WIFO ■ WORKING PAPERS
670/2024

Assessing Regional Production Potential to Strengthen the Security of Supply in Strategic Products

Matthias Firgo
Fabian Gabelberger
Andreas Reinstaller
Yvonne Wolfmayr

Assessing Regional Production Potential to Strengthen the Security of Supply in Strategic Products

Matthias Firgo, Fabian Gabelberger, Andreas Reinstaller,
Yvonne Wolfmayr

WIFO Working Papers 670/2024
January 2024

Abstract

Recent shocks to global value chains and geopolitical tensions have reignited the debate on domestic production of strategic goods and technologies. This paper proposes an analytical framework for identifying and prioritising activities and regions for potential reshoring policies combining methods from international, industrial and regional economics. Particularly, we assess import dependencies, potentials and risks for competitive domestic production, and evaluate the embeddedness of existing and potential production in cognitively and technologically related activities in a region. We highlight the relevance of this approach as a policy tool using industries manufacturing strategic products and regions in Austria as an example.

E-Mail: fabian.gabelberger@wifo.ac.at, yvonne.wolfmayr@wifo.ac.at

2024/1/W/0

© 2024 Austrian Institute of Economic Research

Media owner (publisher), producer: Austrian Institute of Economic Research
1030 Vienna, Arsenal, Objekt 20 | Tel. (43 1) 798 26 01 0 | https://www.wifo.ac.at
Place of publishing and production: Vienna

WIFO Working Papers are not peer reviewed and are not necessarily based on a coordinated position of WIFO. The authors were informed about the Guidelines for Good Scientific Practice of the Austrian Agency for Research Integrity (ÖAWI), in particular with regard to the documentation of all elements necessary for the replicability of the results.

Free download: https://www.wifo.ac.at/wwa/pubid/71326

Assessing regional production potential to strengthen the security of supply in strategic products

Matthias Firgo
Munich University of Applied Sciences & Austrian Institute of Economic Research,
matthias.firgo@hm.edu

Fabian Gabelberger
Austrian Institute of Economic Research,
fabian.gabelberger@wifo.ac.at

Andreas Reinstaller
Office of the Austrian Productivity Board,
andreas.reinstaller@oenb.at

Yvonne Wolfmayr
Austrian Institute of Economic Research,
yvonne.wolfmayr@wifo.ac.at

January 2024

Abstract

Recent shocks to global value chains and geopolitical tensions have reignited the debate on domestic production of strategic goods and technologies. This paper proposes an analytical framework for identifying and prioritizing activities and regions for potential reshoring policies combining methods from international, industrial and regional economics. Particularly, we assess import dependencies, potentials and risks for competitive domestic production, and evaluate the embeddedness of existing and potential production in cognitively and technologically related activities in a region. We highlight the relevance of this approach as a policy tool using industries manufacturing strategic products and regions in Austria as an example.

Keywords: strategic products, reshoring, industrial policy, comparative advantage, import dependency, skill-relatedness

JEL Codes: F14, F60, L52, L60, R12, R58

1. Motivation

Decades of globalization have led to fragmented global value chains. The international specialization and division of labor has increased efficiency and thus been regarded a major source of wealth creation around the globe. However, fragmented value chains are also highly vulnerable to global risks (Seric et al., 2020). This has been demonstrated since the outbreak of the COVID-19 pandemic in the first quarter of 2020 and has become even more pronounced with the geopolitical upheavals in the wake of the war in the Ukraine starting in February 2022. In 2020, the disruptive impact of supply bottlenecks and import dependency was most severely felt with respect to COVID-19 strategic goods such as protective equipment (masks, gloves) and medical technology (respirators). The outbreak of the war in Ukraine led to a supply shock in agricultural production, and the political crisis between Russia and the West resulted in a shortage in the supply of oil and gas, which - especially in Europe - has stoked fears of a severe energy crisis.

All this has reignited and intensified the policy debate on the economic independence and the resilience of international supply and value chains. It has given additional weight to concepts of strategic autonomy, of production relocations ("reshoring") of strategic products and regionalization of value chains ("near-shoring") in Europe and the United States (European Commission 2020a, 2021a; Evenett et al. 2020) . Often grounded by merely protectionist motives, such policies provide viable practices in two instances: Firstly, to increase the security of supply of strategic products (such as medical goods or energy), and secondly, to secure and expand an economy's sovereignty with respect to technology in the pursuit of greater strategic autonomy in a changing international order. A fundamental question is whether domestic production of strategic products can be competitive under market economy conditions or whether subsidies are necessary. This is relevant both from a legal (state aid law) and economic (efficient of allocation of public budget) perspective. Any industrial strategy to promote reshoring therefore requires careful assessments of import dependencies as well as the economic viability of domestic production at specific regions serving as potential locations of production.

Against this background, we propose a data-driven approach for such an assessment of production potential for focal activities at the regional level. Combining methods from the literature in international (Arriola et al., 2020; European Commission, 2021b), industrial (Hausmann et al., 2007; Hidalgo et al., 2007; Klimek et al., 2012) and regional economics (Neffke and Henning, 2013; Otto et al., 2014; Neffke et al., 2017, Balland et al., 2019), we develop an analytical framework identifying import dependencies, potentials and risks for competitive domestic production and the embeddedness of production at the regional level in terms of complementary, technologically or cognitively “close” or “related” activities for strategic products as well as key technologies. The assessment builds on numerous indicators based on trade data at the very detailed product level and the construction of composite indicators. Identifying strategic products with import dependencies, for which regional comparative advantages could potentially be established in such a way that local production would be economically viable and competitive in global trade, provides an important policy tool in an otherwise rather ideologically biased policy discussion on the reshoring of strategic products. Our approach is also related to Balland et al. (2019) who propose an assessment for smart specialization around the concepts of relatedness and knowledge complexity. In contrast to their study, however, we are not focusing on diversification into technologically more complex activities based on existing local capabilities, but on assessing the potential to reduce import dependencies in products of strategic importance - regardless of their complexity and technology intensity.

We provide an application of the framework proposed exemplarily for Austria and COVID-19 strategic products as well as technologies.[1] Given that the country is part of the European Common Market, import dependencies are defined relative to extra-EU countries. Based on the existing specialization patterns (national as well as regional) of the Austrian economy in specific relevant NACE 4-digit industries, the analysis proceeds with an empirical identification of highly import dependent, strategic manufacturing industries and products, and highlights regions for which economic "start-up advantages" for domestic production of these products are likely.

2. Analytical Framework

As outlined in Figure 1, the analytical framework to analyze the potential for re-location of the production of strategic products pursued in this paper consists of three distinct analytical steps:

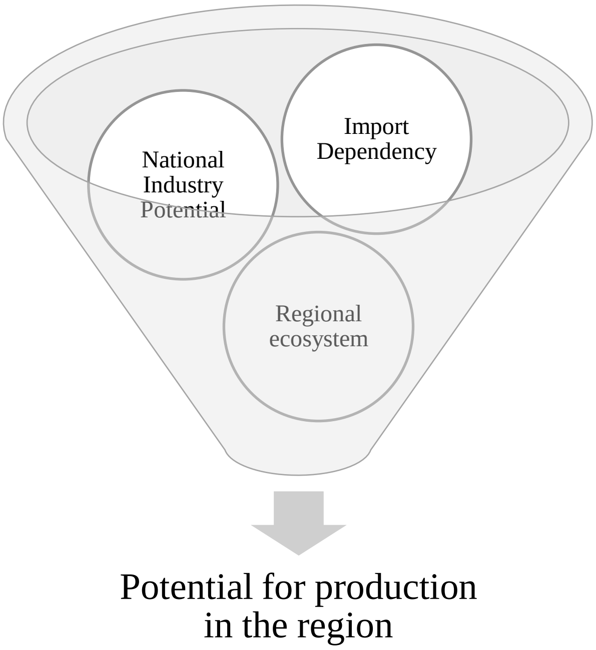
i) The identification of import dependencies in strategic products,

[1] The definition of critical products relies on predefined product classifications for critical sanitary products and products of strategic importance (key technologies) provided by the World Bank and the European Commission. Thus, the aim of the analysis is not to identify critical products, but to analyse import dependencies and potentials for production in critical products at the regional level. The relevant data sources as well as results from an exemplary analysis for Austria will be presented in Section 3.

ii) the identification of industrial potentials and risks associated with the domestic production of each product, and

iii) assessment of its embeddedness in regional industrial eco-systems.

Figure 1: Assessing the regional production potential for strategic products



Source: Authors.

The following section outlines the rationale for each of these analytical steps and presents their operationalization in the empirical application. In steps i) and ii) we proceed as follows: we first identify indicators which appropriately map each of the specific analytical steps and goals; we then condense the set of indicators selected to distinct composite indicators for import dependence and industry potential of activities of interest.[2] The composite indicators on import-dependence of strategic products are combined with those on industrial potential to obtain a list of strategic products with import dependence and high domestic industrial potential.[3] This information is then integrated in step iii), i.e. the analysis for the assessment of the development potential of strategic products at the regional level. It is important to note that the paper focuses on presenting the methodology as a novel policy tool. Details on the construction of individual

[2] While composite indicators have been viewed critically, as they are not able to characterize the relative importance of and the potential interplay between their constituting variables, they are widely used due to their capacity to summarize complex issues. See Booysen (2002), Foa and Tanner (2012), and Nardo et al. (2005) for comprehensive discussions of the advantages and disadvantages of composite indicators.

[3] To construct composite indicators, all underlying individual indicators are normalized based on the min-max method. Thus, all individual indicators reflect standardized variables taking values between zero and one, reflecting the position relative to the range of variation of an indicator.

indicators and empirical results for the case study of strategic products and Austria can be found in a comprehensive Online Appendix.

2.1 Identifying import dependencies in strategic products

2.1.1 Determinants of import dependence in strategic products

When analyzing import dependencies, it should first be noted that the advantages from international trade integration do not only arise from exports, but also from imports (Coe et al., 1997). Openness to imports secures a broad supply of raw materials, technology and low-cost products and thus increases product diversity and choice for domestic companies and consumers. By facilitating international knowledge spillovers, particularly small open economies can participate in important innovations abroad (Coe and Helpman, 1995). In addition, imports stimulate competition and thus lower prices or increase the real income of domestic consumers. Competition through foreign trade channels is also associated to a certain extent with higher innovation rates and is thus an important driver of technological progress. In a study of 11 OECD countries, Badinger (2007) shows that around 30% of the trade effects on per capita income can be attributed to international competition. In addition, technology imports - also via direct investment - contribute significantly to technology diffusion (Keller, 2002; Foster-McGregor et al., 2017; Haukes and Knell, 2009). However, too much dependence on imports can be problematic, especially if there is too much concentration on individual sources of supply and thus on only a few countries of origin (Arriola et al., 2020). Especially in crisis situations, this can be associated with a high probability of failure in the supply of important components in production. In the discussion on self-sufficiency in strategic products, an evaluation of import dependency is therefore a crucial aspect.

A correct and comprehensive mapping of import dependency must go beyond an analysis of the (origin) country structure of imports. It should include indicators measuring imports in relation to domestic production and exports. The analysis should also consider the embeddedness of a country in trade blocs and the import dependency of the country relative to the import dependency of the trade bloc. Typically, there are stable trade relationships within such economic integration areas that contribute to alleviate the risk of strategic dependencies by any single economy. This is especially relevant for members states of the European Union which are embedded in a tight network of intra-EU trading relationships. Import interdependencies in the integrated EU internal market are considered less relevant with respect to import dependency in the context of strategic products. Hence, the analysis focuses on import dependencies with respect to Extra-EU markets.

Other important dimensions considered in the analysis are the comparison of each EU country's situation with that of the EU as a whole and the evolution of the respective indicators over time. Calculating the position of individual EU member states relative to the EU provides information on the product lines in which each country's dependence on imports is particularly pronounced, also in an EU comparison. Taking account of changes in all indicators over time reveals whether dependencies at the product level are of a permanent nature and thus structural and create strategic vulnerabilities.

In sum, the following key criteria are considered:

- the *geographical concentration of imports from extra-EU sources,*
- the *dependence of EU supply on imports from extra-EU sources,* and
- the *trade balance position in extra-EU trade*
- *the relative position of individual EU countries to the EU in the indicators*
- *the medium to long run change of the indicators*

2.1.2 Measurement of import dependence in strategic products

Accounting for each of the criteria noted above to analyze import dependency among strategic products, twelve different indicators are calculated at a highly disaggregated product level (HS 6-digit level) and are merged into an overall composite index. Table 1 provides an overview, and we shortly discuss the individual indicators in the following.

Geographical concentration of imports from extra-EU sources ($HHI\_M_{p,i}$): The indicator for the geographical concentration of imports is calculated as a Herfindahl-Hirschman concentration index. It indicates the dispersion of imports in individual product lines across individual countries of origin. It is derived from the sum of squared market shares of product level imports from a country, over all extra-EU trading partners. The Herfindahl-Hirschman index for the geographical concentration of imports takes values in the range [0.1]. In the extreme case, with a value of 1, imports are only sourced from a single foreign market; with a value of 0, there is complete diversification of imports across many partner countries.

Dependence of domestic production on imports from extra-EU sources, ($smprod_{p,i}$): This indicator is calculated as the share of imports from extra-EU partners in domestic production of country *i* in product line p.

Trade balance position in extra-EU trade, ($relimex_{pi}$): The indicator is calculated as the ratio of imports to exports in extra-EU trade and provides information on the trade balance position in a product line of country *i*. It is the reciprocal of the export-import ratio otherwise used in the literature. All values greater than 1 signal a negative trade balance, as more is imported than exported in the respective product. Conversely, all values smaller than 1 indicate a positive trade balance in the respective product line.

As already noted, for each of the indicators, the *relative position of individual EU member states to the EU* is calculated as the ratio between the indicator value of country *i* and the indicator value for the total EU ($relEU\_HHI\_M_{p,i}$; $relEU\_smprod_{p,i}$; $relEU\_relimex_{p,i}$) as well as the respective changes over time ($\Delta HHI\_M_{p,i}$; $\Delta smprod_{p,i}$; $\Delta relimex_{p,i}$; $\Delta relEU\_HHI\_M_{p,i}$; $\Delta relEU\_smprod_{p,i}$; $\Delta relEU\_relimex_{p,i}$). Where Δ refer to changes over a longer time period.

Composite index of import dependency from extra-EU markets, $\mathbf{MD_{p,i}}$: From these twelve indicators the composite import dependency index is derived as the weighted sum of all indicators:

$$\begin{aligned} MD_{p,i} = \frac{1}{12}\big(&NHII\_M_{p,i} + Nsmprod_{p,i} + Nrelimex_{p,i} + NrelEU\_HII\_M_{p,i} \\ &+ NrelEU\_smprod_{p,i} + NrelEU\_relimex_{p,i} + N\Delta HII\_M_{p,i} + N\Delta smprod_{p,i} \\ &+ N\Delta relimex_{p,i} + N\Delta relEU\_HII\_M_{p,i} + N\Delta relEU\_smprod_{p,i} \\ &+ N\Delta relEU\_relimex_{p,i}\big). \end{aligned} \tag{1}$$

Where the letter N refers to the normalized variables by the indicator range. All 12 indicators enter with equal weight (see Online Appendix for a more detailed description). Products with high import dependence are identified by the top quartile – i.e., the 25% highest values – of the value distribution of the composite import dependence indicator.

Table 1: Overview table for the indicators to construct the composite index for import dependency (MD-Index)

Variable	**Interpretation**	**Definition**	**References**
$HHI\_M_{p,i}$ and $\Delta HHI\_M_{p,i}$	Geographical import concentration and its change over time	Concentration of imports of product *p* in country *i* over all extra-EU trading partners based on the Herfindahl-Hirschman Index (HHI)	Standard indicator
$smprod_{p,i}$ and $\Delta smprod_{pi}$	Dependence of domestic production on imports from extra-EU sources and its change over time	Share of extra-EU imports in total production	Standard indicator
$relimex_{p,i}$ and $\Delta relimex_{p,i}$	Trade balance position in extra-EU trade and its change over time	Ratio of extra-EU imports over extra-EU exports of country *i* in product *p*	Standard indicator
$relEU\_HHI\_M_{p,i}$ and $\Delta relEU\_HHI\_M_{p,i}$	Relative import concentration and its change over time	Ratio of the concentration index of country *i* in product *p* over the respective concentration index for the total EU	Authors
$relEU\_smprod_{p,i}$ and $\Delta relEU\_smprod_{p,i}$	Relative import dependence of production and its change over time	Ratio of the share of extra-EU imports in production of country *i* in product *p* over the respective import share in production for the total EU	Authors
$relEU\_relimex_{p,i}$ and $\Delta relEU\_relimex_{p,i}$	Relative trade balance position and its change over time	Ratio of the import-export ratio in extra-EU trade of country *i* in product *p* over the respective import-export ratio for the total EU	Authors

Source: Authors. Note: Δ denotes log changes.

2.2 Assessing the industry potential for the domestic production of strategic products

2.2.1 Determinants of industry potentials in strategic products

Continuing with our analytical framework, the subsequent stride involves evaluating the industrial potential for domestic production of strategic products with import dependencies. By "industrial potential for domestic production," we mean the inherent capacity of the business sector within a country to embark on the production and exportation of specific products in an economically viable manner over a defined period. To achieve this, it is essential that the decision to (re-)initiate production aligns seamlessly with the overarching objective of business firms, which is to strategically invest and maximize the value of the firm.

In the framework proposed in this paper we consider three dimensions of economic viability related to any strategic product:

- the *product-level competitiveness*,
- the *economic potential*, and
- the *market risk*.

In this context, product-level competitiveness is perceived as the distinctiveness of a product within the (global) market and the adeptness with which domestic firms can leverage local technological expertise and production capabilities to manufacture it.

The concept of economic potential pertains to the likelihood of a firm engaging in the production of a strategic product to generate value and create economic opportunities. This potential is intrinsically linked to factors such as the market size, its growth trajectory, and the possibility of fragmentation, which opens doors to engaging in monopolistic competition within smaller niche markets.

Lastly, the market risk is linked to various factors that can adversely impact the profitability of product production. Among these factors are unstable demand patterns and the level of competition prevailing in the market.

Table 2 presents a comprehensive summary of the pivotal indicators we have identified to characterize the industrial potential for strategic products with import dependency. These indicators have been computed to construct a composite index of domestic industrial potential in strategic products. Moving forward, we shall delve into a detailed discussion of each individual indicator.

2.2.2 Measurement of the domestic industrial potential

Product level competitiveness: The assessment of product-level competitiveness considers various location characteristics such as local capabilities, potential spillover effects, and the technological attributes and product quality. Drawing upon literature in the realm of industrial branching and diversification (Klepper, 2010; Boschma et al., 2012b; Neffke et al., 2011, among others), we have identified three distinct indicators to capture the dimensions of competitiveness within an industrial location concerning the production of a specific product line:

Proximity, $PRI_{p,i}$: The proximity of a product to a country's industrial specialization is calculated using the notion of the product space following Hidalgo et al. (2007). This measure varies between 0 and 1, where values closer to one indicate a higher degree of relatedness or product *p* to the export specialization of country *i* and thus a potentially higher degree of factor mobility across activities and local spillovers in production.

Sophistication, PCI_p: The technological sophistication of a product with import dependence has been calculated from trade data using product complexity (Hidalgo and Hausmann, 2009) as a proxy. It is obtained from the analysis of co-export patterns of products across countries that reveal latent information about specific, unobservable technological capabilities or factors of production needed to produce a specific product. The intuition behind this indicator is that if several countries systematically export the same products with a comparative advantage, it can be assumed that similar resources and production factors such as technical know-how, management skills and the like flow into the product. The more unique these capabilities are and the broader the knowledge base available in the exporting country the more technological complex is a specific product.

Logarithmic ratio of the unit value, $LUVR_{p,s,i}$: The unit value, i.e., the value of the imported or exported goods converted to the quantity of the goods measured in tons, is a proxy for the average price that can be obtained in a product line for export on international markets. Schott (2004) shows that unit values at the level of individual product lines are systematically higher for countries with high capital and skill intensity than for countries with high labor intensity. Thus, unit values are influenced by the factor endowments and manufacturing techniques of the exporting countries. We have used the ratio of the average price of strategic goods imported in a country compared to the average export unit values observed in the in the domestic industry associated with this product line at the NACE 4-digit level in country *i* to capture this aspect of quality competition.

Table 2: Overview table for the indicators to construct the composite index for the industrial potential (IP-Index)

Variable	Definition	Interpretation	Reference
Product level competitiveness			
$PRI_{P,i}$	Product relatedness	Proximity of product *p* to a country *i*'s industrial specialization	Hidalgo et al. (2007)
PCI_p	Product complexity	Technological sophistication of product *p*	Hidalgo and Hausmann (2009)
$LUVR_{p,S,i}$	Unit value ratio relative to sector products	Average price competitiveness of in the domestic industry exporting product p relative to imports of product *p* at of industry *s* at the NACE 4-digit level in country *i*	Schott (2004)
Economic potential			
$\bar{G}_p$	Product market growth	Avg. growth rate of global trade volume for product *p*	standard indicator
S_p	Product market volume	Avg. market share of global trade volume for product *p*	standard indicator
$IPI_{p,S,i}$	Implicit product level productivity relative to sector	Potential contribution of product *p* to the performance of a domestic industry *s*	Hausmann et al. (2007)
CI_p	Clustering in exports coefficient product level	Cascading/clustering effect in export market entry (simultaneous entry)	Klimek et al. (2012)
GLI_p	Intra-industry trade	Proxy for diversification of products and market niche creation	Grubel - Lloyd (1975)
Market risk			
VI_p	Product level unit value volatility	Risk content of traded products related to price instability	di Giovanni - Levchenko (2010)
DI_p	Displacement index product level	Risk of displacement associated with any product	Klimek et al. (2012)
$HHI\_MP_{p,i}$	Market concentration	Avg. market concentration faced by exporters of country *i* for product p	standard indicator

Source: Authors

Economic potential: The economic potential is intended to capture important aspects of value creation for its potential domestic producers for any product line with import dependence. Five indicators have been used to capture this aspect:

Global market growth and share in global market volume, $\bar{G}_p$ *and* S_p: Higher growth in trade volumes of a product line and a higher share of a product in global trade volumes have been used as proxies for the market opportunity of a product line.[4]

Potential contribution of a product to the implicit productivity of an industry, $IPI_{p,S,i}$*:* We constructed a counterfactual implicit productivity index reflecting the potential contribution of a newly added product to the average implicit productivity of the industry *S* in country *i.* It compares the implicit productivity of a product with the average implicit productivity of the domestic industry's product portfolio to assess whether the uptake of a product will induce higher performance in the domestic industry. The implicit productivity of a product is an indicator proposed by Hausmann et al. (2007) and it corresponds to a weighted average of the real GDP per capital of the countries exporting a product.

Potential for clustering of market entry in related product lines, CI_p*:* When a country starts producing and exporting a product, this may induce cascading effects in as the production of a product may requires the development of new production capacities and skills that subsequently allow the production and export of other, technologically related products. This reflects an aspect of market opportunity for producers of related products. We calculated a related clustering index proposed by Klimek et al. (2012). The higher this indicator the more export opportunities arise for countries that produce and export products with a high cluster coefficient, as the uptake of such a product increases the likelihood of the country starting to export other related products as well.

Potential for intra-industry diversification (niche creation), GLI_p*:* Important characteristic of trade between developed countries is intra-industry trade reflecting the diversification of

[4] A potential limitation of these indicators is that trade in specific product lines is often concentrated geographically and given that geographical distance is an important determinant of trade this may limit cross country comparisons based on these indicators.

products that goes along the creation of specific niches reflecting monopolistic competition (cf. Debaere 2005). More intense intra-industry trade thus goes also along with more opportunities to develop specific market niches. We calculated a standard Grubel-Lloyd Index (Grubel - Lloyd 1975) at the product level to capture this aspect of competition and value creation.

Market risks: The risk assessment plays an important part in the decision of firms to enter a specific market. We have chosen the following three indicators to capture the risk associated with the uptake of the production and export of a product line with import dependence:

Unit value volatility, VI_p: Unit value volatility reflects the risk content of traded products related to price instability and implies higher fluctuations in export earnings for exporting firms. Companies thus have an incentive to adjust their export portfolio to the risk content of its constituting products. If the risk content of a product is very high, the start of its production in any location also requires companies to expect high expected return. We calculate a time-invariant indicator for the period of observation proposed by di Giovanni - Levchenko (2010).

Displacement index, DI_p: When a country starts producing and exporting a product, this can lead other countries to stop exporting the same or related products with some delay. This happens if the new exporter is more cost competitive than its competitors that decide to either abandon or relocate the production of old product lines. The displacement index proposed by Klimek et al. (2012) considers these interdependencies and reflects the risk of displacement associated with any product.

Market concentration, $HHI\_MP_{p,i}$: We calculated the average (global) market concentration in each product line for country *i* using a Herfindahl - Hirschmann index. A higher concentration indicates that the export market is more concentrated, and competition takes place between a smaller number of exporting countries. Market concentration does not measure the intensity of competition, as in itself is says little about the contestability of specific markets. The indicator is a measure of the division of a market in a product line between different exporters. In combination with various other indicators used in this exercise it captures market concentration as an important element of international competition.

Composite index of industrial potential, IP_p : From these eleven indicators the composite index for the industrial potential of product *p* in country *i* has been constructed as follows:

$$IP_{p,i} = \frac{1}{11}\Big(NPRI_{p,i} + NPCI_p + NLUVR_{p,S,i} + N\overline{\mathrm{G}}_{\mathrm{p}} + \mathrm{NS}_{\mathrm{p}} + NIPI_{p,S,i} + NCI_p + \mathrm{NGLI}_{\mathrm{p}} + NVI_p + NDI_p + NHHI\_MP_{p,i}\Big). \quad (2)$$

This composite indicator is now the key input into the regional SWOT analysis of regional production potentials outlined in the next section. As before the letter N refers to the normalized variables by the indicator range. All indicators have been normalized in such a way that higher index values are associated with a higher implicit industrial potential (see Online Appendix for a more detailed description).

2.3 A relatedness-based SWOT analysis of regional production potential

Technological and spatial proximity are crucial for successful industry specialization (Orlando, 2004). There is significant literature, originating from Frenken et al. (2007), that suggests an industry's strength goes beyond just its "critical mass". Rather, sustainable strengths exist when large, specialized industries cohabit with complementary, technologically or cognitively related activities. This creates a supporting "industrial ecosystem" (Berger, 2013), which drives their development. If this ecosystem is absent, these activities might be considered risky due to potential vulnerability to outside shocks, regardless of their size or employment contribution.

Against this backdrop, the assessment of the development potential of a strategic product in a particular region requires both an assessment of the critical industrial mass at the regional level (represented by the regional degree of specialization in an industry), and by the extent to which they encounter a stimulating environment of complementary, (technologically or cognitively) "related" industries in the region. This embeddedness can be assessed by using data of job changes at the sector level (Neffke et al., 2017) from which it is possible to construct indices of the skill-relatedness of industries at the regional level.

We use the location quotient as a measure of relative regional specialization at the industry level. It is calculated as

$$LQ_{ir} = \frac{emp_{ir}}{emp_r} \Big/ \frac{emp_i}{emp}, \tag{3}$$

with *emp* being the number of employees, *i* the NACE 4-digit industry class and *r* region of within country *c*. $LQ_{ir} > 1$ indicates regional specialization compared to the benchmark, i.e. the country.

The degree of embeddedness is defined as

$$LQ_{ir}^{rel} = \frac{emp_{ir}^{rel}}{emp_r} \Big/ \frac{emp_i^{rel}}{emp}, \tag{4}$$

with emp_{ir}^{rel} being employment in industries "related" to industry i (technologically or cognitively) in region r and with emp_i^{rel} being employment in these industries "close" to industry i in the country. If the value of this degree of embeddedness is > 1, industry i is well embedded in the regional economy because it can draw on a large pool of "related" industries with complementary knowledge bases.

Our assessment of an industry's development potential is thus determined by both its degree of specialization and its degree of embedding in the regional industry structure. Following Otto et al. (2014), an empirical SWOT analysis can thus distinguish the following categories for individual industry classes (Table 3):

i) If region *r* is particularly specialized in industry i ($LQ_{ir} > 1.1$) and if this industry is also particularly well embedded in "related" industries ($LQ_{ir}^{rel} > 1.1$), the probability that it will continue to develop favorably is likely to be high. Such an industry should therefore be seen as a regional "strength".

ii) In contrast, an industry with a low degree of specialization and embedding ($LQ_{ir} < 0.9$ and $LQ_{ir}^{rel} < 0.9$) will have only a low development potential, ceteris paribus. It is therefore to be regarded as a regional "weakness" and will hardly be the focus of structural policy initiatives to build up viable areas of strength.

iii) Industries that are still weakly developed in region r ($LQ_{ir} < 0.9$), although a favorable regional environment of technologically or cognitively "related" industries (and thus diverse possibilities for using a common knowledge base) would be available for them

($LQ_{ir}^{rel} > 1.1$) will offer "opportunities" to develop new strengths via structural policy initiatives.

iv) Ultimately, industries that exhibit specialization in the region ($LQ_{ir} < 1.1$) but are weakly embedded in complementary industries in the region ($LQ_{ir}^{rel} < 0.9$), can be considered a structural "threat" that could be reduced solely by strengthening complementary industries through structural policy.

v) Location quotients > 1.1 and < 0.9 are used to distinguish between significantly higher and lower values in both dimensions. For industries with indicator values between 0.9 and 1.1, no pronounced development expectation is therefore assumed. They are therefore interpreted as "neutral" in the following SWOT analysis.

Several different approaches have been developed in the literature to identify the (cognitive) proximity of industries. We follow the work of Neffke and Henning (2013), who derive the technological or cognitive proximity of industries from inter-industry job switches, and thus from the labor mobility between the industries. The latter are central for knowledge spillovers. We distinguish total of 597 4-digit industry classes of the NACE 2.0 classification for this purpose, following the model of Neffke et al. (2017). This allows us to study a total of 356,409 target-source industry pairs to be mapped in a symmetric matrix. For each of these bilateral relationships, a "Skill-Relatedness" index (SR_{ij}) is calculated. It represents the relative magnitude of the respective labor flows between two industries i and j as a measure of their skill relatedness. It is used as a measure of the cognitive proximity between two industries i and j calculated as

$$SR_{ij} = \frac{F_{ij}}{\hat{F}_{ij}}, \tag{5}$$

where F_{ij} s the number of observed job changes between industries i and j and $\hat{F}_{ij}$ is the number of expected job changes between industries i and j that would have resulted from random (unsystematic) switching behavior and the given number of employees in each of i and j. If this "skill-relatedness" index is > 1, then the actual labor flows between the two industries are larger than would be expected under purely random job entry and exit. In this case, the industry pair is considered technologically or cognitively or skill "related". With index values < 1, job changes between the two industries are less frequent than would be expected; in this case, there is no revealed technological or cognitive "relatedness". Based on the matrix of the indicator values for all pairs of NACE 4-digit classes, it is possible to represent the entire network of related industries and subsequently to use them for the calculation of the degree of embeddedness for each industry and region. For further methodological details on the approach used, see Neffke et al. (2017).

Table 3: **Categories of the empirical SWOT analysis**

Development potentials according to degree of specialization and embeddedness

		Regional embeddedness of industry *i*	
		Low $LQ_{ir}^{rel} < 0.9$	high $LQ_{ir}^{rel} > 1.1$
Regional specialization of industry *i*	low $LQ_{ir} < 0.9$	Weakness (W)	Opportunity (O)
	high $LQ_{ir} > 1.1$	At Threat (T)	Strength (S)

Source: Author's own illustration adapted from *Otto et al.* (2014).

3. Application to COVID-19-strategic products and Austrian Regions

3.1 Data

Definition of strategic products

Two classifications for epidemic-relevant goods and for key technologies were used to define strategic goods. The classification of epidemic-relevant goods was developed by the World Bank (World Bank, 2020). It distinguishes between anti-epidemic products, medical devices, medical material, and pharmaceuticals. The group of anti-epidemic products includes goods that contain the spread of the epidemic, such as disinfectants, face masks, but also all parts that are used to produce them. The group of medical materials includes syringes, filter systems and test tubes to cultures of microorganisms, blood actions and immunological products, while the group of medical equipment ranges from surgical utensils to X-ray or magnetic resonance equipment. The classification for Advanced Technologies for Industry (ATI), on the other hand, was developed on behalf of the European Commission (European Commission, 2020b). These are technologies considered important for the long-term competitiveness of European industry.

Indicators on import dependence and production potential

The assessment of import dependence and the indicators used to capture important factors influencing firm level production decisions and competitiveness rely on the BACI database (Base pour l'Analyse du Commerce International) of the Centre d'Études Prospectives et d'Informations Internationales (CEPII). This is a cleaned and harmonized version of the UN COMTRADE data (see Gaulier and Zignago, 2010 for details). This data set is available for different classifications of the Harmonized System (HS) of customs statistics. For most calculations in paper the data set based on the HS2017 classification has been used. For indicators where longer time series were needed the data set based on the HS2012 classification has been used offering a longer time series from 2012 onwards. BACI includes data for 232 countries and for over 5,000 commodities and at the time of the analysis ended in 2018. The aggregation level corresponds to the 6-digits of the Harmonized System. Thus, the calculations in this study take place at a level with a very high level of detail.[5]

To calculate import dependencies, it is also necessary to consider domestic production (in Austria and the EU) in addition to imports and exports. Such data are available in the production

[5] Arjona et al. (2023) highlight the issue of re-exports in the identification of foreign dependencies. Re-exports involve the transit of imported goods through various intermediate countries before reaching their final destination and may bias estimations of dependency levels. They use the FIGARO database, which provides information on the country of origin and the country of consignment, to disentangle re-exports for EU countries. However, the FIGARO data at the detailed product level is not publicly accessible. Moreover, the process of identifying re-exports is beset by challenges due to asymmetries in the statistical reporting of re-exported goods among countries. Thus, while acknowledging the potential bias in dependency assessments introduced by re-exports, we recognize the inherent limitations in the methods and available data for this disentanglement. Consequently, we abstain from undertaking this disentanglement and instead rely on the BACI dataset, including re-exports. BACI is also chosen for its accessibility, the more uniform treatment of all countries, its greater completeness, and its accommodation of "trade asymmetries" or disparities between exports and the mirror flow of imports.

statistics of Statistics Austria and Eurostat and are also available at the 6-digit level. This data set uses the PRODCOM classification at the six-digit level for which correspondence tables for the HS classification, exist and have been recoded. A major challenge in this conversion is that the PRODCOM classification changes annually. Different versions of the classification thus need to be harmonized over time. For this purpose, later product classes must be assigned to earlier ones and the production values must be imputed proportionally. The resulting panel data set has certain uncertainties due to these transformation steps. A second issue related to the use of PRODCOM data are missing data entries due to confidentiality requirements. In the empirical analysis of import dependence, this results in gaps in the calculation of the overall index, which had to be imputed by means of a regression procedure based on the observed values. Both, the indicators based on trade and production statistics at the detailed product level were then assigned to NACE 4-digit industries using correspondence tables available from Eurostat.

All relevant indicators on import dependency and industrial potential, risk profiles and competitiveness introduced in chapter 2 refer to the most recent year (2018) available at the time the analysis was carried out. Tables with descriptive statistics of the plain indicators and their transformed variables are available in the Online Appendix. Variants of these baseline indicators have been calculated to compare the Austrian situation with the relevant the EU28, and for changes between 2012 and 2018. This permits to include information on whether the gap to the EU has widened or narrowed as well as to assess whether dependencies are of a long-term nature. Both, the comparison to the group of EU28 (including the United Kingdom) as well as the choice of years has been dictated by the availability of data at the time of analysis.

Regional specialization and embeddedness

The degree of cognitive or technological "relatedness" between sectors in line with Neffke et al. (2017) can be inferred from the magnitude of labor flows between these sectors. Such information can be derived from the database of the confederation of the Austrian social security institutions (INDI-DV). This data set contains the employment histories of all employees subject to social insurance contributions in Austria. It contains an anonymized person ID for each person on the Austrian labor market, which can be assigned to the NACE 4-

digit class of the employing company via an anonymized company ID. This assignment can be used to count the frequency of job changes within or between sectors for each pair of NACE 4-digit sectors. To avoid distortions caused by the labor market turbulences of the crisis years 2009 and 2020, only job changes in the period 2010 to 2019 are considered in the analysis.[6] The same data base is used to calculate NACE 4-digit employment levels and location quotients for 2019 for Austrian NUTS 2 regions ("Bundeslaender").

3.2 Results of the SWOT analysis for Austrian NUTS 2 regions

In the following paragraphs, the results of the regional SWOT analysis are presented for strategic products with high import dependence (Table 4). In addition, we illustrate the results for all strategic products exemplarily for the federal state of Upper Austria (Figure 2). Figures for the other federal states can be found in the Online Appendix. Upper Austria is highlighted here as the state with the largest share of industry among Austrian federal states.

For each industry manufacturing strategic products with high import dependency Table 4 highlights NUTS 2 regions where such activities can be regarded as "S" (Strength) based on existing specialization (location quotient) within the country and a high degree of embeddedness in related activities in the region (location quotient of related activities). In addition, Table 4 illustrates "O" (Opportunity), i.e. activities with a high degree of embeddedness but medium to low levels of specialization. Activities with a high degree of embeddedness in the region that are not yet produced in the region, are also regarded as opportunities and highlighted with an asterisk in Table 4. (S) and (O) indicate strengths and opportunities that are less pronounced ($1.0 < LQ_{ir} \leq 1.1$ and/or $1.0 < LQ_{ir}^{rel} \leq 1.1$).

[6] While we follow Neffke et al. (2017) as far as possible, differences in the nature of the data sets make two adaptations necessary: First, instead of including full-time employment contracts only, we consider employment above the median social security assessment base of the respective reference group (NACE 4-digit industry, gender, age cohort) due a lack of information on working hours. Therefore, we include predominantly higher-skilled who should play a greater role for knowledge spillovers between industries than low-skilled persons. Second, Neffke et al. (2017) calculate SR_{ij} separately for each year and subsequently use the arithmetic average. In contrast, we calculate SR_{ij} "pooled" for the entire period analysed. Given the smaller scale of the Austrian labor market – and the associated imprecision in cases of very low numbers of job changes for specific pairs of industries – this promises more robust results, and has the advantage of weighting the individual years according to their respective actual dynamics in terms of job changes.

As Table 4 reveals, not all strategic products with a high import dependency have a low industry potential, i.e. a low potential for domestic production according to Section 2.2. Rather low potentials for Austria are identified mostly for strategic products in the chemical and pharmaceutical industry, the electrical and electronics industry and in mechanical engineering of relevant products. A rather high industry potential despite high degrees of import dependencies from non-EU countries is identified for strategic products from the paper and ceramics industry, as well as manufacture of metal forming machinery and machine tools.

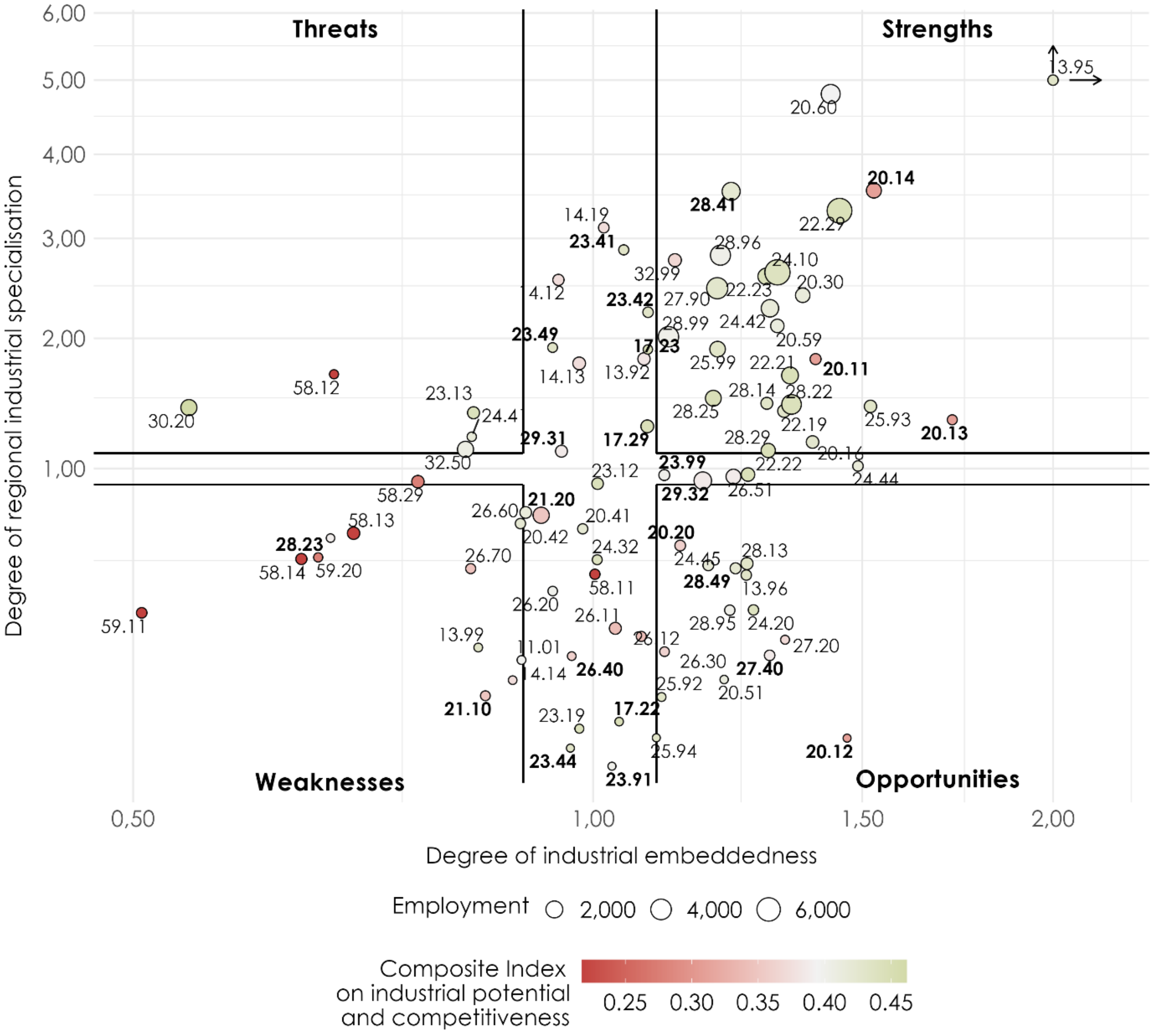
Irrespective of the industry potential at the national level, the analysis shows a clear locational hierarchy within the country for nearly all industries manufacturing strategic products and technologies: For nearly all NACE 4-digit industries considered, one NUTS 2 region stands out where the activity can be regarded as strength S based on existing specialization (location quotient) within the country and a high degree of embeddedness in related activities in the region (location quotient of related activities). For those industries that cannot be regarded as strength in at least one region, Table 4 highlights that in several regions the activities can be regarded as opportunities, either based on existing production or in case of production still to be established.

Table 4: Regional Strengths and Opportunities for Strategic Products with High Import Dependency

Industry Potential for Austria	NACE Code and Name		Region (NUTS-Code)								
			Burgen-land (AT11)	Lower Austria (AT12)	Vienna (AT13)	Carin-thia (AT21)	Styria (AT22)	Upper Austria (AT31)	Salz-burg (AT32)	Tyrol (AT33)	Vorarl-berg (AT34)
	C 13.91	**M.o. knitted and crocheted fabrics**		(O)							S
	C 17.22	**M.o. household & sanitary goods**			O			(O)	(S)		
	C 17.23	**M.o. paper stationery**	(S)	O				(S)	*		*
	C 17.29	**M.o. other articles of paper**	O	(O)		O		(S)		S	S
	C 20.11	**M.o. industrial gases**		(S)	(O)			S			
	C 20.12	**M.o. dyes & pigments**		S				O			
	C 20.13	**M.o. other inorganic basic chemicals**		(S)			O	S			(O)
	C 20.14	**M.o. other organic basic chemicals**		(S)			O	S			
	C 20.20	**M.o. pesticides & o. agrochem. prod.**						O			*
	C 21.10	**M.o. basic pharmaceutical products**			O		(O)			S	
	C 21.20	**M.o. pharmaceutical preparations**			S		(O)				
	C 23.41	**M.o. ceramic household**	O	O		(O)		(S)	O	O	O
	C 23.42	**M.o. ceramic sanitary fixtures**	*	S		O		(S)	O		
	C 23.43	**M.o. ceramic insulators**					*	*	*		*
	C 23.44	**M.o. other technical ceramic prod.**					S				*
	C 23.49	**M.o. other ceramic products**	O	S		*	(O)		O	O	
	C 23.91	**P.o. abrasive products**	(O)	O		(S)	(O)	(O)	(O)	S	
	C 23.99	**M.o. other mineral products n.e.c.**	O	S		S		(O)		(O)	
	C 26.40	**M.o. consumer electronics**			S		O				
	C 27.40	**M.o. electric lighting equipment**		(S)			O	O			S
	C 28.23	**M.o. office machinery & equipment**	*			*			S	*	
	C 28.41	**M.o. metal forming machinery**		(O)			O	S			
	C 28.49	**M.o. other machine tools**		O			S	O	(O)		
	C 29.31	**M.o. electr. equip. for motor vehicles**		(O)			*		O		(S)
	C 29.32	**M.o. other parts for motor vehicles**		(S)			S	(O)			

Source: INDI-DV, authors' own calculations. – S… Strength, O… Opportunity, (S) and (O)… Less pronounced strength or opportunity ($1.0 < LQ_{ir} \leq 1.1$ and/or $1.0 < LQ_{ir}^{rel} \leq 1.1$), *… Potential Opportunity: no production in region yet, but $LQ_{ir}^{rel} > 1.1$; Color: Industry potential for Austria from high (green) to low (red), see Section 2.2. for details;

Figure 2: SWOT-Profile on strategic products for the region of Upper Austria (AT31)



Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Figure 2 shows the SWOT-profile for strategic products for the state of Upper Austria (AT31). It illustrates not only those with high import dependency but all strategic products. The vertical axis in Figure 2 represents the regional degree of specialization (location quotient) for the respective industry. The horizontal axis represents the degree of embeddedness (weighted average location quotient of "related" industries). The four quadrants "Strength", "Opportunity", "Threat", "Weakness" provide information on the respective SWOT characteristics of the industries, including a "neutral" zone for industries without a pronounced SWOT profile. This neutral zone is visually demarcated in the diagrams by the black lines. Similar diagrams for the other eight NUTS 2 regions of Austria can be found in the Online Appendix. In addition to their position in the SWOT analysis, the diagram again provides information on the import dependency (>75% percentile in bold) and industrial potential (color) of an industry in Austria as a whole. For illustrative reasons, only those industries can be shown in the SWOT diagrams that are already located in a federal state.

As a state with a strong orientation toward manufacturing, Upper Austria has excellent locational conditions for a broad spectrum of industries with strategic products, as Figure 2 reveals. Particularly, its broad industrial base also offers a wide range of opportunities through synergies with cognitively or technologically "related" industries (high degrees of embeddedness). For strategic products, pronounced areas of strength can be found in the manufacture of chemical products (C20), the manufacture of rubber and plastic products (C22), the production of aluminum (C24.42), pig iron and steel (C24.10), in specific areas of the metal processing industry (C25), as well as in large parts of the mechanical engineering sector (C28).

4. Conclusions

The COVID-19 crisis and recent geopolitical dislocations have given new weight to questions of supply security and resilience of value chains. Against this backdrop, the paper proposed an analytical framework for data-driven evaluation of possible production reshoring for strategic products to strengthen the independence of an economy if – for a given reason – policymakers concluded that certain strategic products should be relocated or bred in the domestic economy. Any political considerations for strengthening the location of production or efforts to reshore strategic products should include the following steps: Which products have a strategic dependence on imports? What is the international competitiveness of (possible) domestic production of such products? Which regions within the country are most suitable for (reshored) production? The analytical framework proposed in the paper allows for an evaluation of production potential according to these three guiding questions. However, it is also important to point out that identifying possible production locations of strategic goods should be understood as only a single component of a broader strategy to strengthen supply security and resilience and should not be grounded in ideological or protectionist motives.

We illustrate the relevance of the approach as a policy tool for the example of COVID-19-strategic products and Austrian regions as (potential) production locations. Results of the study illustrate relatively favorable location conditions for almost all activities, at least in individual provinces (NUTS 2 regions). For those strategic product manufacturing industries for which Austria has a high dependence on imports and a low industrial potential, the location patterns within Austria are mostly clearly pronounced. Nevertheless, even in the case of overall unfavorable location conditions in international competition, existing strengths and relatively favorable location conditions can be found in individual Austrian provinces for almost all relevant industries - provided that domestic production is desired and should be promoted.

The exemplary empirical analysis serves as a case study on the assessment of production potential for a single country such as Austria. However, the approach can also be applied to the European Single Market as a whole and to the regional level in the EU. While the data requirements for an EU-wide regional analysis at a highly disaggregated industry level are beyond the scope and possibilities of the present analysis, a pan-European analysis would be an important scope for future research. The proposed method and empirical analysis in the paper is explicitly related to the question of production potential for strategic products. However, the method can equally be used as a basis for decision-making on location and industrial policy in general - independent of the nature and purpose of tradable goods. We leave these applications for future research.

References

Arjona, R., Connell, W., Herghelegiu, C. (2023). An enhanced methodology to monitor the EU's strategic dependencies and vulnerabilities," Single Market Economics Papers WP2023/14, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (European Commission), Chief Economist Team.

Arriola, C., Guilloux-Nefussi, S.-H. Koh, P. Kowalski, E. Rusticelli, and F. Van Tongeren (2020), "Efficiency and risks in global value chains in the context of COVID-19", OECD Economics Department Working Papers, No. 1637, OECD Publishing, Paris, https://doi.org/10.1787/3e4b7ecf-en.

Badinger, H. (2007), "Market size, trade, competition and productivity: evidence from OECD manufacturing industries", Applied Economics, 39(17), 2143-2157.

Balland, P.A., Boschma, R., Crespo, J., Rigby, D.L. (2019), “Smart specialization in the European Union: relatedness, knowledge complexity and regional diversification, Regional Studie, 53(9), 1252-1268.

Berger, S., A (2013), Preview of the MIT Taskforce on Innovation and Production Reports, MIT Press, Cambridge, MA.

Booysen F. (2002), “An Overview and Evaluation of Composite Indices of Development”, Social Indicators Research 59 (1), 115-151.

Boschma, R., Minondo, A., Navarro, M. (2012b), “The emergence of new industries at the regional level in Spain: A proximity approach based on product relatedness“, Economic Geography, 89 (1), 29–51.

Coe, D., Helpman, E. (1995), "International R&D spillovers", European Economic Review, 39(5), 859–887.

Coe, D., Helpman, E., and A.W. Hoffmaister (1997), “North-south R&D spillovers”, Economic Journal, vol.107, 134-149.

Debaere, P. (2005). Monopolistic competition and trade revisited: Testing the model without testing for gravity. Journal of International Economics 59: 1-24.

European Commission (2020a), 2020 Strategic Foresight Report. Strategic Foresight – Charting the Course towards a more resilient Europe, COM(2020) 493 final, Brussels 09.09.2020.

European Commission (2020b), Advanced Technologies for Industry – Methodological Report, Brussels.

European Commission (2021a), Communication “Trade Policy Review - An Open, Sustainable and Assertive Trade Policy”, COM(2021) 66 final, Brussels 18.02.2021.

European Commission. (2021b). Strategic dependencies and capacities. Commission staff working document, SWD (2021) 352.

Evenett, S., Fiorini, M., Fritz, J., Hoekman, B., Lukaszuk, P., Rocha, N., Ruta, M., Santi, F., Shingal, A. (2020), “Trade policy responses to the COVID-19 pandemic: Evidence from a new dataset”, VoxEU.org, 11 December.

Frenken, K., van Oort, F.G., Verburg, T. (2007), "Related Variety, unrelated Variety and regional economic Growth", Regional Studies, 41(5), 685-697.

Foa, R.; Tanner, J. (2012), “Methodology of the Indices of Social Development”, ISD Working Paper Series, No. 2012-04; Indices of Social Development, 2012; Available online: https://repub.eur.nl/pub/50510/

Foster-McGregor, N., Pöschl, J., Stehrer, R. (2017), "The importance of absorptive capacities: productivity effects of international R&D spillovers through intermediate inputs", Economics of Innovation and New Technology, 26(8), 719-733.

Gaulier, G., Zignago, S. (2010), “BACI: International Trade Database at the Product–level”, CEPII Working Paper, (2010–23).

Haukes, J., Knell, M. (2009), "Embodied knowledge and sectoral linkages: An input–output approach to Embodied knowledge and sectoral linkages: An input–output approach to the interaction of high- and low-tech industries", Research Policy, 38(3), 459–469.

Hausmann, R., Hwang, J., & Rodrik, D. (2007), “What you export matters”, Journal of Economic Growth, 12, 1-25.

Hidalgo, C.A., Hausmann, R. (2009), “The building blocks of economic complexity”, Proceedings of the National Academy of Sciences of the United States of America, 106 (26), 10570–10575.

Hidalgo, C.A., Klinger, B., Barabasi, L., Hausmann, R. (2007), „The product space conditions the development of nations” Science, 317 (5837), 482–487.

Keller, W. (2002), "Trade and the Transmission of Technology", Journal of Economic Growth, 7(1), S. 5-24.

Klepper, S. (2010), “The origin and growth of industry clusters: The making of Silicon Valley and Detroit”, Journal of Urban Economics, 67 (1), 15–32.

Klimek, P., Hausmann, R., & Thurner, S. (2012). Empirical confirmation of creative destruction from world trade data. PloS one, 7(6), e38924.

Nardo, M., Saisana, M., Saltelli, A., Tarantola, S. (2005). “Tools for Composite Indicators Building”, European Commission, Institute for the Protection and Security of the Citizen, JRC: Ispra, Italy.

Neffke, F., Henning, M., Boschma, R. (2011), “How do regions diversify over time? Industry relatedness and the development of new growth paths in regions”, Economic Geography, 87 (3), 237–265.

Neffke, F.M.H., Henning, M.S. (2013), " Skill-relatedness and firm diversification", Strategic Management Journal, 34(2), 297-316.

Neffke, F.M.H., Otto, A., Weyh, A. (2017), Skill-relatedness matrices for Germany. Data method and access, FDZ-Methodenreport, 04/2017, Nürnberg.

Orlando, M.J. (2004), “Measuring spillovers from industrial R&D: on the importance of geogprahic and technological proximity”, The RAND Journal of Economics, 35 (4), 777–786.

Otto, A., Nedelkoska, L., Neffke, F. (2014), "Skill-Relatedness und Resilienz: Fallbeispiel Saarland", Raumforschung und Raumordnung, 72(2), 133-151.

Seric, A., Görg, H., Mösle, S., Windisch, M. (2020), “Managing COVID-19: How the pandemic disrupts global value chains”, UNIDO Industrial Analytics Platform, April.

Schott, P.K. (2004), “Across-product versus within-product specialization in international trade”, Quarterly Journal of Economics 119, 647–678.

Appendix

A. Indicator construction for the assessment of the import dependency of strategic products

Geographical concentration of imports from extra-EU sources: The indicator for the geographical concentration of imports is calculated as a Herfindahl-Hirschman concentration index. It indicates the concentration of imports of a country in individual product lines over all extra-EU trading partners. The geographical concentration of imports of country *i* from countries j in product line p in year is calculated as follows:

$$HHI\_M^{i}_{jt,p} = \sum_j \left(sm^2_{ijt,p}\right) \text{ with } sm_{ijt,p} = \frac{m_{ijt,p}}{\sum_j m_{ijt,p}}. \tag{A.1}$$

At the respective time t, m_{ijtp} describes the imports of the reporting country *i* from country *j*. Thus $sm_{ijt,p}$ corresponds to the import share of the country of origin *j* in the total import of goods of the reporting country *i* in the product line p. $\sum_j m_{ijt,p}$ describes the sum of the imports of reporting country *i* from all countries of origin *j*. In the study, imports are summed up across all extra-EU partner countries *j*. The Herfindahl-Hirschman index for the geographical concentration of imports takes values in the range [0.1]. In the extreme case, with a value of 1, imports are only sourced from a single foreign market; with a value of 0, there is complete diversification of imports across many partner countries.

Dependence of domestic production on imports from extra-EU sources: This indicator is calculated as the share of imports in domestic production. For imports of product line p in year t the import share of the country of origin *j* in the production of p ($prod_{i,p}$) in reporter country i is given by:

$$smprod^{i}_{jt,p} = \frac{\sum_j m_{ijt,p}}{prod_{it,p}}. \tag{A.2}$$

Again, imports are summed over all extra-EU trading partners.

The trade balance position in extra-EU trade: This indicator is the reciprocal of the export-import ratio otherwise used in the literature and provides information on the trade balance position of a country in the respective product line. The ratio of imports of reporting country *i* in product line *p* across all countries of origin *j* to exports of the reporting country in product line *p* to partner countries *j* in year *t* is therefore calculated as follows:

$$relimex_{jt,p}^{i} = \frac{\sum_j m_{ijt,p}}{\sum_j x_{ijt,p}}, \tag{A.3}$$

where $\sum_j m_{ijt,p}$ and exports $\sum_j x_{ijt,p}$ sum over all extra-EU trading partners j. All values greater than 1 signal a negative trade balance, as more is imported than exported in the respective product line. Conversely, all values smaller than 1 indicate a positive trade balance in the respective product line.

The relative position of a country with the EU: The position of individual EU member state *i* relative to the EU28 (EU including the United Kingdom) is calculated as

$$relEU_{V}{}_{jkt,p}^{i} = \frac{V_{jkt,p}^{i}}{V_{jkt,p}^{EU}}, \text{with k} = \ HHI_{M}{}_{jt,p}^{i},\ smprod_{jt,p}^{i}, relimex_{jt,p}^{i}, \tag{A.4}$$

where $V_{jkt,p}$ represents the respective subindicator k for individual EU countries and the EU 28.[1]

Medium to long term changes of all indicators considered: Finally, the change of these indicators between the first and last year available in the dataset (2012 and 2018) are calculated as

$$\Delta V_{jk,p}^{i} = \log\left(V_{jk,p,2018}^{i}\right) - \log\left(V_{jk,p,2012}^{i}\right) \text{ and} \tag{A.5}$$

$$\text{relEU}_{\Delta \text{V}}{}_{jk,p}^{i} = \log\left(relEU_{V}{}_{jk,p,2018}^{i}\right) - \log\left(relEU_{V}{}_{jk,p,2012}^{i}\right). \tag{A.6}$$

B. Indicator construction for the assessment of the industrial potential for the domestic production of strategic products

Product level competitiveness: The product level competitiveness is therefore assessed on the one hand based on location characteristics in terms of local capabilities, potential spillovers and industry specific unit values, as well as the technological characteristics of any product:

[1] Due to the availability of data in the production statistics at the detailed product level in the PRODCOM dataset, this comparison could only be made with the EU28 – i.e., including the United Kingdom.

Proximity: The proximity of a product to a country's industrial specialization is calculated using the notion of the product space following Hidalgo et al. (2007). We generate the network capturing the relatedness of products across exporting countries based on pairwise conditional probabilities φ_{pq} for two products *(p,q)* being exported with comparative advantage across countries. Accordingly, the proximity index PRI_P of a product p with import dependence to the export specialization of the country is then given by

$$PRI_P \; = \sum_p z_p \; \varphi_{pq} / \sum_p \varphi_{pq} \; , \tag{A.7}$$

where z_p equals 1 when product line *p* is exported by the country with RCA>1. This measure varies between 0 and 1.

Sophistication: The technological sophistication of a product with import dependence has been calculated with product complexity (Hidalgo and Hausmann, 2009) as a proxy. To calculate the indicator, a matrix $M(j,p)$ is formed, which for each exporting country (j) shows the value 1 for those products that are exported with comparative advantage (RCA>1) and otherwise takes the value 0 for the element.[2] The complexity score for each product is then obtained from the eigenvector associated with the second largest eigenvalue of the matrix

$$M_{pq} = \sum_j \frac{M_{j,p} M_{j,q}}{k_{j,0} k_{p,0}}, \tag{A.8}$$

where $k_{j,0} = \sum_p M(j,p)$, and $k_{p,0} = \sum_j M(j,p)$. The indicator $\mathrm{PCI_p}$ generated from the eigenvector is referred to as product complexity index.[3]

Logarithmic ratio of the unit value: Following Schott (2004) it is calculated as:

$$LUVR_{p,S} = \frac{\log(uvm_p)}{\log(\overline{uvx}_s)}, \tag{A.9}$$

[2] The revealed comparative advantage in this paper following Balassa (1965) is always calculated as the ratio of the world market share of a product line exported by the country relative to the world market share across all product lines of that country.
[3] https://atlas.cid.harvard.edu/glossary

where $uvm_p = {}^{m_p}/_{Q_p}$, corresponds to the unit value, i.e. the ratio of the import value m_p in US$ and the quantity Q_p in tonnes of a strategic product *p*, and $\overline{uvx}_s$ corresponds to the average unit values x_p of all products exported by industry *s*, weighted by the export shares.

Economic potential: The indicators for the economic potential have been constructed as follows:

Global market growth and share in global market volume: Higher growth in trade volumes of a product line and the share of a product in global trade are good proxies for its market opportunities.[4] The average global market growth rate $\overline{\mathrm{G}}_{\mathrm{p}}$ over some period $\Delta t = \mathrm{T} - \mathrm{t}$, has been calculated as:

$$\overline{\mathrm{G}}_{\mathrm{p}} = \frac{1}{\Delta t} \sum_{t=1}^{T} g_{p,t}, \tag{A.10}$$

where $g_{p,t} = \log(\mathrm{X}_{\mathrm{p,t}}) - \log(\mathrm{X}_{\mathrm{p,t-1}})$ with $\mathrm{X}_{\mathrm{p,t}} = \sum_{\mathrm{j}} \mathrm{x}_{\mathrm{j,p,t}}$ reflecting the global export value of product *p* at time *t* summed up over all exporting countries *j*. The market volume has simply been calculated as the market share S_{p} of product *p* in the volume of total global exports X_{t} at time:

$$\mathrm{S}_{\mathrm{p}} = \frac{\mathrm{x}_{\mathrm{p,t}}}{\mathrm{X}_{\mathrm{t}}}. \tag{A.11}$$

Potential contribution of a product to the implicit productivity of an industry: An indicator has been used that compares the implicit productivity of a product with the average implicit productivity of the industry's already produced and exported goods portfolio. Implicit productivity of a product an indicator referred to as PRODY, was proposed by Hausmann et al. (2007). It corresponds to a weighted average of the real GDP per capital of the countries exporting a product and the weights correspond to the observed RCA values of each exporting country. When the PRODY of a product is above the GDP per capita of a country starting to export it will improve its implicit productivity. Following this logic, we calculate a counterfactual implicit productivity index $IPI_{p,S}$ reflecting the potential contribution of a newly

---

[4] A potential limitation of these indicators is that trade in specific product lines is often concentrated geographically and given that geographical distance is an important determinant of trade this may limit cross country comparisons based on these indicators.

added product to the average implicit productivity of the industry *S* producing product *p* in the country:

$$IPI_{p,S} = \frac{PRODY_p}{\frac{1}{n}\sum_{q \in s} PRODY_q}, \qquad \text{(A.12)}$$

where *n* corresponds to the number of products exported by industry *s* in a country with comparative advantage RCA>1. This indicator is now larger than one if the product would increase the implicit productivity of the product portfolio exported by domestic industry *s*.

Potential for subsequent market entry in related product lines: When a country starts producing and exporting a product, this also affects other products that are already being produced or exported. This relationship can be substitutive, i.e., it can lead to a new product displacing other products if the new product is more profitable or competitive than its alternatives and companies decide to either abandon or relocate the production of old product lines. The relationship can also be complementary if the production of a product requires the development of new production capacities and skills that subsequently allow the production and export of other, technologically related products. In this case, the introduction of a product in one location can lead to a cascade effect and to market entry in clusters of related products. Both dynamics are an important part of economic renewal and structural change.

To capture such dynamics, we use indicators proposed by Klimek et al. (2012). One of these indicators measures for each product how often the export uptake of a product by a country leads to the uptake of other products within a given period. The displacement indicator will be discussed later. The clustering index at the product level is calculated across countries as follows:

$$CI_p = \frac{1}{\mathcal{N}} \sum_q \frac{PA_{p,q}}{\max[PA_p, PA_q]}, \qquad \text{(A.13)}$$

Where $PA_{p,q}$ maps how often a product *p* appears together with another product q in the export basket of a country *j* in t periods, $\max[PA_p, PA_q]$ is the maximum number of counts for the appearance of either product *p* or *q* used for normalization and $\frac{1}{\mathcal{N}}$ is a rescaling factor chosen in such a way that CI_p lies in the unit interval. The higher this indicator the more export opportunities arise for countries that produce and export products with a high cluster coefficient, as the uptake of such a product increases the likelihood of the country starting to export other related products as well.

Potential for intra-industry diversification (niche creation): Using bilateral trade flows, we thus calculate a standard Grubel-Lloyd Index (Grubel - Lloyd 1975) at the product level:

$$\mathrm{GLI_p} = 1 - \frac{|x_{ji,p} - m_{ij,p}|}{x_{ji,p} + m_{ij,p}}, \tag{A.14}$$

where now $x_{ji,p}$ and $m_{ij,p}$ correspond to bilateral import and export flows between countries *i* and *j* of the product with import dependence *p*.

Market risks: The following three indicators have been calculated to capture the risk associated with the uptake of the production and export of a product line with import dependence:

Unit value volatility: reflects the risk content of traded products related to price instability. It implies higher fluctuations in export earnings for exporting firms. Companies thus have an incentive to adjust their export portfolio to the risk content of its constituting products. If the risk content of a product is very high, the start of its production in any location also requires companies to expect high expected return.

To capture price volatility, we follow di Giovanni - Levchenko (2010). They propose an indicator in which global shocks are calculated from the time series of the unit values of a product line to obtain a unit value volatility VI_p for product *p*:

$$VI_p = \boldsymbol{s}'_{jt}\Sigma, \tag{A.15}$$

where Σ is the variance-covariance matrix of unit values of a product line *p* and all other product lines over time across countries, and vector $\boldsymbol{s}'_{jt}$ reflects the export shares $s_{j,p,t}$ of a product *p* in the total exports of a country *j* at time *t*. The resulting indicator is time-invariant over the period of observation.

Displacement risk: The displacement index reflects the risk of displacement associated with any product. We calculate the displacement index proposed by Klimek et al. (2012). It is constructed in a similar fashion as the clustering coefficient presented earlier. The difference is that instead of measuring the co-appearance of products in the export basket of countries it captures the likelihood of displacement of a product following the appearance of any other product in a country's export basket across countries and over time. Like the clustering index this is a product specific and is calculated as

$$DI_p = \frac{1}{\mathcal{N}} \sum_q \left[PAD_{p,q}^{(t)} - PAD_{q,p}^{(t)} \right], \tag{A.16}$$

where $PAD_{p,q}^{(t)}$ is the frequency with which a product p displaces a product q during period t after its appearance in the basket of goods of a country and $PAD_{q,p}^{(t)}$ is the reciprocal value. As before $\frac{1}{\mathcal{N}}$ is a rescaling factor chosen in such a way that DI_p lies in the unit interval.

Export market concentration: To estimate the specific competitive environment that exporters of a product can expect, the average market concentration is measured with a Herfindahl - Hirschmann index, which is higher the more the global market shares of a product are concentrated in a few exporting countries and lower the more these market shares are scattered over a large number of exporting countries with small market shares.

$$HHI\_MP_{p,c} = \sum_c \left(ms_{c,p}^2 \right), \tag{A.17}$$

where $ms_{c,p}^2$ corresponds to the world market share of exporting country c in product line p of total goods exports worldwide in this product line. This index takes values in the range [0,1], where a value close to zero indicates very low concentration, while a value of 1 indicates complete concentration. A higher concentration indicates that the export market is more concentrated, and competition takes place between a smaller number of exporting countries. Market concentration does not measure the intensity of competition, as in itself is says little about the contestability of specific markets. The indicator is a measure of the division of a market in a product line between different exporters. In combination with various other indicators used in this exercise it captures market concentration as an important element of international competition.

C. Composite indicators for import dependency ID_p and the industrial potential, IP_p

From the indicators outlined in the previous sections, we have constructed a composite summary indicator (cf. JRC 2002, Mayoux 2002, Freudenberg 2003, Hoffman et al 2005). As the indicators differ partly in scales and statistical properties a normalization is necessary. The goal is to obtain a rank order for all products with import dependence from the most to the least suited for domestic production. The normalization should therefore preserve the rank order. For this purpose, either standardization in terms of dispersion (z-score) or range (min-max) would be suitable.[5] In the present study, the indicators were standardized based on the min-max method:

$$NI_p = \frac{I_p - min(I)}{max(I) - min(I)}, \quad \text{(A.18)}$$

where NI_p corresponds to the normalised indicator value I_p for product p and min(I) and max(I) correspond respectively to the minimum and maximum of any of our eleven indicators I measured across all products at a point in time.

Normalization is then followed by aggregation of the normalized indicators into an overall or partial index. The process of weighting the individual normalized indicators is very important. Ideally, this should result from theoretical considerations (cf. Diewert and Nakamura 2003). In practice it is very difficult to assess the relative importance each indicator.[6] Different analyses have shown, however, that a uniform weighting is generally preferable, as the weighting hardly leads to any changes in the rankings relative to other weighting procedures (Sajeva et al 2005). For this reason, we aggregate all normalized indicators into one aggregate composite indicators for the overall import dependency and industrial potential of any product p for production in a specific location, respectively. The composite indicator of import dependency is given by:

$$MD_p = \sum \; w * NIM_p \,, \quad \text{(A.19)}$$

[5] See Talkuder et al (2017) for an extensive discussion of normalization and aggregation techniques in the construction of composite indicators.

[6] In such situations, expert surveys are used to obtain a so-called Benefit of the Doubt (BOD) weighting (cf. Cherchye et al 2007, Saisana et al 2005).

For all $NIM_p \in \big(HHI\_M_P$, $smprod_P$, $relimex_{p,}$, relEU_HHI_M$_p$, $relEU\_smprod_p$, $relEU\_relimex_p$, ΔHHI_M_P , $\Delta smprod_P$, $\Delta relimex_{p,}$, ΔrelEU_HHI_M$_p$, $\Delta relEU\_smprod_p$, $\Delta relEU\_relimex_p\big)$, and $w = 1/12$, an where the variables in NIM_p are obtained from the calculations detailed in this appendix. [7]

The composite indicator of industrial potential is given by:

$$IP_p = \sum \; w * NIP_p \;, \tag{A.20}$$

For all $NIP_p \in \big(PRI_P\, , PCI_P\, , LUVR_{p,S}, \overline{\mathrm{G}}_\mathrm{p}, \mathrm{S}_\mathrm{p}, IPI_{p,S}, CI_p, \mathrm{GLI}_\mathrm{p}, VI_p, DI_p, HHI\_MP_{p,c}\big)$, and $w = 1/11$, an where the variables in NIP_p are again obtained from the calculations detailed in this appendix.

D. Descriptive statistics for the indicators on import dependency and industrial potential

Tables D.1 to D.5 summarize the descriptive summary statistics of the indicators used in an application to Austrian data. The upper part describes the characteristics of the non-transformed variables, while the lower part summarizes the key figures for the normalized variables used in the composite index of import dependence and industrial potential. In addition, a distinction is made between COVID-19 strategic products and key advanced technologies (ATI), and within these a comparison is made between goods with high import dependence and those without. Finally, a comparison is made with other goods, outside the respective group of strategic goods.

The mean values (arithmetic averages or medians) are significantly higher across all indicators in the group of strategic goods with high import dependency than in the respective comparison group of strategic products without particular import dependency. The selection procedure using the overall import dependency indicator thus successfully differentiates according to the import dependency of the groups. The n.e.c products (comprising all non-strategic products),

[7] All 12 indicators are included in the calculation of the composite index with equal weight. In the case of very strong changes in the indicators over time, this could lead to the problem that products with relatively low and negligible (absolute) import dependence also have a higher value in the overall index. In this respect, a sensitivity analysis shows that the selection of products with high import dependence is very robust to different weightings of the indicators and leads to only minor changes in the ranking. Even in the case of calculating the overall index only based on the absolute values (without taking changes into account), the results prove to be robust.

shows a particularly high dispersion. Therefore, in this case, the median is preferable as a comparator, as it is more robust against outliers. The medians of the respective indicators of the strategic goods groups with high import dependence also exceed the values that result on average for all other, non-strategic products.

Finally, Figures D.1 to D.4 show the distribution of Austria's overall import dependence indicator (MD) and the composite index of the industrial potential (IP) for COVID strategic products as well as for key advanced technologies (ATI), separates products with high import dependence from those without import dependence and compares each of these with the distribution of all other goods ("n.e.c. products"). The vertical lines in the respective boxplot boxes display the respective medians, that are all clearly higher for products revealing high import dependency in Austria.

Table D.1: Descriptive statistics for product level import dependency indicators – Austria 2018

	Advanced technologies for industries						COVID-strategic products					
	mean	med	min	max	standard deviation	obs	mean	med	min	max	standard deviation	obs
untransformed variables												
products without import dependence												
Concentration, HHI_M$_p$	0.31	0.29	0.00	0.65	0.13	154	0.31	0.29	0.00	0.66	0.13	104
Share in production, smprod$_p$	1.46	0.43	0.00	13.76	2.72	32	2.87	0.64	0.06	24.62	5.00	43
Relation to exports, relimex$_p$	5.76	0.88	0.00	134.06	18.59	143	6.92	1.09	0.00	312.92	31.25	104
RelEU Concentration, relEU_HHI_M$_p$	1.31	1.27	0.00	3.58	0.56	154	1.27	1.18	0.00	3.58	0.55	104
RelEU Share in production, relEU_smprod$_p$	1.88	1.00	0.01	7.60	2.07	32	6.54	1.11	0.05	125.96	21.78	43
RelEU Relation to exports, relEU_relimex$_p$	4.48	0.97	0.00	143.39	15.85	143	5.67	1.39	0.00	351.74	34.37	104
products with import dependence												
Concentration, HHI_M$_p$	0.73	0.74	0.33	1.00	0.19	74	0.71	0.67	0.24	1.00	0.18	43
Share in production, smprod$_p$	3.75	2.16	0.03	16.58	4.47	18	7.58	0.95	0.01	49.33	13.89	13
Relation to exports, relimex$_p$	10.67	1.58	0.00	173.05	27.14	70	4.09	1.05	0.00	46.95	9.38	43
RelEU Concentration, relEU_HHI_M$_p$	2.45	2.26	0.96	5.63	1.10	74	2.59	2.40	1.04	4.51	0.92	43
RelEU Share in production, relEU_smprod$_p$	9.37	4.68	0.01	37.24	10.68	18	10.23	3.25	0.02	51.86	16.17	13
RelEU Relation to exports, relEU_relimex$_p$	11.42	1.79	0.00	126.16	25.84	70	7.30	1.60	0.00	124.52	20.01	43
n.e.c.												
Concentration, HHI_M$_p$	0.48	0.42	0.00	1.00	0.26	4,046	0.47	0.42	0.00	1.00	0.26	4,012
Share in production, smprod$_p$	4.92	0.16	0.00	977.02	35.37	1,281	4.90	0.17	0.00	977.02	35.99	1,229
Relation to exports, relimex$_p$	20.86	1.08	0.00	13,418.21	237.07	4,046	19.53	1.05	0.00	13,418.21	238.54	4,012
RelEU Concentration, relEU_HHI_M$_p$	1.79	1.46	0.00	11.07	1.17	4,046	1.79	1.47	0.00	11.07	1.17	4,012
RelEU Share in production, relEU_smprod$_p$	10.42	0.72	0.00	3,316.33	110.50	1,281	10.55	0.72	0.00	3,316.33	112.72	1,229
RelEU Relation to exports, relEU_relimex$_p$	13.78	1.34	0.00	4,759.64	120.43	4,046	13.02	1.30	0.00	4,759.64	120.48	4,012
normalised indicators												
products without import dependence												
Concentration, HHI_M$_p$	0.307	0.287	0.000	0.655	0.131	154	0.311	0.286	0.000	0.664	0.128	104
Share in production, smprod$_p$	0.000	0.000	0.000	0.003	0.001	32	0.001	0.000	0.000	0.006	0.001	43
Relation to exports, relimex$_p$	0.001	0.000	0.000	0.147	0.012	143	0.001	0.000	0.000	0.026	0.003	104
RelEU Concentration, relEU_HHI_M$_p$	0.097	0.094	0.000	0.263	0.041	154	0.093	0.087	0.000	0.263	0.040	104
RelEU Share in production, relEU_smprod$_p$	0.000	0.000	0.000	0.001	0.000	32	0.001	0.000	0.000	0.022	0.004	43
RelEU Relation to exports, relEU_relimex$_p$	0.001	0.000	0.000	0.040	0.004	154	0.001	0.000	0.000	0.043	0.004	104
products with import dependence												
Concentration, HHI_M$_p$	0.732	0.740	0.326	1.000	0.193	74	0.709	0.668	0.240	1.000	0.182	43
Share in production, smprod$_p$	0.001	0.001	0.000	0.004	0.001	18	0.002	0.000	0.000	0.012	0.003	13
Relation to exports, relimex$_p$	0.004	0.000	0.000	0.213	0.025	70	0.000	0.000	0.000	0.004	0.001	43
RelEU Concentration, relEU_HHI_M$_p$	0.181	0.166	0.070	0.414	0.081	74	0.191	0.177	0.077	0.332	0.068	43
RelEU Share in production, relEU_smprod$_p$	0.002	0.001	0.000	0.007	0.002	18	0.002	0.000	0.000	0.009	0.003	13
RelEU Relation to exports, relEU_relimex$_p$	0.008	0.000	0.000	0.484	0.056	70	0.001	0.000	0.000	0.015	0.002	43
n.e.c.												
Concentration, HHI_M$_p$	0.476	0.424	0.000	1.000	0.263	4,046	0.474	0.422	0.000	1.000	0.262	4,012
Share in production, smprod$_p$	0.001	0.000	0.000	0.239	0.009	1,281	0.001	0.000	0.000	0.239	0.009	1,229
Relation to exports, relimex$_p$	0.002	0.000	0.000	1.120	0.020	4,046	0.002	0.000	0.000	1.120	0.020	4,012
RelEU Concentration, relEU_HHI_M$_p$	0.132	0.108	0.000	0.814	0.086	4,046	0.132	0.108	0.000	0.814	0.086	4,012
RelEU Share in production, relEU_smprod$_p$	0.002	0.000	0.000	0.590	0.020	1,281	0.002	0.000	0.000	0.590	0.020	1,229
RelEU Relation to exports, relEU_relimex$_p$	0.002	0.000	0.000	0.580	0.015	4,046	0.002	0.000	0.000	0.580	0.015	4,012

Source: BACI data (Gaulier – Zignago 2010), Authors' own calculations.

Table D.2: Descriptive statistics for product level import dependency indicators – Austria, changes between 2012 and 2018

	Advanced technologies for industries						COVID-strategic products					
	mean	med	min	max	standard deviation	obs	mean	med	min	max	standard deviation	obs
untransformed variables												
products without import dependence												
Δ Concentration, DHHI_M$_p$	-0.08	-0.06	-1.35	1.00	0.42	154	-0.10	-0.06	-1.13	1.00	0.36	104
Δ Share in production, Dsmprod$_p$	0.15	0.00	-0.66	2.53	0.68	32	0.28	0.20	-1.12	1.95	0.64	43
Δ Relation to exports, Drelimex$_p$	-0.02	0.00	-3.99	5.03	1.31	143	0.16	0.25	-3.96	3.71	1.08	104
Δ RelEU Concentration, DrelEU_HHI_M$_p$	-0.08	-0.03	-1.61	1.00	0.46	154	-0.10	-0.05	-1.53	1.00	0.42	104
Δ RelEU Share in production, DrelEU_smprod$_p$	-0.03	-0.06	-2.02	2.25	0.88	32	0.00	0.06	-5.35	1.89	1.09	43
Δ RelEU Relation to exports, DrelEU_relimex$_p$	-0.11	-0.10	-4.07	4.71	1.40	143	0.05	0.28	-5.45	3.73	1.15	104
products with import dependence												
Δ Concentration, DHHI_M$_p$	0.30	0.26	-0.49	1.31	0.38	74	0.31	0.28	-0.12	0.88	0.31	43
Δ Share in production, Dsmprod$_p$	0.74	0.78	-0.52	2.84	0.86	18	0.84	0.67	-1.28	1.83	0.95	13
Δ Relation to exports, Drelimex$_p$	0.24	0.24	-5.25	6.95	2.00	70	0.30	0.38	-6.59	4.97	1.96	43
Δ RelEU Concentration, DrelEU_HHI_M$_p$	0.35	0.28	-0.52	1.89	0.46	74	0.38	0.36	-0.72	1.26	0.42	43
Δ RelEU Share in production, DrelEU_smprod$_p$	-1.03	-0.09	-11.12	2.09	3.49	18	1.19	1.12	-0.83	2.77	1.29	13
Δ RelEU Relation to exports, DrelEU_relimex$_p$	0.21	0.25	-5.28	9.10	2.19	70	0.27	0.51	-6.48	4.63	2.01	43
n.e.c.												
Δ Concentration, DHHI_M$_p$	0.00	0.00	-2.06	1.62	0.48	4046	0.00	0.00	-2.06	1.62	0.48	4,012
Δ Share in production, Dsmprod$_p$	0.06	0.12	-6.11	5.86	1.30	1281	0.04	0.11	-6.11	5.30	1.28	1,229
Δ Relation to exports, Drelimex$_p$	0.11	0.19	-9.46	9.60	1.77	4046	0.10	0.17	-8.67	9.60	1.76	4,012
Δ RelEU Concentration, DrelEU_HHI_M$_p$	0.00	0.01	-7.00	2.48	0.63	4046	0.00	0.01	-7.00	2.48	0.63	4,012
Δ RelEU Share in production, DrelEU_smprod$_p$	-0.25	-0.04	-16.23	4.24	1.64	1281	-0.30	-0.06	-16.23	4.24	1.68	1,229
Δ RelEU Relation to exports, DrelEU_relimex$_p$	-0.38	0.06	-249.06	9.37	7.08	4046	-0.33	0.04	-249.06	9.37	6.74	4,012
normalised indicators												
products without import dependence												
Δ Concentration, DHHI_M$_p$	0.184	0.184	0.000	0.354	0.065	154	0.182	0.187	0.064	0.295	0.051	104
Δ Share in production, Dsmprod$_p$	0.002	0.001	0.001	0.013	0.003	32	0.002	0.001	0.000	0.007	0.001	43
Δ Relation to exports, Drelimex$_p$	0.000	0.000	0.000	0.001	0.000	143	0.000	0.000	0.000	0.000	0.000	104
Δ RelEU Concentration, DrelEU_HHI_M$_p$	0.113	0.114	0.000	0.228	0.044	154	0.113	0.114	0.026	0.298	0.039	104
Δ RelEU Share in production, DrelEU_smprod$_p$	0.001	0.001	0.000	0.007	0.002	32	0.001	0.001	0.000	0.005	0.001	43
Δ RelEU Relation to exports, DrelEU_relimex$_p$	0.000	0.000	0.000	0.001	0.000	154	0.000	0.000	0.000	0.000	0.000	104
products with import dependence												
Δ Concentration, DHHI_M$_p$	0.287	0.256	0.121	0.737	0.119	74	0.284	0.262	0.176	0.479	0.090	43
Δ Share in production, Dsmprod$_p$	0.003	0.002	0.001	0.018	0.004	18	0.004	0.002	0.000	0.007	0.003	13
Δ Relation to exports, Drelimex$_p$	0.000	0.000	0.000	0.007	0.001	70	0.000	0.000	0.000	0.001	0.000	43
Δ RelEU Concentration, DrelEU_HHI_M$_p$	0.192	0.158	0.072	0.796	0.118	74	0.190	0.172	0.059	0.422	0.081	43
Δ RelEU Share in production, DrelEU_smprod$_p$	0.003	0.002	0.000	0.012	0.003	18	0.005	0.003	0.000	0.012	0.005	13
Δ RelEU Relation to exports, DrelEU_relimex$_p$	0.001	0.000	0.000	0.069	0.008	70	0.000	0.000	0.000	0.001	0.000	43
n.e.c.												
Δ Concentration, DHHI_M$_p$	0.208	0.196	0.000	0.998	0.104	4,698	0.208	0.196	0.000	0.998	0.105	4,578
Δ Share in production, Dsmprod$_p$	0.003	0.001	0.000	0.371	0.014	1,344	0.003	0.001	0.000	0.213	0.009	1,280
Δ Relation to exports, Drelimex$_p$	0.000	0.000	0.000	0.093	0.002	4,085	0.000	0.000	0.000	0.093	0.002	4,048
Δ RelEU Concentration, DrelEU_HHI_M$_p$	0.135	0.120	0.000	1.427	0.089	4,698	0.135	0.120	0.000	1.427	0.090	4,578
Δ RelEU Share in production, DrelEU_smprod$_p$	0.002	0.001	0.000	0.138	0.007	1,344	0.002	0.001	0.000	0.124	0.005	1,280
Δ RelEU Relation to exports, DrelEU_relimex$_p$	0.000	0.000	0.000	0.090	0.002	4,085	0.000	0.000	0.000	0.090	0.002	4,048

Source: BACI data (Gaulier – Zignago 2010), Authors' own calculations.

Table D.3: Descriptive statistics for product level competitiveness indicators

	Key enabling technologies					COVID-strategic products				
	Avg.	min	max	standard deviation	obs	Avg.	min	max	standard deviation	obs
untransformed variables										
products without import dependence										
Proximity, PRI_P	0,33	0,20	0,43	0,05	158	0,34	0,21	0,43	0,05	106
Sophistication, PCI_p:	0,76	-1,15	2,60	0,59	158	0,19	-2,38	1,59	1,02	106
Log. ratio unit value, $LUVR_{p,S}$:	0,81	-0,25	2,11	0,35	154	0,68	0,08	1,23	0,23	104
products with import dependence										
Proximity, PRI_P	0,32	0,23	0,43	0,05	71	0,36	0,26	0,43	0,04	41
Sophistication, PCI_p:	0,71	-1,14	2,23	0,66	71	0,37	-1,37	2,02	0,66	41
Log. ratio unit value, $LUVR_{p,S}$:	0,73	-0,01	1,82	0,40	71	0,66	-0,28	1,27	0,33	41
n.e.c.										
Proximity, PRI_P	0,33	0,16	0,90	0,05	5.151	0,33	0,19	0,90	0,05	4.963
Sophistication, PCI_p:	-0,03	-4,30	2,88	1,00	5.151	-0,03	-4,30	2,88	1,00	4.963
Log. ratio unit value, $LUVR_{p,S}$:	0,71	-4,40	1,02	0,71	4.969	0,71	-4,40	1,02	0,70	4.793
normalized indicators										
products without import dependence										
Proximity, PRI_P	0,23	0,05	0,37	0,07	158	0,24	0,07	0,36	0,06	106
Sophistication, PCI_p:	0,71	0,44	0,96	0,08	158	0,63	0,27	0,82	0,14	106
Log. ratio unit value, $LUVR_{p,S}$:	0,36	0,29	0,45	0,02	154	0,35	0,31	0,39	0,02	104
products with import dependence										
Proximity, PRI_P	0,23	0,10	0,37	0,07	71	0,27	0,13	0,37	0,05	41
Sophistication, PCI_p:	0,70	0,44	0,91	0,09	71	0,65	0,41	0,88	0,09	41
Log. ratio unit value, $LUVR_{p,S}$:	0,35	0,30	0,43	0,03	71	0,35	0,28	0,39	0,02	41
n.e.c.										
Proximity, PRI_P	0,23	0,00	1,00	0,07	5.151	0,23	0,04	1,00	0,07	4.963
Sophistication, PCI_p:	0,59	0,00	1,00	0,14	5.151	0,60	0,00	1,00	0,14	4.963
Log. ratio unit value, $LUVR_{p,S}$:	0,35	0,00	1,00	0,05	4.969	0,35	0,00	1,00	0,05	4.793

Source: BACI data (Gaulier – Zignago 2010), Authors‘ own calculations.

Table D.4: Descriptive statistics for economic potential indicators

	Key enabling technologies					COVID-strategic products				
	Avg.	min	max	standard deviation	obs	Avg.	min	max	standard deviation	obs
untransformed variables										
products without import dependence										
Global market growth $\bar{G}_n$	0,08	-1,23	0,74	0,17	155	0,07	-0,73	0,38	0,15	106
Global market volume S_n	0,01	0,00	0,07	0,01	155	0,01	0,00	0,27	0,03	106
clustering market entry rel. product lines, CI_n	0,01	0,00	0,02	0,00	155	0,01	0,00	0,01	0,00	106
intra-industry divers. (niche creation), GLI_n	0,55	0,00	0,99	0,26	155	0,63	0,00	1,00	0,25	105
Impl. Productivity contrib. to industry, $IPI_{n,s}$	38.764,80	12.613,61	88.264,99	9.745.637,00	158	33.940,71	4.985.066,00	66.072,43	13.301,45	106
products with import dependence										
Global market growth $\bar{G}_n$	0,13	-0,20	0,63	0,15	71	0,08	-0,16	0,31	0,09	40
Global market volume S_n	0,00	0,00	0,01	0,00	71	0,01	0,00	0,03	0,01	40
clustering market entry rel. product lines, CI_n	0,01	0,00	0,01	0,00	71	0,01	0,00	0,01	0,00	40
intra-industry divers. (niche creation), GLI_n	0,47	0,00	0,98	0,30	71	0,49	0,00	0,98	0,34	41
Impl. Productivity contrib. to industry, $IPI_{n,s}$	38.926,29	7.779.799,00	80.901,91	10.650,79	71	37.932,34	15.529,73	70.370,33	12.666,05	41
n.e.c.										
Global market growth $\bar{G}_n$	0,07	-2,59	2,06	0,19	5.139	0,08	-2,59	2,06	0,19	4.949
Global market volume S_n	0,00	0,00	1,00	0,02	5.139	0,00	0,00	1,00	0,02	4.949
clustering market entry rel. product lines, CI_n	0,01	0,00	0,02	0,00	5.139	0,01	0,00	0,02	0,00	4.949
intra-industry divers. (niche creation), GLI_n	0,47	0,00	1,00	0,30	5.020	0,48	0,00	1,00	0,30	4.842
Impl. Productivity contrib. to industry, $IPI_{n,s}$	29.900,48	1.478.345,00	125.750,30	13.015,31	5.151	30.454,44	1.941.705,00	125.750,30	12.838,51	4.963
normalized indicators										
products without import dependence										
Global market growth $\bar{G}_n$	0,57	0,29	0,71	0,04	155	0,57	0,40	0,64	0,03	106
Global market volume S_n	0,01	0,00	0,07	0,01	155	0,01	0,00	0,27	0,03	106
clustering market entry rel. product lines, CI_n	0,52	0,04	0,92	0,17	155	0,53	0,13	0,85	0,16	106
intra-industry divers. (niche creation), GLI_n	0,55	0,00	0,99	0,26	155	0,63	0,00	1,00	0,25	105
Impl. Productivity contrib. to industry, $IPI_{n,s}$	0,26	0,08	0,63	0,05	158	0,25	0,03	0,79	0,07	106
products with import dependence										
Global market growth $\bar{G}_n$	0,58	0,51	0,69	0,03	71	0,57	0,52	0,62	0,02	40
Global market volume S_n	0,00	0,00	0,01	0,00	71	0,01	0,00	0,03	0,01	40
clustering market entry rel. product lines, CI_n	0,44	0,00	0,83	0,20	71	0,50	0,07	0,78	0,16	40
intra-industry divers. (niche creation), GLI_n	0,47	0,00	0,98	0,30	71	0,49	0,00	0,98	0,34	41
Impl. Productivity contrib. to industry, $IPI_{n,s}$	0,25	0,04	0,48	0,05	71	0,25	0,10	0,42	0,06	41
n.e.c.										
Global market growth $\bar{G}_n$	0,57	0,00	1,00	0,04	5.139	0,57	0,00	1,00	0,04	4.949
Global market volume S_n	0,00	0,00	1,00	0,02	5.139	0,00	0,00	1,00	0,02	4.949
clustering market entry rel. product lines, CI_n	0,45	0,00	1,00	0,18	5.139	0,45	0,00	1,00	0,19	4.949
intra-industry divers. (niche creation), GLI_n	0,47	0,00	1,00	0,30	5.020	0,48	0,00	1,00	0,30	4.842
Impl. Productivity contrib. to industry, $IPI_{n,s}$	0,25	0,00	1,00	0,09	5.151	0,25	0,00	1,00	0,08	4.963

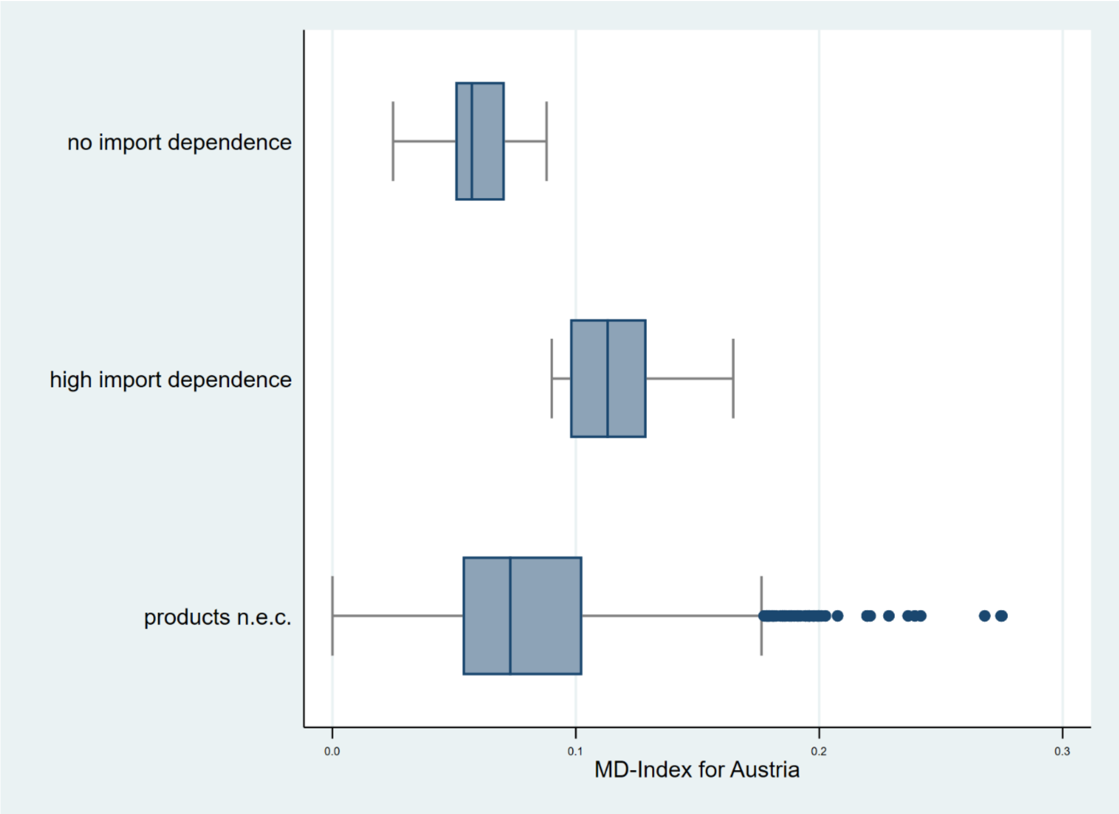
Source: BACI data (Gaulier – Zignago 2010), Authors‘ own calculations.

Table D.5: Descriptive statistics for market risk indicators

	Key enabling technologies					COVID-strategic products				
	Avg.	min	max	standard deviation	obs	Avg.	min	max	standard deviation	obs
untransformed variables										
products without import dependence										
Unit value volatility, VI_p:	24.510,35	–91,59	67.742,13	26.737,27	158	14.919,18	–91,59	67.742,13	23.652,97	106
Displacement index, DI_p:	0,00	–0,01	0,01	0,00	155	0,00	–0,01	0,01	0,00	106
Market concentration, $HHI\_MP_{p,c}$:	0,16	0,05	0,97	0,11	158	0,15	0,05	0,58	0,09	106
products with import dependence										
Unit value volatility, VI_p:	21.595,46	–91,59	67.742,13	25.969,81	71	27.084,01	–91,59	67.742,13	30.743,60	41
Displacement index, DI_p:	0,00	–0,01	0,01	0,00	71	0,00	–0,01	0,02	0,01	40
Market concentration, $HHI\_MP_{p,c}$:	0,20	0,06	0,68	0,12	71	0,16	0,05	0,71	0,12	41
n.e.c.										
Unit value volatility, VI_p:	10.119,90	–91,59	67.742,13	20.840,88	5.151	10.813,29	–91,59	67.742,13	21.330,58	4.963
Displacement index, DI_p:	0,00	–0,01	0,02	0,00	5.139	0,00	–0,01	0,02	0,00	4.949
Market concentration, $HHI\_MP_{p,c}$:	0,19	0,03	1,00	0,13	5.151	0,19	0,03	1,00	0,13	4.963
normalized indicators										
products without import dependence										
Unit value volatility, VI_p:	0,36	0,00	1,00	0,39	158	0,22	0,00	1,00	0,35	106
Displacement index, DI_p:	0,42	0,07	0,77	0,13	155	0,49	0,13	0,80	0,12	106
Market concentration, $HHI\_MP_{p,c}$:	0,14	0,02	0,97	0,11	158	0,12	0,03	0,56	0,10	106
products with import dependence										
Unit value volatility, VI_p:	0,32	0,00	1,00	0,38	71	0,40	0,00	1,00	0,45	41
Displacement index, DI_p:	0,37	0,14	0,68	0,13	71	0,51	0,11	1,00	0,14	40
Market concentration, $HHI\_MP_{p,c}$:	0,17	0,03	0,67	0,13	71	0,13	0,02	0,70	0,13	41
n.e.c.										
Unit value volatility, VI_p:	0,15	0,00	1,00	0,31	5.151	0,16	0,00	1,00	0,31	4.963
Displacement index, DI_p:	0,41	0,00	1,00	0,14	5.139	0,41	0,00	0,96	0,14	4.949
Market concentration, $HHI\_MP_{p,c}$:	0,16	0,00	1,00	0,14	5.151	0,16	0,00	1,00	0,14	4.963

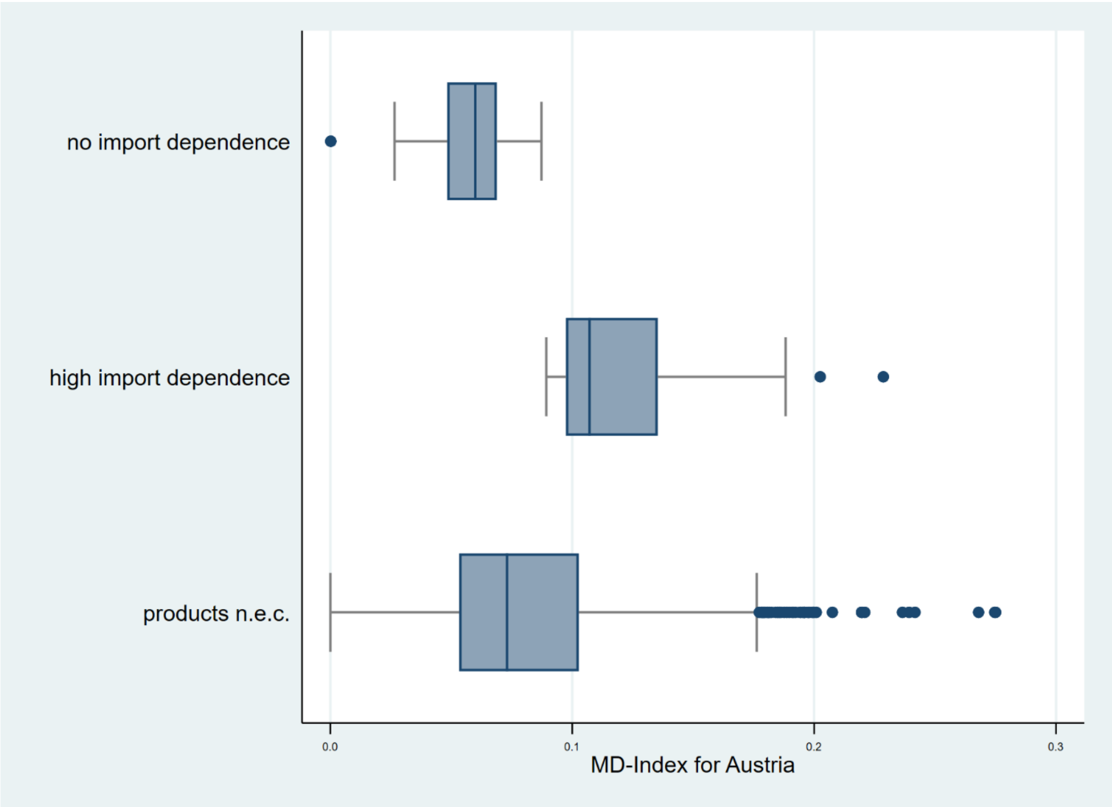
Source: BACI data (Gaulier – Zignago 2010), Authors‘ own calculations.

Figure D.1: Distribution of the MD-Index for COVID-19 products



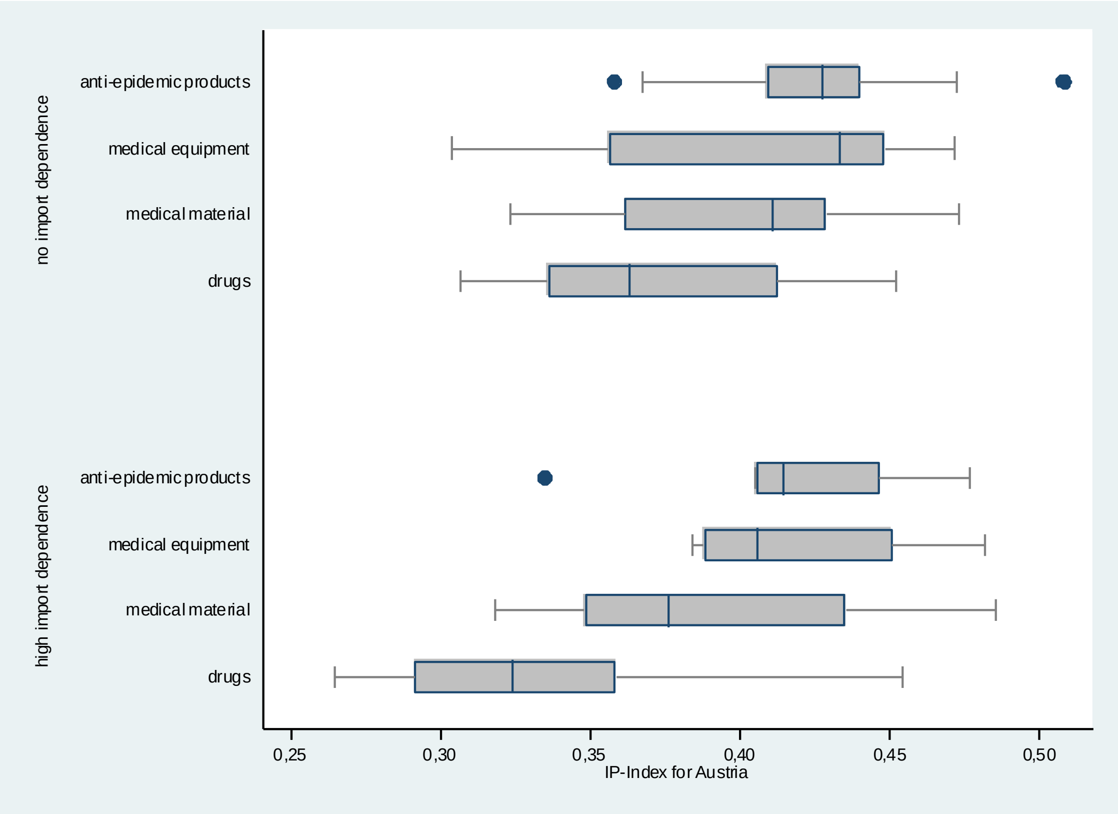
Source: Authors' own calculations.

Figure D.2: Distribution of the MD-Index for Advanced Technologies for Industry (ATI)



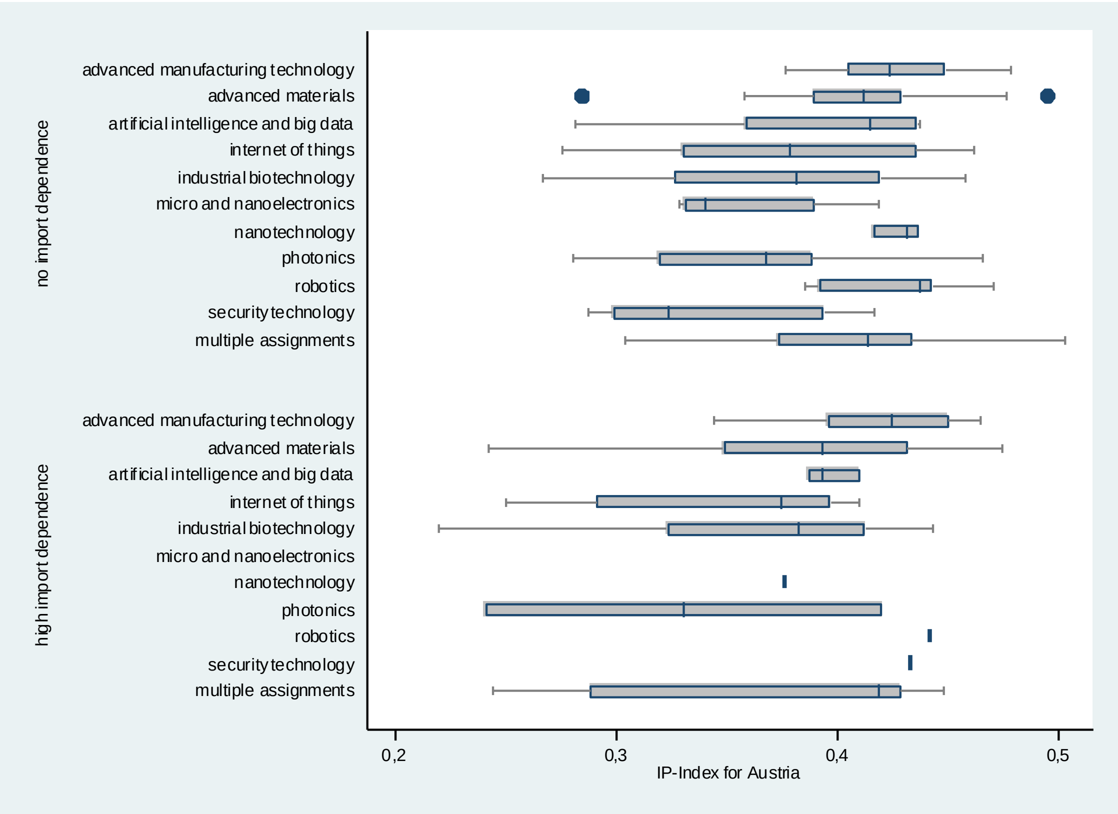
Source: Authors' own calculations.

Figure D.3: Distribution of the IP-Index for Austria: COVID-19 products



Source: Authors' own calculations.

Figure D.4: Distribution of the IP-Index for Austria: Advanced Technologies for Industry (ATI)



Source: Authors' own calculations.

Table D.6 provides an overview of the average index values for the Industrial Potential IP-index at the level of individual NACE 2-digit industries in the manufacturing sector in Austria. The averages were calculated for all products that can be assigned to an industry and not just for product lines with high import dependence, for COVID-strategic goods or key enabling technologies. Neglecting the manufacture of tobacco products, the industrial potential is lowest in the pharmaceutical industry.

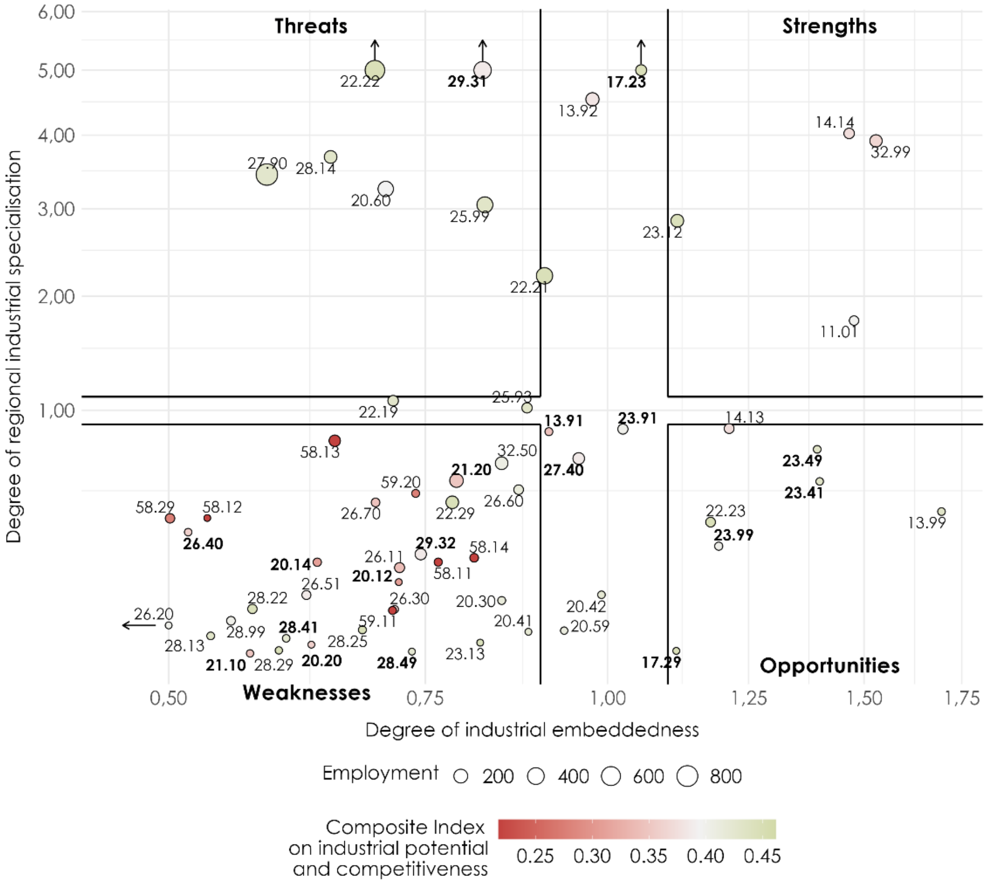
Table D.6: Industrial potential by industry, Austria

NACE 2008	Industry (2-digit)	Industrial potential (IP)
C 10	Manufacture of food products	0.46
C 11	Manufacture of beverages	0.49
C 12	Manufacture of tobacco products	0.40
C 13	Manufacture of textiles	0.45
C 14	Manufacture of wearing apparel	0.43
C 15	Manufacture of leather and related products	0.45
C 16	Manufacture of wood and of products of wood and cork, except furniture	0.47
C 17	Manufacture of paper and paper products	0.48
C 18	Printing and reproduction of recorded media	0.47
C 19	Manufacture of coke and refined petroleum products	0.47
C 20	Manufacture of chemicals and chemical products	0.45
C 21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.40
C 22	Manufacture of rubber and plastic products	0.49
C 23	Manufacture of other non-metallic mineral products	0.47
C 24	Manufacture of basic metals	0.47
C 25	Manufacture of fabricated metal products, except machinery and equipment	0.48
C 26	Manufacture of computer, electronic and optical products	0.43
C 27	Manufacture of electrical equipment	0.48
C 28	Manufacture of machinery and equipment n.e.c.	0.48
C 29	Manufacture of motor vehicles, trailers and semi-trailers	0.49
C 30	Manufacture of other transport equipment	0.43
C 31	Manufacture of furniture	0.47
C 32	Other manufacturing	0.44
Average over all manufacturing industries		0.45

Source: Authors' own calculations;

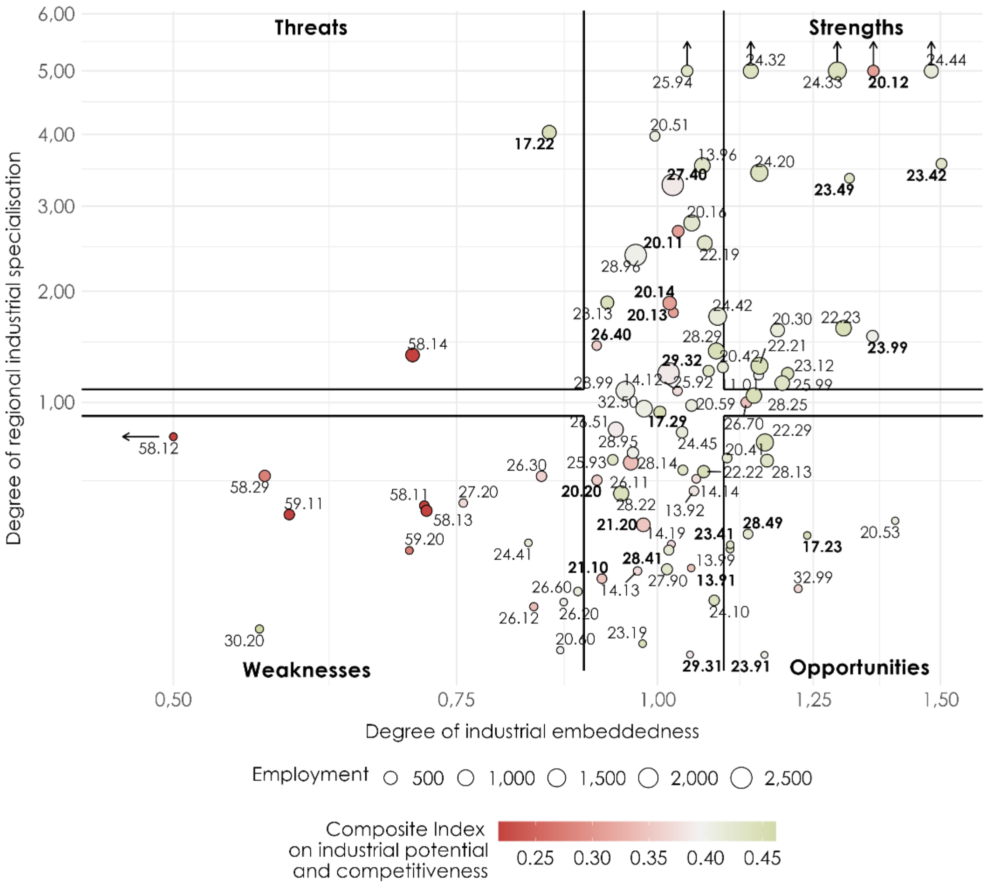
E. SWOT Profiles of the remaining federal states of Austria

Figure E.1: SWOT-Profile on strategic products for the region of Burgenland (AT11)



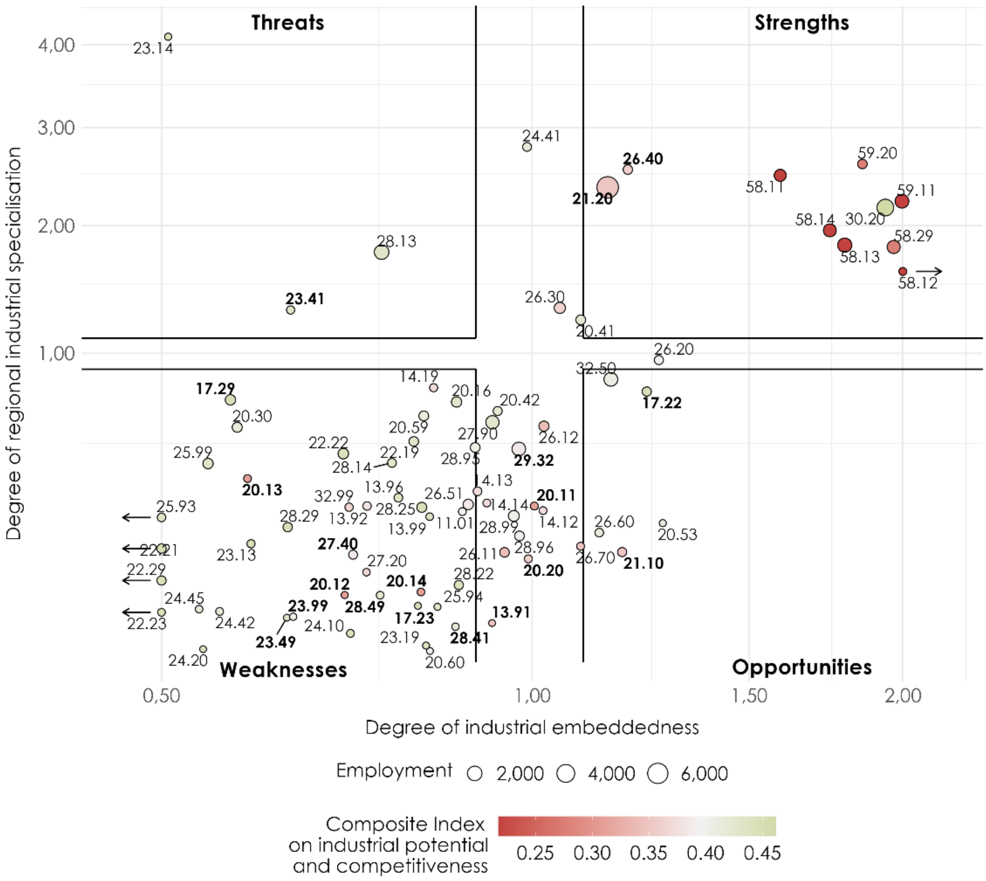
Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Figure E.2: SWOT-Profile on strategic products for the region of Lower Austria (AT12)



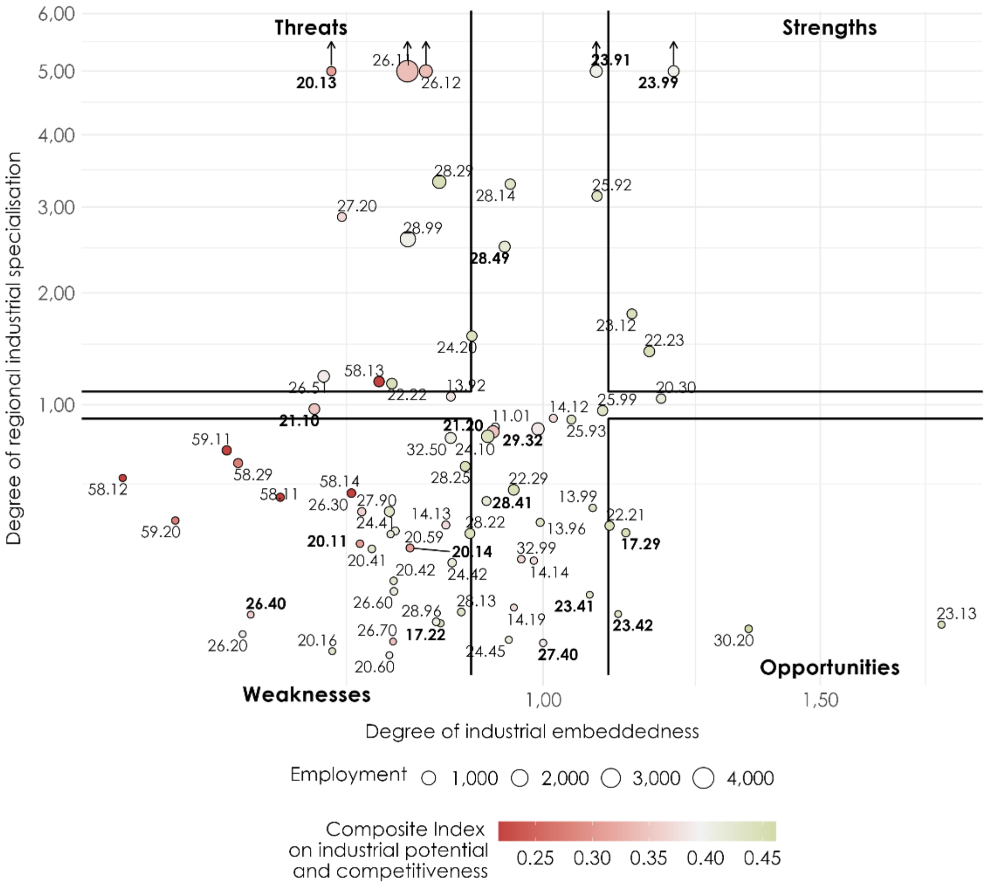
Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Figure E.3: SWOT-Profile on strategic products for the region of Vienna (AT13)



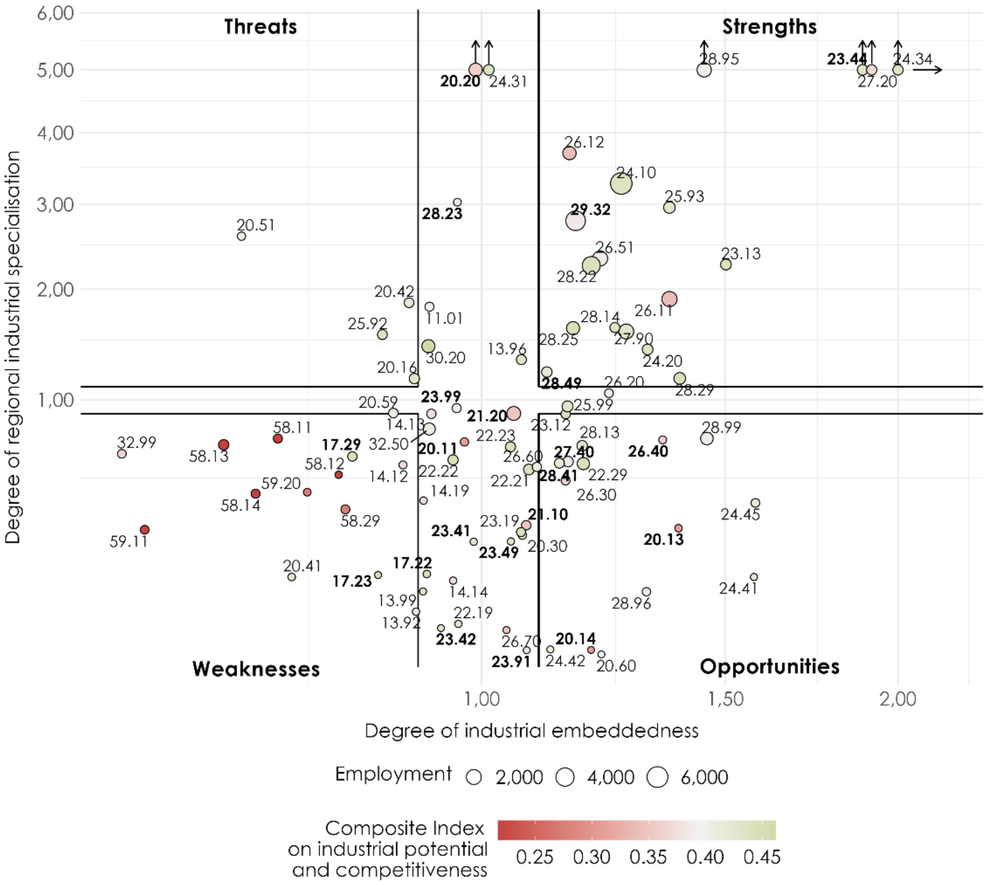
Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Figure E.4: SWOT-Profile on strategic products for the region of Carinthia (AT21)



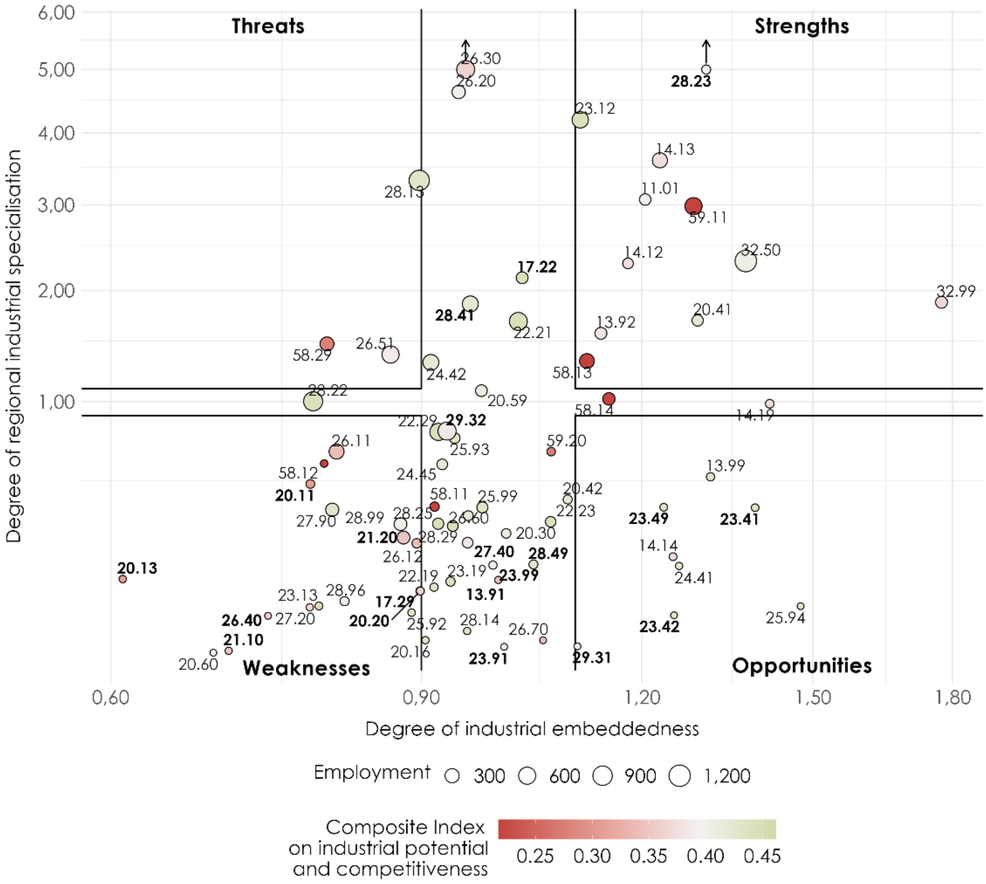
Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Figure E.5: SWOT-Profile on strategic products for the region of Styria (AT22)



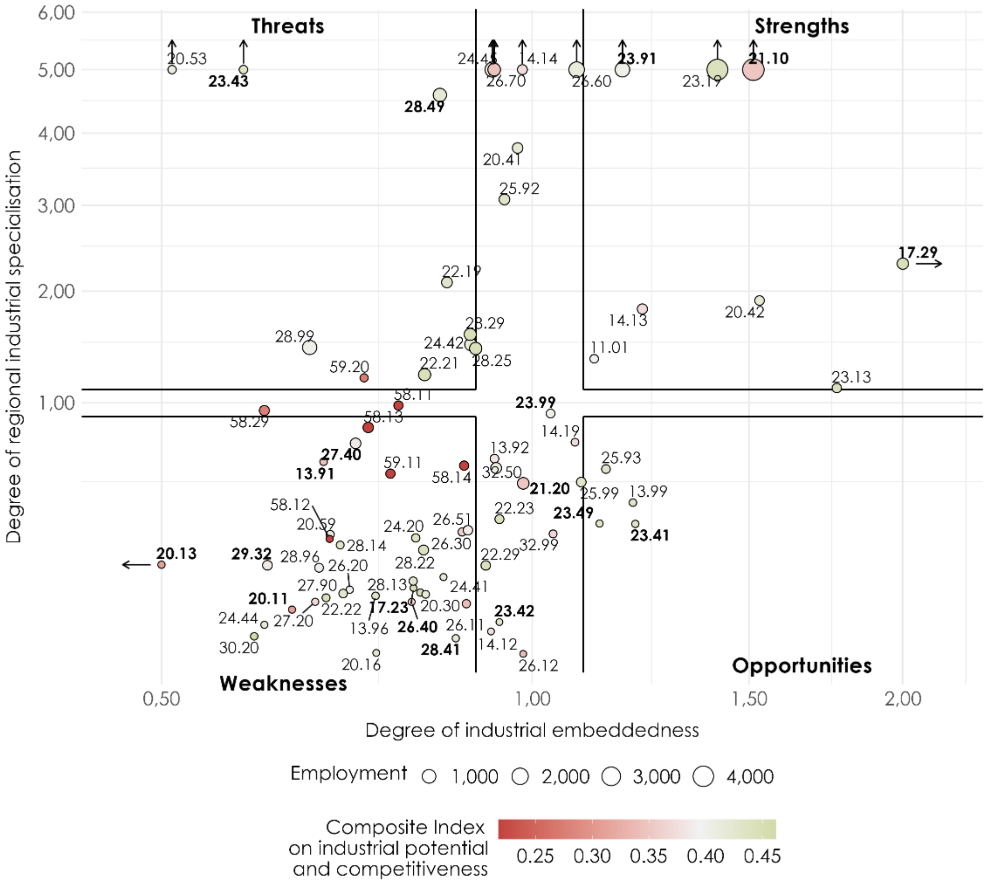
Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Figure E.6: SWOT-Profile on strategic products for the region of Salzburg (AT32)



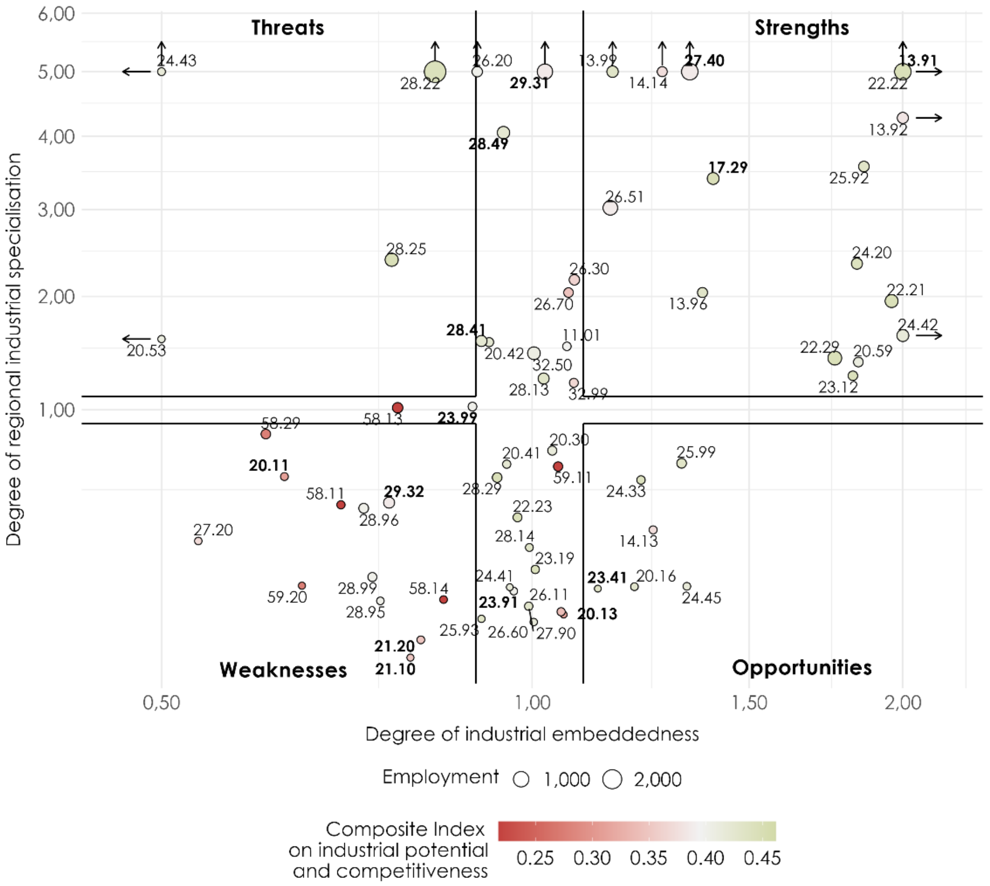
Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Figure E.7: SWOT-Profile on strategic products for the region of Tyrol (AT33)



Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Figure E.8: SWOT-Profile on strategic products for the region of Vorarlberg (AT34)



Source: INDI-DV, authors' own calculations. - For the industry names of the individual NACE 4-digit codes, see Table 4; for details on the total industrial potential index, see Section 2.2; industries marked in bold indicate a particularly high degree of import dependency (>75% percentile) for COVID-strategic products and key enabling technologies vis-à-vis third countries (see Section 2.1 for further details).

Additional references cited in the Appendix

Balassa B. (1965). Trade Liberalization and 'Revealed' Comparative Advantage, Manchester School 33, 99-123.

Cherchye L., Knox Lovell C.A., Moesen W. Van Puyenbroeck T. (2007). One market, one number? A composite indicator assessment of EU internal market dynamics. European Economic Review 51, 749-779.

Diewert W.E., Nakamura A.O. (2003). Index number concepts, measures and decomposition of productivity growth. Journal of Productivity Analysis 19, 127-159.

Freudenberg M. (2003). 'Composite Indicators of Country performance: a critical assessment', STI Working Paper 2003/16, Paris: OECD

Gaulier, G., Zignago, S., (2010). BACI: International Trade Database at the Product-level, CEPII Working Paper No. 2010-23.

Hoffman A., Giovannini E., Nardo M., Saisana M., Saltelli A., Tarantola S. (2005). Handbook for constructing composite indicators: Methodology and user guide. STD Working Paper 2005/3, Paris: OECD

Joint Research Centre (JRC) (2002). State-of-the-art report on current methodologies and practices for composite indicator development, Prepared by the Applied Statistics Group JRC, verfügbar über die JRC Internet Seite, Zugriff 15. Dezember 2007.

Mayoux L. (2002). 'What Do We Want to Know? Selecting Indicators', Paper of the Enterprise Development Impact Assessment Information Service, University of Manchester, verfügbar über die EDIAIS Internet Seite, Zugriff 15. Dezember 2007.

Saisana M., Saltelli A., Tarantola S. (2005). Uncertainty and sensitivity analysis as tools for the quality assessment of composite indicators. Journal of the Royal Statistical Society Series A 168, 1-17.

Sajeva M., Gatelli D., Tarantola S., Hollanders H. (2005). Methodology Report on the European Innovation Scoreboard 2005. European Trend Chart on Innovation. European Communities.

Talukder B., Hipel K.W., van Loon G.W. (2017). Developing Composite Indicators for Agricultural Sustainability Assessment: Effect of Normalization and Aggregation Techniques. Resources 6 (66), doi:10.3390/resources6040066.