expense in 2020 from 4.8 to 5.7 percent of total sales revenue and has maintained it at over 5 percent over the past few years.

Figure 9. Market Share and Deliveries of Passenger Jets





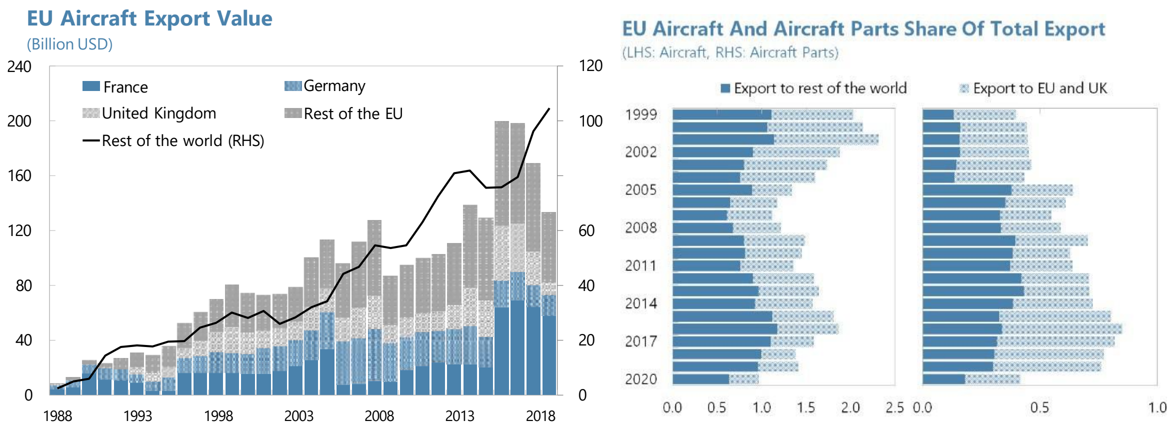
Note: (LHS) Other equivalent wide-body jets include Boeing B747/B767, Lockheed L-1011, and McDonnell Douglas DC-10 jets. (RHS) passenger jets include combi, quick change, and jets.

Sources: Tobias A. Jopp and Mark Spoerer (2020), Statista, and IMF staff estimates.

[37] The three industrial partners are: British Aerospace (BAe), Aerospatiale and Messerchmitt-Bolkow-Blohm (MBB).

[38] There was state support beyond the initial infant-industry aid as evidenced in the World Trade Organization's dispute between Airbus and Boeing. Starting in 2004 and lasting for 17 years, it ended in 2021 when the U.S. and the EU decided to seek other ways to resolve the differences and address global challenges in the industry. Whether the state support was justified from an economic standpoint would depend on whether it addressed certain market failures like innovation and knowledge spillovers or other considerations like economic security. Similar to the German solar industry discussed below, changed market circumstances would require changes to state support and firm decisions. These issues are, however, beyond the scope of this paper.

Figure 10. EU Aerospace Industry Export



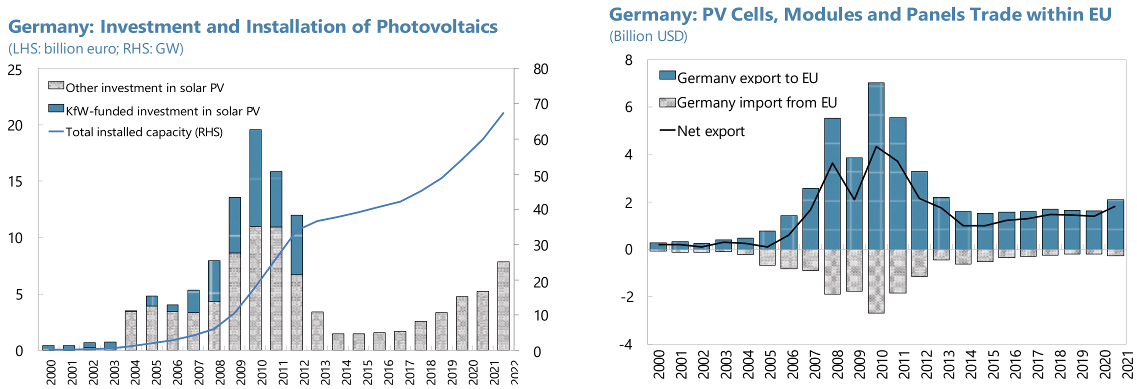
Notes: (LHS) Includes aircraft and spacecraft industry. (RHS) Aircraft use HS 8801 and 8802 product code, Aircraft parts use HS 8803 product code.

Sources: International Trade and Production Database for Estimation (ITPD-E), Eurostat, and IMF staff estimates.

B. Germany's Photovoltaic Industry: KfW Catalyzing Investment in the Green Transition

Germany's national development bank (KfW) successfully mobilized private investment into photovoltaic (PV) manufacturing to overcome financial constraints. Germany had been providing strong and longstanding R&D support for the photovoltaic (PV) technology since the 1970s, but policy and demand uncertainties were barriers to financing and investment. Starting in 2000, KfW's provision of low-cost loans empowered PV electricity generators in Germany to quickly adapt to government demand incentives, notably a feed-in-tariff scheme that made producing solar electricity profitable, for both domestic and foreign firms. Instead of directly being involved in projects, KfW entered contracts with financial intermediaries who bore the credit risk of loans to producers. Acting as a "banks' bank," KfW offered subsidized fixed-interest and long-maturity (up to 20 years) loans through financial intermediaries that could provide up to 100 percent of a generator's financing needs (Griffith-Jones 2016). In the early 2000s, KfW was the single largest source of financing for PV adoption, providing at least 400 million euro of support every year. Domestic solar panel installation rose steeply and Germany emerged as a key player in solar panel exports in the EU (Figure 11).

Figure 11. Germany's Domestic PV Investment and Trade in EU



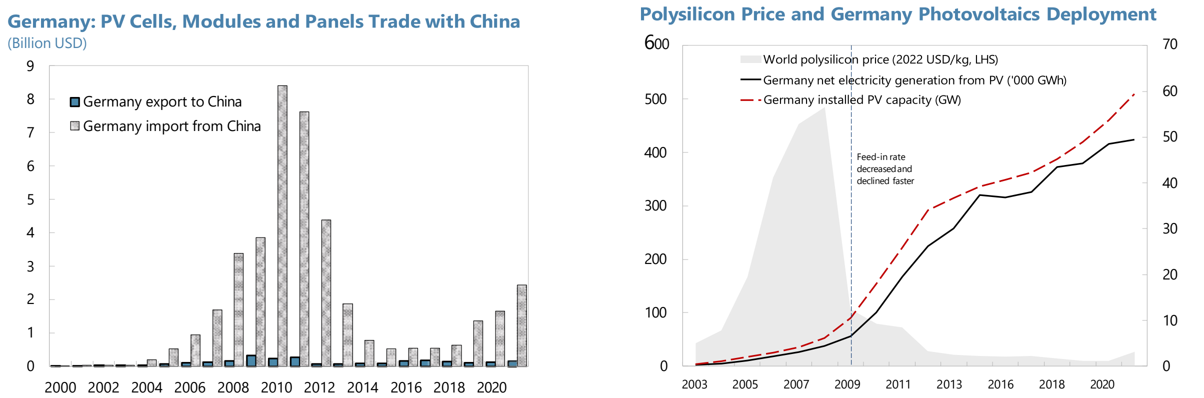
Sources: KfW annual reports, Griffith-Jones (2016), Global Economic Governance Initiative (2016), Germany Working Group on Renewable Energy Statistics (AGEE-Stat, Sep 2023), UN Comtrade, and IMF staff estimates.

Note: The main PV products (PV cells, modules and panels) are captured by HS code 854140 (Algieri et al., 2011). The code also includes light emitting diodes that lack a single classification.

By the early 2010s, lack of domestic innovation, foreign competition, and inadequate manufacturing capacity undermined the German PV industry, illustrating the risks and limits of industrial policy. Over time, German PV manufacturers struggled to keep pace with technological improvements as quickly as Chinese competitors, which also scaled up production heavily, achieving lower unit costs. Imports from China increased starting in 2004 to meet the rise in demand for solar panels, creating strong headwinds for domestic manufacturers (Figure 12) (Ball et al. 2017)[39]. Compared to the Airbus case, the German industrial policies were not designed to leverage cross-border coordination to enable scale, address structural bottlenecks (e.g., related to grid and flexibility), and exploit comparative advantages across EU countries. As a result, German firms could not benefit from the necessary efficiency gains, technology spillovers, and product innovation to keep up with increasing PV demand and competition from China and other trading partners, all key issues at the center of ongoing discussions at the EU level (SolarPower Europe 2023). Moreover, from 2008 onward, the global financial crisis resulted in reduced access to capital and negative profit margins, driving many German PV manufacturers out of the market. Germany's experience over the last decade showcased that even though industrial policy overcame market failures such as financial constraints and initially exploited scale effects for a single country, lack of coordination on a broader scale limited innovation and competitiveness over a longer horizon.

[39] Chinese factories purchased equipment from Germany, which sent technicians to service and provide training, assembled panels domestically, and exported them to Europe as early as the mid-2000s (Zhu, He and Gu, 2021).

Figure 12. Germany's PV Market Over Time



Sources: IRENA, Germany Working Group on Renewable Energy Statistics (AGEE-Stat, Sep 2023), UN Comtrade, and IMF staff estimates.

Note: (LHS) Trade with China includes with Hong Kong. The main PV products (PV cells, modules and panels) are captured by HS code 854140 (Algieri et al., 2011). The code also includes light emitting diodes that lack a single classification.

V. Conclusions

There is an emerging consensus on the many reasons why industrial policies can fail, but there is less clarity on how to design industrial policies that are welfare-enhancing from both a domestic and international perspective. The analysis presented in this paper contributes to the current debate by focusing specifically on industrial policies that are motivated by well-identified market failures rather than by inefficient attempts to 'pick winners' or by rent-seeking behaviors that are fiscally costly and damaging for growth. Examples of well-designed industrial policies explicitly discussed in this paper include exploiting untapped scale externalities at the industry level (i.e., "Marshallian externalities"), fostering international competition in a given industry and solving coordination problems in the creation of domestic value chains.

Unilateral industrial policy, even when it increases domestic productivity, can generate welfare losses in the domestic economy as well as negative productivity effects in other countries. Model-based analyses show that unilateral implementation of industrial policies, by not internalizing the presence of production externalities in foreign sectors, can create negative productivity spillovers to other countries through production relocation externalities. This is an even more pressing issue for groups of countries, like those in the EU, that are tightly integrated through strong trade linkages. As a consequence, even when they are well- designed domestically, unilateral industrial policies fail to fully exploit underlying comparative advantages within the EU, and lead to a less-than-optimal calibration of sectoral investment at the national level. The sub-optimal nature of unilateral industrial policies emerges even when we consider overall welfare effects for the implementing country, which depend on (i) a combination of domestic gains in production efficiency and (ii) corresponding changes in the terms of trade. Model simulations show that industrial policies that fully exploit domestic scale economies can cause a deterioration in a country's terms of trade because of the lower demand elasticities in industries with higher scale economies. For economies that are relatively small and open to trade, like European countries, this deterioration in the terms of trade would translate to a welfare loss in the absence of other forms of integration – such as in the labor market. This, in turn, could act as a break on a country's individual incentives to pick policies that fully exploit available productivity gains.

Coordination can increase the benefits of production-efficiency enhancing industrial policy. In the presence of production externalities, productivity and thus comparative advantages are endogenous to policy measures. Therefore, policy coordination is the best tool to achieve efficient production levels in all countries and avoid inefficient production relocation effects away from underlying comparative advantages. A coordinated implementation of industrial policy also has the advantage of attenuating potentially adverse terms of trade effects (not only export prices, but also a country's import prices may now fall), leading to a self-reinforcing system that provides incentives to countries to agree to adopt efficient industrial policies.

State-aid rules have helped provide a minimum level of coordination. State aid rules, supported by data collection and transparency, are a useful and unique framework, providing guardrails against policy misuse and minimizing adverse spillovers across countries, by requiring the review of market failures tackled by state aid, while avoiding competition distortions and welfare losses. These policies have served the EU well and have helped to establish a level-playing field.

Additional policies are needed to foster a strategic, competitive EU-level industrial policy. Ongoing efforts, such as under the Green Deal Industrial Plan and the Important Projects of Common European Interests IPCEI), can be considered steps in the right direction, provided they are targeted at correcting market failures and lead to true cross-border coordination for R&D and first industrial deployment projects to enable scale, exploit comparative advantages in the different stages of production, and promote efficient financing and investment allocation across EU countries. The case study on the creation of the Airbus manufacturing consortium is a clear example in this sense. To facilitate EU-wide coordination on strategic priorities, Europe might need a singular decision-making body to reform the current approach with overlapping programs and coordination instruments. Finally, recent initiatives to foster greater flexibility in the approval of state aid in critical areas should be balanced by the need to preserve crucial information sharing and transparency that help to safeguard efficiency and competitiveness.

A larger and more integrated single market within the EU can amplify the gains from "good" industrial policies. As also emphasized in the recent reports by Letta (2024) and Draghi (2024), Europe is suffering from a "size gap" and by entrenching Europe as a true single market, the region can enable market forces to drive consolidation and growth in scale, in compliance with EU competition rules. Closer integration would allow both firms and workers to more easily relocate across member countries to better exploit scale economies, as our model-based analysis suggests. This will require efforts to harmonize taxes and subsidies across countries, while developing infrastructure networks, energy grids and interconnectivity (IMF, 2024a). As Draghi (2024) has noted, these are investments from which all countries will benefit, but no country can carry out alone. By contrast, uncoordinated unilateral initiatives, even when production efficient domestically, raise concerns about fragmentation risks within the single market at a time of already rising geopolitical tensions externally. Deeper EU integration may also require an EU-wide central fiscal capacity, or a more ambitious EU budget, with centralized projects of mutual interest. This needs to be complemented by efforts to mobilize private sector support for entrepreneurialism across borders, by strengthening the capital market union (or the savings and investment union), which can increase private cross-border risk sharing, lower the cost of finance and improve access to funding. Meanwhile, strengthening public finances and rebuilding fiscal buffers, in line with EU rules, remains an important task to increase resilience against future shocks.

Global cooperation on industrial subsidies through the WTO framework is the best way to avoid harmful retaliatory policies. Even with EU countries acting in a coordinated way via closer EU integration, there can still be winners and losers among non-EU countries, as our model-based analysis reveals. Working within the multilateral framework remains the best way to resolve differences in approaches to industrial policy and unlock mutual benefits.

Annex I. The Model and Data

The model of Lashkaripour and Lugovskyy (2023) used in this paper is from a recent strand of literature in which industrial policies are modelled as subsidies that remove distortions arising from external economies of scale at the sectoral level (Bartelme et al. 2019; Haaland and Venables; 2016). Liu (2019) investigates the impact of industrial policies in a setup with input and output linkages, finding that these policies are most effective when they remove distortions in upstream sectors. Another strand of literature studies the role of industrial policies in facilitating technological adaptation and promoting economic development (Buera and Trachter; 2024; Choi and Levchenko; 2024).

Besides industrial policies, the model of Lashkaripour and Lugovskyy (2023) considers the extent to which import tariffs and export subsidies are effective tools in improving efficiency. There is a large body of literature studying optimal trade policies (Caliendo and Parro; 2022, Costinot et al; 2015, Itoh and Kiyono; 1987). Relatedly, Ossa (2014) studies optimal tariff policies and demonstrates that in the absence of retaliation, countries can gain considerably at the expense of others by imposing tariffs. However, in the event of retaliation, imposing tariffs can lead to trade wars leaving all countries worse off. Lashkaripour (2021) quantifies the costs arising from a world-wide trade war. Ferrari and Ossa (2023) investigate the notion of optimal trade subsidies, and subsidy wars, and note that unlike tariffs, subsidy wars can potentially improve overall welfare because there are spillovers to other countries.

This paper also relates to the empirical literature that studies the conditions under which industrial policies have been successful in the past. In this respect, Juhasz et al (2023) provide an extensive review of historical approaches to industrial policy and identify those that have been successful. Evenett et al (2024) introduce a new database of stylized facts and recent trends showing the rise of industrial policy. In particular, they show that the main instrument of choice in Europe for implementation of industrial policy has been domestic subsidies. In line with their finding, the model in Section II characterizes industrial policy as industry-specific production subsidies.

The next section describes the main features of the model of Lashkaripour and Lugovskyy (2023), focusing on the version of the model that we use for simulations in the main body of our paper.

Model Description

The model is the multi-industry, multi-country Krugman-style model of Lashkaripour and Lugovskyy (2023). In this model, industries differ by the degree of scale economies or elasticity of trade volumes to prices. Each country $i \in \bar{C}$ has population of L_i individuals who each supply one unit of labor inelastically. Labor is the sole factor of production in each country.[1] Workers are perfectly mobile across industries *within* countries, but cannot cross international borders, so are paid country-specific wage w_i.

Consumers. The representative consumer in country i maximizes utility subject to a budget constraint. The consumer chooses a vector of industry-level product bundles from each $k \in \bar{K}$ industries. Each industry-level product bundle has a corresponding price index $\widetilde{P_{i,k}}$ and may contain goods sourced from multiple countries. Each industry-specific product bundle is an aggregation over various country-specific varieties, each of which is itself an aggregation over firm-level varieties from that country. The within-industry utility aggregator has a nested CES structure, so that the parameter determining the elasticity of substitution between country-specific varieties *differs* from the parameter determining the elasticity of substitution between firm-specific varieties. The

[1] The model can be extended to introduce intermediate goods.

former parameter σ_k determines the degree of price-elasticity of foreign demand in industry k (i.e. the higher the market power, the lower is price-elasticity of foreign demand) , while the *latter* parameter γ_k determines the degree of firm-level market power and 'love-of-variety' preferences, with $\gamma_k > 1$.

Firms and Production. Each country $i \in \bar{C}$ is populated with a mass $M_{i,k} = \Omega_{i,k}$ of monopolistically competitive firms producing a single product in industry $k \in \bar{K}$, using labor as the only factor of production.

Under the assumption of *free entry of firms*, a pool of ex ante identical firms can pay an entry cost $w_i f_k^e$ to operate in industry k from country i. Each firm $\omega \in \Omega_{i,k}$ draws a random productivity $z(\omega) \geq 1$ from distribution $G_{i,k}(z)$ and faces a marginal cost $\tau_{ij,k} w_i / z(\omega)$ for producing and delivering goods to destination $j \in \bar{C}$, where $\tau_{ij,k}$ if a flat, iceberg transport cost. Given these assumptions, the average unit labor cost in origin i is declining in the number of firms and varieties. One way to demonstrate this is to note that the elasticity of the Producer Price Index (PPI) of the composite good in industry k, produced in country i, is negative: $-\mu_k = \partial lnP_{ij,k} / \partial M_{ik} < 0$ and its absolute value μ_k is the industry-level scale elasticity, being the elasticity of the PPI to the number of firms. It is equivalent to observe that μ_k is the elasticity by which variety-adjusted total factor productivity increases with industry -level employment, which is proportional to firm mass $L_{i,k} \propto M_{i,k}$. The scale elasticity is exactly equal to a constant firm-level mark-up within that industry, $1/(\gamma_k - 1)$, which also determines the extent of love of variety. The equivalence between firm mark-up and scale elasticity is a specific feature of the Krugman-style model, although it is not needed for the optimal policy results which follow. Because of the assumption of *free entry of firms,* profits are driven to zero. Under *restricted entry*, the profit margin (on average for firms in country i) will be higher, the higher are sales in high mark-up industries.

Policy Instruments. The simulations that we present in the main body of this paper are based on a version of the Lashkaripour and Lugovskyy (2023) model where the only policy instrument available to a government in each country i is an industry-specific production subsidy applied to industry k's output produced in country i, irrespective of where the output is sold. The subsidy is financed via lump sum taxes to consumers.

Global Efficiency. A globally efficient allocation of production is characterized by the solution to an optimization problem of a social planner, who maximizes global welfare via good-specific taxes and lump sum international transfers. Goods-specific taxes allow the planner to restore allocative efficiency, while lump-sum transfers allow for international redistribution. Specifically, the taxes allow the planner to restore marginal cost pricing, while the resulting income gains are re-distributed across countries using lump-sum transfers. The policy that restores marginal cost pricing globally involves zero trade taxes and Pigouvian industrial production subsidies.

Market-Determined Equilibrium. In the absence of a social planner, the allocation of resources is not globally efficient, because of cross-country heterogeneity in markups (in the case of restricted firm entry) or scale elasticities (in the case of free entry, where scale effects are not internalized).

Welfare Implications of Industrial Policy. The welfare implications of unilateral industrial subsidies are quantitative questions, depending on the calibration of parameters, notably the scale elasticity μ_k and the price-elasticity of foreign demand σ_k. Lashkaripour and Lugovskyy (2023) find that σ_k and μ_k are negatively correlated empirically[2] (see Table A1). This implies that production subsidies (i) correct misallocation, by expending output in high returns-to-scale (high μ_k) industries, while also (ii) worsening the terms of trade by expanding exports in these same industries which have lower price-elasticity of foreign demand (low σ_k).

Under these parameter values, it also follows that unilateral implementation of Pigouvian industrial subsidies worsens the terms of trade, which can offset some or all of the welfare gains from establishing allocative efficiency. This is referred to as an 'immiserizing' welfare effect.

[2] Lashkaripour and Lugovskyy (2023) estimate σ_k and μ_k using micro data and their results align with others in the literature.

Table A1
Industry-level Trade Elasticities and External Scale Parameters
Econometric estimation results used for model calibration
(standard errors in parentheses)

	Trade Elasticity: foreign demand elasticity minus one (export prices to output)	**External Scale Parameter**
Agriculture and Mining	6.2	0.1
	(2.3)	(0.1)
Food	2.3	0.4
	(0.8)	(0.1)
Textiles, Leather & Footwear	3.4	0.2
	(0.4)	(0.02)
Wood	3.9	0.2
	(1.9)	(0.1)
Paper	2.6	0.3
	(1.1)	(0.1)
Petroleum	0.6	1.2
	(0.5)	(0.9)
Chemicals	4	0.2
	(0.4)	(0.02)
Rubber & Plastic	5.2	0.1
	(1.2)	(0.03)
Minerals	5.3	0.2
	(1.7)	(0.06)
Metals	3	0.2
	(0.5)	(0.03)
Machinery	7.8	0.1
	(1.3)	(0.02)
Elec. & Optical Equip.	1.2	0.6
	(0.3)	(0.1)
Transport Equip.	2.8	0.1
	(0.9)	(0.04)
Recycling and others	6.2	0.2
	(1)	(0.02)

Source: Lashkaripour and Lugovskyy (2023), based on Colombian trade data at level of Harmonized System 10-digit product category, 2007-13. In model's calibration, the services sector is assumed to have a trade elasticity of 11 and an external scale parameter of zero.

Data Description

Observable data used to characterize the first and second best unilateral industrial subsidies and trade policy include data from 43 countries (including all EU member states) on production and expenditure across 56 industries, from the 2014 World Input-Output Data (WIOD) (Timmer and others, 2015). Following the methodology in Costinot and Rodriguez-Clare (2014), the 56 industries in the WIOD are aggregated into 15 traded industries (for which Lashkaripour and Lugovskyy (2023) have estimated trade σ_k and scale elasticities μ_k, plus a services sector (assumed to have $\mu_k = 0$ and $\sigma_k = 11$).

Data on bilateral applied import tariffs (i.e., the status quo for import tariffs) are constructed following the methodology of Kucheryavyy, Lyn and Rodriguez-Clare (2023), based on data from UNCTAD Trade Analysis Information System (TRAINS), using latest data available (mainly from 2022). Following Lashkaripour and Lugovskyy (2023), the status quo for export subsidies and industrial Pigouvian subsidies are assumed to be zero.

Annex II. Sensitivity Analysis

As discussed in Section III, the welfare impact of unilateral production subsidies depends on the efficiency gains of exploiting scale externalities, the production relocation externality on other countries *and* the change in the terms of trade that occurs because expanded production can depress export prices. Unilateral production subsidies are found to be welfare-reducing for many individual EU countries that have high openness to trade, under a model calibration in which the size of scale externalities across sectors is correlated with the elasticity of export prices to sectoral output.

This annex illustrates how the calibration of the foreign demand elasticity, the scale elasticity, and the trade openness determines the overall welfare gains from industrial policy. To do this, a more parsimonious model, which nonetheless retains all the main feature of the model in Section III, is simulated for a broad set of parameters.

This simplified model of a small open economy contains a domestic tradable good used for consumption and exports, as well as a domestic non-tradable good and a foreign tradable good that is imported. The economy is small enough that it takes the price of the imported good as given, but the domestically-produced tradable good is differentiated so that there is a downward sloping international demand curve and changes in production levels can affect export prices.

The welfare impact of production subsidies in this model depends on three key parameters:

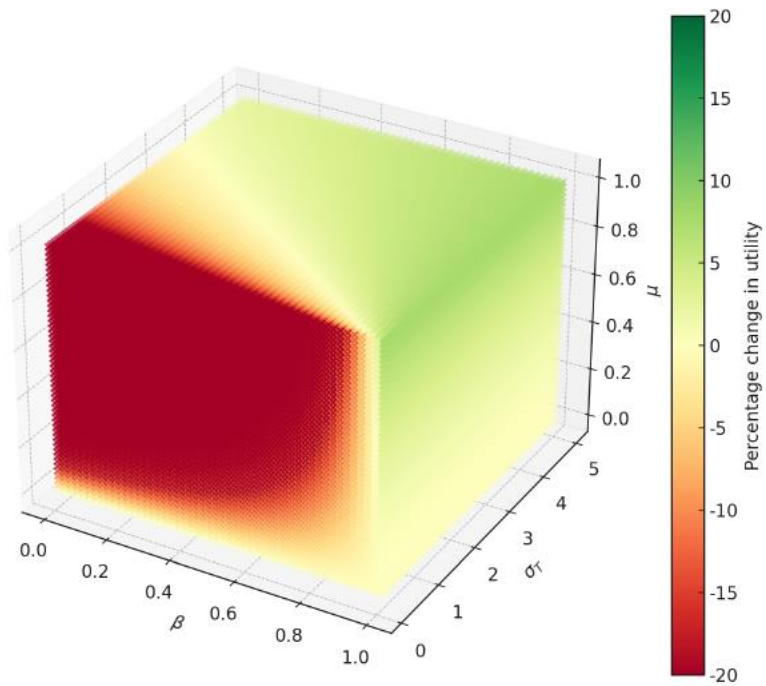
- **Scale Externality (μ).** This parameter determines the impact of production subsidies in the tradable sector on productivity in this sector.
- **Openness (1-β).** This parameter determines the share of the domestically-produced tradable good that is consumed rather than exported. The smaller is this parameter, the more open is the economy and the more of the increased production caused by the subsidies that is exported.
- **Elasticity of Foreign Demand (σ_T).** The more elastic is foreign demand, then the increased production of the tradable good induced by subsidies is absorbed by foreigners with only a small reduction in price.

When the economy is more open and foreign demand is inelastic, then production subsidies cause export prices to decline, reducing the terms of trade, which is particularly important for welfare since a large share of increased production of the tradable good is exported, rather than absorbed domestically. In this case, the terms of trade effect can become so significant that it more than offsets the efficiency gains caused by the subsidies and leads to an overall welfare loss.

The three-dimensional figure below shows how the welfare impact of production subsidies that fully internalize the scale externalities in the domestic tradable sector, correcting the market failure, depend on the three parameters above.

The top face of the figure shows that for a given value of scale externalities, production subsidies are welfare-improving unless the trade elasticity is low, when there can be welfare losses that get worse as economic openness increases. It is in these cases that the adverse terms of trade effect outweighs the efficiency gains induced by the subsidies. The left side of the object shows only cases when trade elasticity is low, so that there are mostly overall welfare losses caused by subsidies, particularly in cases of high scale externalities and economic openness. The right face of the object shows a fully closed economy. In this case, the production relocation externality and the elasticity of foreign demand are irrelevant, so that there are only welfare gains from production subsides, that increase with the size of the scale externalities.

Ultimately, this analysis shows that production subsidies – designed to correct for scale or agglomeration externalities - are always welfare-improving in a closed economy, when the elasticity of foreign demand is irrelevant, or when the foreign demand is completely elastic, so that additional output induced by the subsidy scheme can be absorbed without a drop in export prices. In other cases, there is a tension between the efficiency gains from correcting market failures and the impact of subsidy-induced production increases on export prices and the terms of trade, which can in some cases result in industrial policy causing an overall welfare loss.



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