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"SCAN" (Supply Chain Alert Notification) monitoring system

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“SCAN” (Supply Chain Alert Notification) monitoring system[1]

Abstract

This note proposes an indicator-based mechanism in order to monitor the evolution of supply chains in the European Union (EU) and identify potential distress. Current events, such as COVID-19 or the Russian aggression against Ukraine, have highlighted the need for a better risk assessment of supply chains, particularly in strategic areas, with the ultimate goal of detecting disruptions as early as possible to avoid potential adverse effects on the economy and society. The proposed monitoring system is entitled “SCAN” (Supply Chain Alert Notification) and its main goal is to identify significant inflationary pressures and/or shortages, resulting from imbalances between demand and supply. This data-driven system could alert policy makers on possible supply chain disruptions, which can occur for specific products and sectors. The SCAN is first applied at the product level, where supply chain disruptions start to materialise. In order to be able to have targeted conclusions, we illustrate how this mechanism performs by focusing on a set of important commodities in two strategic settings – i.e. production of solar panels, commodities affected by the Russian invasion. The SCAN is then applied for the universe of sectors to capture signals of distress with more important aggregate consequences.

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[1] GROW A1: Afonso Amaral (GROW); William Connell (GROW); Francesco Di-Comite (GROW); Cristina Herghelegiu (GROW).

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1. Introduction

The EU benefits from world markets being open and integrated in global value chains both in terms of efficiency and resilience, through cost reduction, economies of scale, increase in innovation, risk reduction or access to foreign inputs (see for instance Shu and Steinwender, 2019; Akcigit and Melitz, 2021; Baldwin and Freeman, 2021). However, despite the overall efficiency and resilience considerations, disruptions in global value chains can affect specific products and inputs that are particularly critical for consumers and producers, leading to important market failures. Indeed, recent events, such as the COVID-19 pandemic and the Russian aggression against Ukraine, triggered several supply chains disruptions that have led to price increases and/or shortages for a wide range of products. Given the increasing economic relevance of these types of disruptions, monitoring the situation of EU supply chains is key to increase preparedness by supporting evidence-based policy making.

The development of tools aiming at monitoring supply chains is not a new concept, as this allows both companies and policy makers to increase preparedness in times of crises. For instance, some companies use developed risk monitoring technologies, targeted to the scope of their business, to understand which disruptions are likely to arise in their specific supply chains and how to best respond to these disruptions.[2] However, the idea of developing tools to monitor supply chains extends well beyond individual businesses. The public sector, the international bodies and the research circles are also making active efforts in this area, in order to get a better grasp of the situation and ensure a smooth functioning of the economy. For example, when it comes to certain agricultural goods, an inter-agency platform – the Agricultural Market Information System (AMIS) – was introduced in 2011 to enhance food market transparency and policy responses for food security.[3] AMIS analyses global food supplies for wheat, maize, rice and soybeans, while providing a platform to coordinate policy responses in times of crises. Another example could be the World Bank's efforts to monitor the commodity markets in terms of prices and produce economic forecasts.[4] Nevertheless, despite these public efforts, the existing monitoring tools in the EU are rather scarce or targeted to specific products. Most importantly, the majority of these cases do not allow the tracking of the real-time evolution of supply chains.[5]

We contribute by proposing a monitoring system, entitled "SCAN" (Supply Chain Alert Notification), targeted to identify signs of distress in EU's supply chains.[6] More precisely, our monitoring system is intended to capture potential significant inflationary pressures and/or shortages, which can result from imbalances between demand and supply, where supply cannot keep up with demand. More precisely, the issue can be due to a demand increase for a constant supply (e.g. increase in the consumer demand of surgical masks), a supply decrease for a constant demand (e.g. logistic crunches due to pandemic restrictions) or a demand increase combined with a supply decrease (e.g. the case of wood where the renovation wave led to a demand increase, but there were also some identified supply

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[2] For example, the *Gartner Supply Chain Top 25* identifies characteristics of firms that demonstrate excellence in supply chain management aiming at building resilience. See for instance the "Gartner Supply Chain Top 25" for specific examples of global firms that according to their methodology are performing exceptionally well.

[3] https://app.amis-outlook.org/#/market-database/supply-and-demand-overview

[4] https://www.worldbank.org/en/research/commodity-markets#1

[5] The data are usually annual and focus on monitoring specific commodities, without taking into account the supply chains of those commodities.

[6] This monitoring tool can be applied to other countries subject to data availability. Having results from different countries across the world would improve the overall assessment of supply chain distress.

problems). The SCAN tool is defined at two levels of aggregation: 1) products, with a focus on strategic ones (either linked to specific contexts such as the Russian invasion of Ukraine or used as inputs to produce strategic products), and 2) industrial sectors, with a comprehensive coverage. The two levels of monitoring serve different purposes. First, since analysing the supply chain of the universe of products would not allow for a targeted monitoring due to the high number of products (more than 5,000 depending on the product aggregation), the SCAN at the product level allows to focus on strategic and/or critical products. While anticipating disruptions of specific products through the use of quantitative indicators is outside the scope of this paper, we can narrow down our monitoring to strategic products where disruptions are expected to occur. For example, as a consequence of the Russian invasion of Ukraine, economic rationale suggests that distress might occur in those products where the EU is heavily dependent on Russia, considering that not immediate alternatives are found. In addition, the green transition is increasing the demand for strategic inputs, potentially generating supply chain distress. In parallel, we analyse the supply chains of the universe of industrial sectors as it allows to identify disruptions with more important consequences at the aggregate level.

Our aim is to identify indicators with the same rationale at different levels of aggregation. To this end, we rely primarily on a set of core indicators – summarised under the SCAN – hinting to potential significant inflationary pressures and/or shortages both at product and sectoral levels. These metrics are then complemented with other indicators, which give additional information on the level of distress, but which are specific to each level of aggregation. While these tools do not provide a comprehensive assessment of the situation of supply chains, they can provide warnings that the ex-ante potential distress product/sector is materialising.

2. Monitoring at a product level

Supply chain distress starts by materialising in specific products, as it was the case for surgical masks and semiconductors during the COVID-19 pandemic, as well as for various commodities in the context of the Russian aggression against Ukraine. While a general monitoring system at the product level can be very informative, exploring systematically the universe (above 5,000 products depending on the level of aggregation) of products will not necessarily bring much value added due to the high number of products. Indeed, the focus on specific baskets of products experiencing potential distress can lead to more targeted conclusions. In what follows, we focus on products relevant in specific contexts - such as the Russian invasion of Ukraine - or further used in the production of strategic products, such as green technologies. On the latter, we rely on the example of raw materials that are used in the production of solar panels, as this can provide early warnings regarding bottlenecks that can impede ramping up the production of this particular renewable technology.

Two types of indicators are used to identify supply chain disruptions at the product level:

- **(Block 1) High-frequency indicators to capture price increases and/or shortages:** This set of indicators use high-frequency proxies of imported prices and quantities in the EU computed at a very disaggregated product level based on customs data.[7] The most distressed products are those that experience a significant

[7] These indicators can be updated every two weeks.

import price increase combined with a significant decrease in imported quantities.[8] [9] High-frequency customs data are also used to detect abnormal falls in the quantity imported, hinting to a potential shortage. More precisely, for both import prices and quantities, we compare the average of the last available three months with the average of the same period over the previous three years.[10] The comparison with the average of the previous three years is used to smooth out the potential abnormalities specific to a given year. All in all, the evolution of both import prices and quantities can be reported every two weeks to prevent some false alarms given the high volatility of trade flows in some products.

- **(Block 2) Structural indicators to assess the ex-ante risk of disruptions:** Block 2 relies on more structural indicators associated with an important ex-ante risk that, under particular circumstances, can materialize in significant import price and quantity fluctuations.[11] In addition, if this risk materialises, these indicators will identify products where the EU is heavily dependent on third markets and more likely to face to supply chains disruptions.[12] To measure the level of foreign dependency of a product, we monitor the concentration of extra-EU imports, as well as the substitution potential of these extra-EU imports with the EU domestic production. The economic intuition behind these indicators considered together is that if the EU relies on heavily concentrated imports without having the domestic production capacity, all else equal, bottlenecks in supply chains due to external shocks can materialise in price increases and/or shortages.

  For concentration, we use two complementary indicators: (1) the extra-EU import concentration and (2) the share of the first source in extra-EU imports, both computed based on the COMEXT dataset. Products highlighted as facing a high ex-ante risk include those with an HHI index above 0.4 (i.e. average imports originating in less than 3 countries) and the share of the first source above 50%.[13] For the substitutability of extra-EU imports with EU's domestic production, we also use two complementary indicators: (1) the ratio between extra-EU imports and total EU exports (proxy for production) computed based on the COMEXT dataset and (2) the exposure index defined as the share of extra-EU imports in EU total supply (sum of domestic production and extra-EU imports), where the trade data from COMEXT is complemented with production information (PRODCOM). The chosen thresholds indicating a high ex-ante risk for the first and second indicator are 1 and 0.6,

[8] Many factors can be associated with price increases and/or shortages at the product level, including trade policy interventions, exchange rate evolutions, shipping bottlenecks, among many others. Given that the effect of these factors across products is heterogeneous, the available data at hand do not allow to dig into all the factors driving the observed disruptions at the product level. Therefore, once disruptions are identified for specific products, our methodology should be complemented with deeper analyses and expert knowledge, in order to have a better understanding of the causes behind the observed distress.

[9] Future potential venues of analysis include calculating alternative proxing of price variations. This could include alternative indicators from trade statististics, as well as alternative sources such as listed price statistics.

[10] For example, if the latest available information is May 2022, the monitoring will take into account the average of the months of May, April and March for 2022 compared to the average of the same three months in 2021, 2020 and 2019.

[11] For more details for the underlying mechanisms, see the first issue of the Directorate-General for Internal Market's Single Market Economic Papers series on *Detecting and Analysing Supply Chain Disruptions.*

[12] For instance, the production of magnesium is heavily concentrated, with China controlling 89% of the world production. The energy crisis in China, including coal shortages, combined with the attempt to reach lower emission targets led to the abrupt closure of some plants producing magnesium. This has induced important disruptions for the EU's supply chains heavily reliant on magnesium.

[13] SWD (2021) 352 on strategic dependencies and capacities: swd-strategic-dependencies-capacities_en.pdf (europa.eu).

respectively.[14] In line with previous European Commission documents,[15] these thresholds suggest that, all else equal, the risk of disruption is considered to be higher for those products where domestic production cannot replace foreign imports. Indeed, the threshold equal to 1 indicates that EU imports are higher than EU exports, which means that in the case of crisis, existing export capacity cannot compensate potentially affected imports.[16] In the case of the threshold equals to 0.6, it considers products where imports accounts for more than 60% of total domestic supply (domestic production plus EU imports). Those products that have values above the indicated thresholds in all four structural indicators present a high risk of disruptions and those products with values above the indicated thresholds in a sub-block of two complementary indicators are considered as medium risk.

2.1 The example of raw materials relevant in the context of the Russian invasion of Ukraine

To illustrate the SCAN at the product level, we focus on a selected basket of raw materials that are known to be particularly relevant in the context of the Russian invasion of Ukraine. The two blocks of indicators described above are displayed in the form of a product SCAN containing a scoreboard and a graph, which show potential problematic products facing supply chain distress. Once again, the information provided in this tool should be complemented with an in-depth analysis, in order to validate and understand the factors behind the observed trends.

Table 1 presents the indicators used to analyse distress in the form of a scoreboard. It focuses on the list of commodities most affected by the Russian invasion of Ukraine. Thus, it includes indicators about the importance of Russia in EU's imports (Columns 1 and 2). Columns 3 and 4 present the high-frequency indicators included in Block 1. The following four columns include the foreign dependency structural indicators from Block 2. Finally, in Column 9, those products with a high ex-ante risk of disruptions are highlighted with two asterisk (**) and those with a medium risk are highlighted with one asterisk (*).

Graph 1 displays the evolution of import prices and quantities for all selected commodities as highlighted in Columns 3 and 4 of Table 1. Two shaded areas aim at identifying the most problematic products that seem to be relatively more affected by ongoing supply chain distress. In this respect, two cases can be distinguished. The first case, corresponding to quadrant II, shows products experiencing an increase in import price combined with a decrease in quantities imported and corresponds to our definition of potential disruptions. The second case, corresponding to quadrant I and products above the 45 degree line, shows commodities that are experiencing a stronger important increase in import price compared to the increase in quantities imported, which might potentially induce disruptions. The intensity of distress of a product can be measured by the distance to the "north-west" corner of quadrant II, where the closer the product is to this upper corner, the higher its potential distress (represented by the darker colour). In the graph, we also highlight with two asterisk

[14] Note that both indicators have their own limitations and for this reason are complementary. While the ratio between extra-EU imports and total EU exports does not capture total domestic production, the share of extra-EU imports and EU total supply replies on two separate databases (COMEXT and PRODCOM), which can lead to some aggregation concerns.

[15] SWD(2021) 352 final on EU strategic dependencies and capacities

[16] Indeed, Benoît et al. (2022) show that products that experience important import price increases and quantity decreases during 2021 (the first stages of the Covid-19 pandemic) are those that have a level of concentration above the chosen thresholds and where the EU is highly reliant on foreign imports.

(**) those products with a high ex-ante risk of disruptions and with one asterisk (*) those characterised by a medium ex-ante risk.

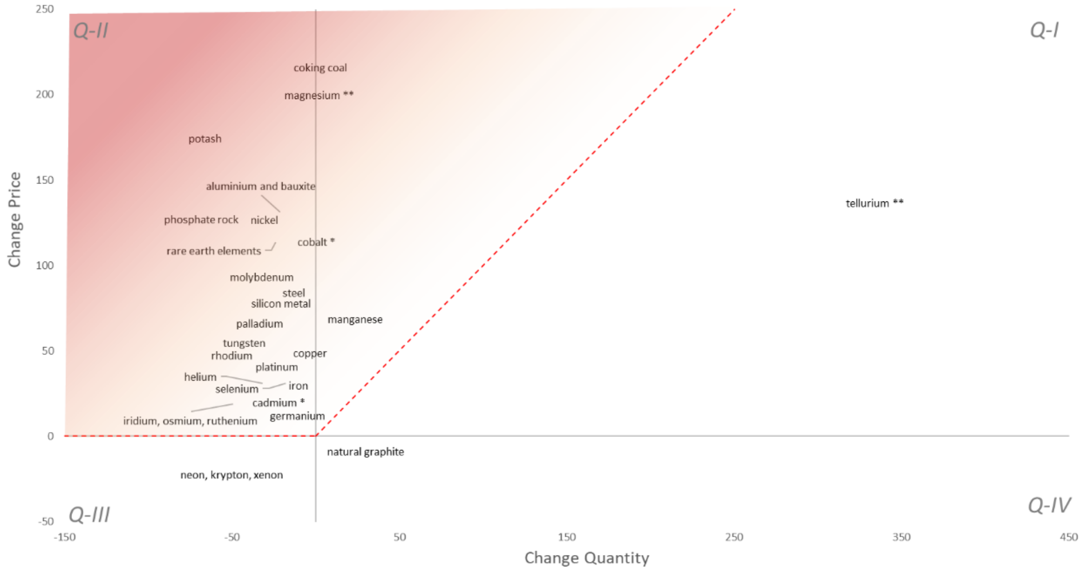
Table 1: Illustration of the SCAN at a product level

	Russia's importance in extra-EU imports		Block 1: High-frequency indicators		Block 2: Structural Indicators				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	RU share of EU imports	RU rank as source of import	Change in import price	Change in quantity	Concentration of extra-EU imports	Share 1st source in extra-EU imports	Ratio of extra-EU imports and total EU exports	Exposure index (without Exports)	Important ex ante risk of disruptions
aluminium and bauxite	7.1%	3	131%	-21%	0.1	27.10%	1	46.94%	
cadmium	13.8%	2	20%	-22%	0.7	83.90%	1	0.27%	*
coking coal	11.6%	3	209%	3%	0.3	41.90%	1.2		
copper	36.6%	1	49%	-3%	0.2	36.60%	0.6	32.44%	
germanium	0.2%	9	12%	-10%	0.3	50.60%	1.6	53.94%	
helium	1.0%	6	31%	-32%	0.3	41.70%	0.6	63.00%	
iridium, osmium, ruthenium	8.6%	4	19%	-49%	0.3	46.90%	0.3	42.99%	
iron	12.7%	5	30%	-18%	0.2	23.80%	2.1	79.50%	
magnesium	1.1%	4	200%	2%	0.8	91.30%	1.3	82.70%	**
manganese	1.2%	8	69%	24%	0.3	41.10%	1.4	67.16%	
molybdenum	1.9%	8	86%	-30%	0.2	22.20%	1	74.16%	
natural graphite	1.4%	11	-1%	4%	0.2	25.20%	1.7	3.91%	
neon, krypton, xenon	20.2%	3	-22%	-50%	0.2	33.60%	0.3	36.19%	
nickel	54.3%	1	130%	-35%	0.3	54.30%	1.2	74.31%	
palladium	37.4%	1	66%	-34%	0.3	37.40%	0.8	84.11%	
phosphate rock	40.7%	1	127%	-42%	0.3	40.70%	11.3	95.62%	
platinum	10.5%	4	32%	-12%	0.3	46.30%	0.6	64.36%	
potash	23.3%	3	174%	-66%	0.2	31.80%	2.7	31.56%	
rare earth elements	0.9%	8	114%	-24%	0.2	34.70%	0.9	21.07%	
rhodium	15.3%	3	47%	-50%	0.3	49.30%	0.5	77.38%	
selenium	31.0%	1	31%	-18%	0.2	31.00%	0.4	54.18%	
silicon metal	1.0%	11	82%	-20%	0.3	50.00%	1	45.29%	
steel	44.8%	1	84%	-13%	0.3	44.80%	1.2	4.42%	
tellurium	1.4%	5	137%	334%	0.4	62.30%	3.1	65.66%	**
tungsten	6.6%	6	55%	-42%	0.2	23.70%	0.4	13.61%	

Source: GROW A1 calculations based on the European Commission customs database, COMEXT and PRODCOM.

Note: For indicators in Block 1, we rely on high-frequency customs data and we compare the average for March/April/May 2022 with the average of the same period of 2021, 2020 and 2019. For the first three indicators in Block 2 we use the most up-to-date information using trade data (COMEXT 2021) and for the fourth indicators, we use trade (COMEXT) and production (PRODCOM) for 2019, to avoid abnormal statistics resulting from the first year of the pandemic, as the most up-to-date data on production refer to 2020. Indicators in Block 2 allow to identify products with an important ex-ante risk of disruptions. Those products with a high risk are highlighted with two asterisk (**) and those with a medium risk are highlighted with one asterisk (*).

Graph 1: Identification of distressed products through the sectoral SCAN



Source: GROW A1 calculations based on the European Commission customs database, COMEXT and PRODCOM. Note: Reference period: Note: For indicators in Block 1, we rely on high-frequency customs data and we compare the average for March/April/May 2022 with the average of the same period of 2021, 2020 and 2019. Changes in import prices are captured by the Y axis and changes in imported quantities are captured by the X axis. This information is complemented with the indicators in Block 2, which allow to identify products with an important ex-ante risk of disruptions. Those products with a high risk are highlighted with two asterisks (**) and those with a medium risk are highlighted with one asterisk (*).

To sum up, almost all raw materials likely to be affected by the Russian aggression of Ukraine experience distress (i.e. import price increases and/or import quantity decreases). The few exceptions include tellurium, neon and natural graphite. Moreover, with the exception of tellurium, all raw materials with an important ex-ante risk of disruptions are subject to import price increases and import quantity decreases (i.e. magnesium, cobalt, cadmium).

2.2 The example of Solar Panels

To further illustrate the SCAN monitoring tool at the product level, we focus on a specific basket of products necessary to produce a strategic final good. Our pilot example uses the most upstream inputs (i.e. raw materials) used in the production of solar panels. Distress occurring in the most upstream part of the supply chain of solar panels can have important implications for ramping up the production of this renewable energy technology. The choice to focus on solar panels is motivated by various factors. First, solar photovoltaic (solar PV) technologies have become the world’s fastest-growing energy technology and play an important role in securing sufficient amounts of decarbonised electricity to meet the goals of the European Green Deal. Second, contrary to the wind sector where the EU industry has a strong position, the EU solar PV industry is more reliant on international supply and value chains. While the EU ranks high in terms of deployment of solar PV installations, EU companies only represent a very small part of global production. Finally, solar cells and panels are an example of a “common dependency”, where the EU and other global actors strongly depend on China’s (upstream) manufacturing capacities.

In order to identify the relevant raw materials used in the production of solar panels, we rely on the concept of technological designs, as different designs require different raw materials. Therefore, the main objective is to identify the prevailing technological designs in the market and trace the raw materials necessary to produce solar panels based on these designs.[17] To illustrate this product-level example, we start by identifying the prevailing technologies to produce solar panels and the raw materials used in their production. Then we follow the same steps/blocks as before.

The sequence of steps is presented below:

1. **Finding critical materials for the prevailing technological designs**

2. **Monitor the real-time evolution of import prices and quantities for each material** (Block 1)

3. **Monitor the systemic risk stemming from foreign dependencies for each material** (Block 2)

4. **Summarising the information using the previously discussed SCAN format – scoreboard and graph**

The first step of this methodology consists in identifying the raw materials used in the prevailing technology-designs of solar panels. Some of the most known designs are crystalline silicon based designs, cadmium telluride designs or cooper indium gallium diselenide designs.[18] A recent study from the Joint Research Centre (JRC) already puts forward the 17 most important raw-materials required to build solar panels.[19] Illustration 1 considers all materials used to manufacture any of these solar panels designs and highlights which of these materials can be considered as critical.[20] However, following the above-mentioned methodology, we focus our analysis only on the most relevant Solar Panels designs. As silicon wafers designs make up around 95% of the current market in Europe,[21] we focus our analysis on the materials used in these designs: Silica, Gallium, Boron, Phosphorus, Indium. To complement this analysis, we consider also four more materials that are always necessary to manufacture any kind of solar panel: Tin, Lead, Silver, Molybdenum. It is worth noting that Tin and Lead are substitutes, that is, they serve the same purpose in solar panels manufacturing.[22] As shown in Illustration 1 by the shaded areas, the final short-list of materials to include in our early warning mechanism for solar panels supply chains includes: Silica, Gallium, Boron, Phosphorus, Tin, Lead, Silver, Molybdenum. In this way, we

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[17] When looking at these technological designs, it is important to consider that some might be more prevailing in a market than others and their level of performance might vary, depending on their application. In terms of substitutability, there are two main considerations to be made (1) either the designs can substitute each other as they achieve similar and acceptable levels of performance (baking different cakes using different recipes), or (2) specific materials in each design can substitute each other as they are required for the same purpose (baking one cake using one recipe but changing one ingredient). When focusing on the prevailing technology designs to produce solar panels, these two aspects will be taken into consideration.

[18] Carrara, S., Alves Dias, P., Plazzotta, B. and Pavel, C. (2020). Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system, EUR 30095 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-16225-4 (online), doi:10.2760/160859 (online), JRC119941

[19] Joint Research Centre, Critical Raw Materials for Strategic Technologies and Sectors in the EU: A Foresight Study; ISBN 978-92-76-15336-8.

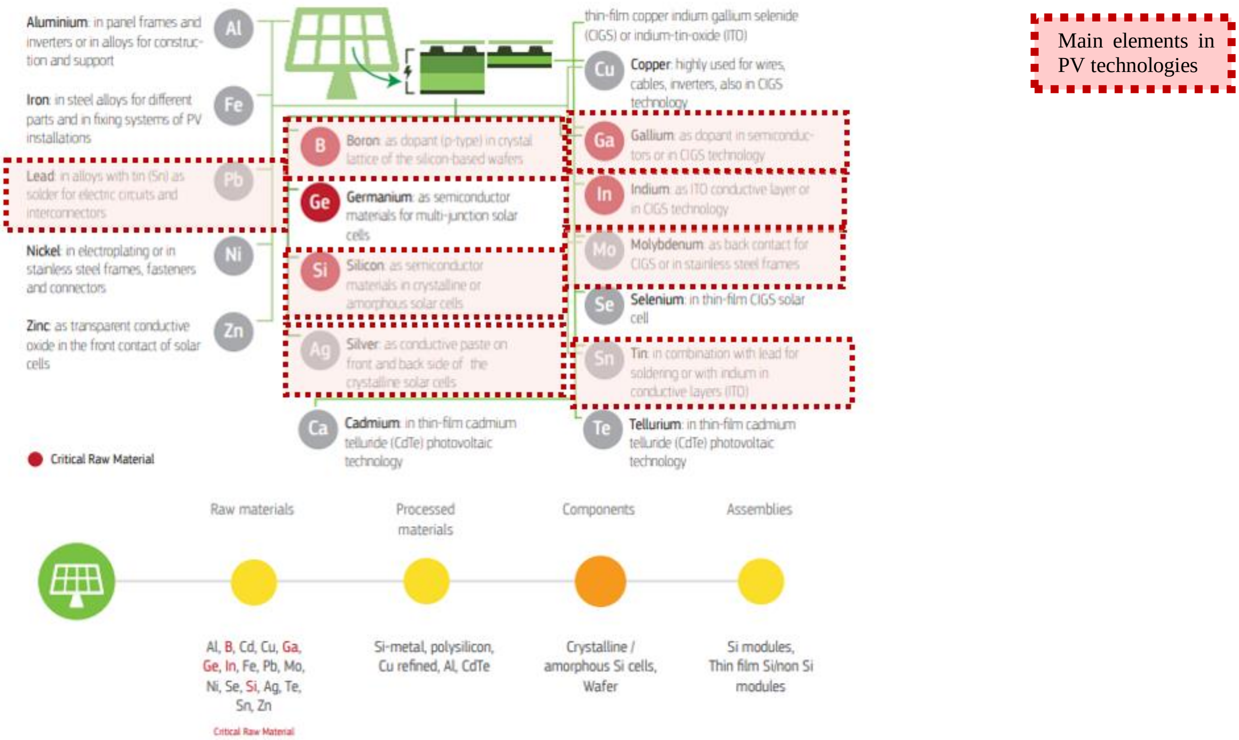
[20] COM(2020) 474 final; Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability.

[21] Fraunhofer Institute for Solar Energy Systems, Photovoltaics report, 24 February 2022

[22] University of Oxford, Lead out, Tin in for a cheap solar cell, May 1st 2014

focus our analysis on only eight out of the initial 17 raw materials that make up solar panels. After identifying the relevant raw materials for the prevailing designs of solar panel technologies, we identify the relevant product codes in the trade and production data (see Annex for a detailed explanation).

Illustration 1 – Raw Materials used in PV technologies



Source: "European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020"

In the second step, we turn to Block 1, where high-frequency customs data on import prices and quantities are used for monitoring (i.e. dynamic monitoring). The third step focuses on Block 2, where in line with the previously established criteria, categories are used to highlight those products with an important ex-ante risk of disruptions. While this approach, based on hard data, is informative, it should be complemented with deeper analyses and expert assessment on each of these raw materials (e.g. Is the market of a specific material expected to increase in the next decades?). Finally, in the last step, two outputs are presented in the form of a scoreboard and a graph, which visually show the potentially problematic raw materials necessary for the production of solar panels.

Table 2 represents the scoreboard for the relevant raw materials for solar panels. Columns 1 and 2 present the high frequency indicators included in Block 1. The next four columns include the foreign dependency structural indicators from Block 2. Finally, in Column 7, the products with a high ex-ante risk of disruptions are highlighted with two asterisks (**) (i.e. phosphorus) and those with a medium ex-ante risk of disruptions are highlighted with one asterisk (*) (i.e. boron, gallium).

Graph 2 displays the evolution of import prices and quantities for all chosen raw materials captures in Block 1 in Table 2. As in the previous case, two shaded areas aim at identifying the raw materials that could be relatively more affected by supply chain distress as they are subject to inflationary and production pressures. In this respect, two cases can be distinguished. The first case, corresponding to quadrant II, shows raw materials experiencing an increase in import price combined with a decrease in quantities imported. The second case, corresponding to quadrant I and above the 45 degree line, shows raw materials which experience a more important increase in import price compared to the increase in quantities imported. Moreover, the intensity of distress of a raw material can be measured by the distance to the "north-west" corner of quadrant II, where the closer the product is to this upper corner, the higher its potential distress. In the shaded areas, the darker the colour, the more distressed a product is. Furthermore, we highlight with two asterisk (**) those products with a high ex-ante risk of disruptions (i.e. phosphorus) and with one asterisk (*) those characterised by a medium ex-ante risk (i.e. boron).

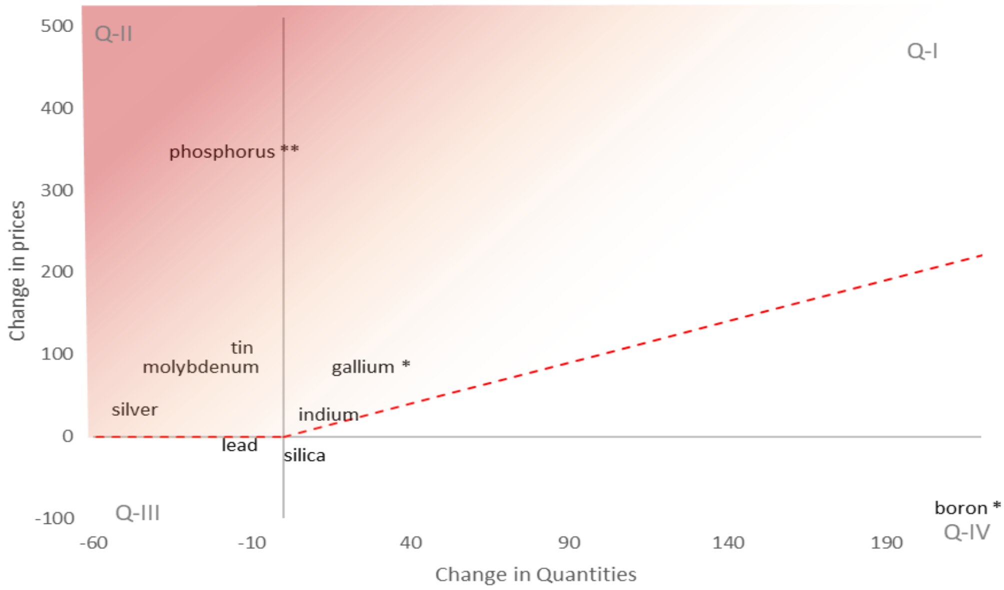
Table 2: Scoreboard for early warning monitoring of solar panels supply chains using critical raw materials

	Block 1: High-frequency indicators		Block 2: Structural Indicators				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Change in import price	Change in quantity	Concentration of extra-EU imports	Share 1st source in extra-EU imports	Ratio of extra-EU imports and total EU exports	Exposure index (without Exports)	Important ex ante risk of disruptions
boron	-86%	216%	0.7	83.10%	0.6	62.60%	*
gallium	85%	28%	0.7	85.50%	1.7	39.20%	*
indium	27%	15%	0.5	70.00%	0.5	36.50%	
lead	0%	-9%	0.1	21.60%	0.6	29.40%	
molybdenum	86%	-26%	0.2	26.20%	0.8	78.30%	
phosphorus	348%	-16%	0.4	59.60%	19	88.60%	**
silica	-22%	7%	0.3	41.10%	0.3	6.00%	
silver	33%	-47%	0.1	25.50%	1.5	12.20%	
tin	109%	-13%	0.2	39.50%	1	73.80%	

Source: GROW A1 calculations based on the European Commission customs database, COMEXT and PRODCOM.

Note: For indicators in Block 1, we rely on high-frequency customs data and we compare the average for March/April/May 2022 with the average of the same period of 2021, 2020 and 2019. For the first indicators in Block 2 we use the most up-to-date information using trade data (COMEXT 2021) and for the fourth indicators, we use trade (COMEXT) and production (PRODCOM) for 2019, to avoid abnormal statistics resulting from the first year of the pandemic. Indicators in Block 2 allow to identify products with an important ex-ante risk of disruptions. Those products with a high risk are highlighted with two asterisk (**) and those with a medium risk are highlighted with one asterisk (*).

Graph 2: Mapping of solar panels raw materials in terms of their price, quantity, and level of exposure and dependency from extra-EU sources.



Source: GROW A1 calculations based on the European Commission customs database, COMEXT and PRODCOM. Note: Reference period: Note: For indicators in Block 1, we rely on high-frequency customs data and we compare the average for March/April/May 2022 with the average of the same period of 2021, 2020 and 2019. Changes in import prices are captured by the Y axis and changes in imported quantities are captured by the X axis. This information is complemented with the indicators in Block 2, which allow to identify products with an important ex-ante risk of disruptions. Those products with a high risk are highlighted with two asterisk (**) and those with a medium risk are highlighted with one asterisk (*).

The methodology proposed for the product-level SCAN proposes a systematic way to monitor products' supply chains by focusing on the raw materials that make up the most prevailing technological designs. For the case of solar panels, there is only one most prevailing design, crystalline silicon design, so that is where we focused our analysis. However, using the SCAN on other products might mean that more than one technological design's raw materials would be tracked. All in all, when it comes to the monitoring of raw materials used in the prevailing technological designs for solar panels, it appears that, with the exceptions of lead, silica and boron, all raw materials experience distress (i.e. import price increases and/or import quantity decreases). For instance, phosphorus, which is a product with a high ex-ante underlying risk, is the raw material with the highest import price increase, combined with an import quantity decrease.

3. Monitoring at a sectoral level

The product monitoring system is then augmented with a SCAN monitoring system at a sectoral level.[23] Similarly to our product analysis, the sectoral monitoring system is intended to capture aggregate significant inflationary pressures and/or shortages. These variables are then complemented with relevant information, which is only available at this level of aggregation. In particular, we refer to quarterly firm level survey data related to self-reported constraints, which give another level of insights on the level of distress across industrial sectors. The advantage of this level of aggregation is that it allows to identify distress with an economically significant aggregate effect for the EU.[24] These indicators are then grouped in two blocks:

- **(Block 1) High-frequency indicators to capture price increases and/or shortages:** Block 1 uses monthly indicators on the evolution of sectoral prices and production. In order to identify distressed sectors in terms of inflationary pressures and/or shortages, two main variables are used in Block 1, namely production and producer prices. As in products, the most distressed sectors are those that experience a significant price increase combined with a significant decrease in quantities produced. For this reason, we compare the average of production and producer prices for the last three months available with their average over the same period in 2021, 2020, and 2019. Comparing the average indicator in the period 2022 with the previous three years prevents our results from being influenced by sectoral specificities over a specific year (for instance, during the COVID-19 pandemic). In addition, the information on producer prices is also complemented with information on import prices (used in the product analysis) in order to understand whether the sectoral inflation is imported. However, looking at the two price series, we observe that they seem to be very correlated. Therefore, the interpretation of the results will mainly focus on producer prices. The data on these aspects, which are extracted from the Short-Term Business Statistics, are available on a monthly basis and have a reporting delay of approximately 2-3 months.

- **(Block 2) Indicators on the type of constraints faced by firms in various sectors:** Survey data are only available at this level of aggregation. The indicators grouped in Block 2 refer to the main self-reported factors restraining the production of firms in the EU: labour, equipment and inputs, finance and other. In terms of monitoring supply chains, the question related to constraints in "equipment and inputs" is, in principle, the most relevant category. The information is extracted from the Business and Consumer surveys,[25] which are regularly updated on a quarterly basis.

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[23] The sectoral monitoring tool builds on the Shortages Alert Mechanism (SAM) presented in the first issue of the Directorate-General for Internal Market's Single Market Economic Papers: "Detecting and Analysing Supply Chain Disruptions" (Benoit et al., 2022). It improves the SAM by considering additional indicators, namely production and import prices. Also, instead of focusing on values for all indicators at different moments as it was the case in the SAM, the SCAN displays directly the changes in the values of these indicators, so as to identify more easily problematic sectors. Finally, the most up-to-date information is used for showing how the SCAN is implemented.

[24] Subject to data availability, the analysis can in principle also be reproduced at the Member State level.

[25] DG ECFIN conducts regular harmonised surveys for different sectors of the economies in the EU and in the applicant countries. They are addressed to representatives of the industry (manufacturing), services, retail trade and construction sectors, as well as to consumers. These surveys allow comparisons among different countries' business cycles and have become an indispensable tool for monitoring the evolution of the EU and the euro area economies, as well as monitoring developments in the applicant countries.

Similarly to the analysis on products, the sectoral SCAN displays the different indicators in a visual manner in the form of a scoreboard and a graph. These tools are meant to aggregate all of the information mentioned above and visually show the potential problematic sectors facing inflationary pressures and/or shortages, as well as the sectors where firms are self-reporting important input constraints. Once again, the information provided in this tool should be complemented with an in-depth qualitative analysis in order to validate and understand the factors behind the observed evolutions.

Table 3 summarises the above information for industrial sectors. Columns 1, 2, and 3 present the indicators from Block 1, namely the evolution of production and producer prices, also complemented with the evolution of import prices for completeness. This information allows to identify distressed sectors in terms of inflationary pressures and/or shortages. The next four columns present the share of firms that indicated a particular production constraint (i.e. labour, equipment, other or finance) in the latest quarter when this information was collected. The sectors highlighted with an asterisk (*) are those in which firms signal their input shortages (i.e. measured as above the sectoral median).[26]

Graph 3 displays the evolution of production in comparison with producer prices for all industrial sectors as displayed in Column 1 and 3 of Table 3. Two shaded areas aim at identifying the sectors that could be relatively more affected by supply chain distress as they are subject to inflationary and production pressures. In this respect, two cases can be distinguished. The first case, corresponding to quadrant II, shows sectors experiencing an increase in import price combined with a decrease in quantities imported. The second case, corresponding to quadrant I and above the 45 degree line, shows sectors which experience a more important increase in import price compared to the increase in quantities imported. Moreover, the intensity of distress of a sector can be measured by the distance to the “north-west” corner of quadrant II, where the closer the product is to this upper corner, the higher its potential distress. In the shaded areas, the darker the colour, the more distressed a product is. The sectors highlighted with an asterisk (*) are those in which firms signal their input shortages (i.e. measured as above the sectoral median).

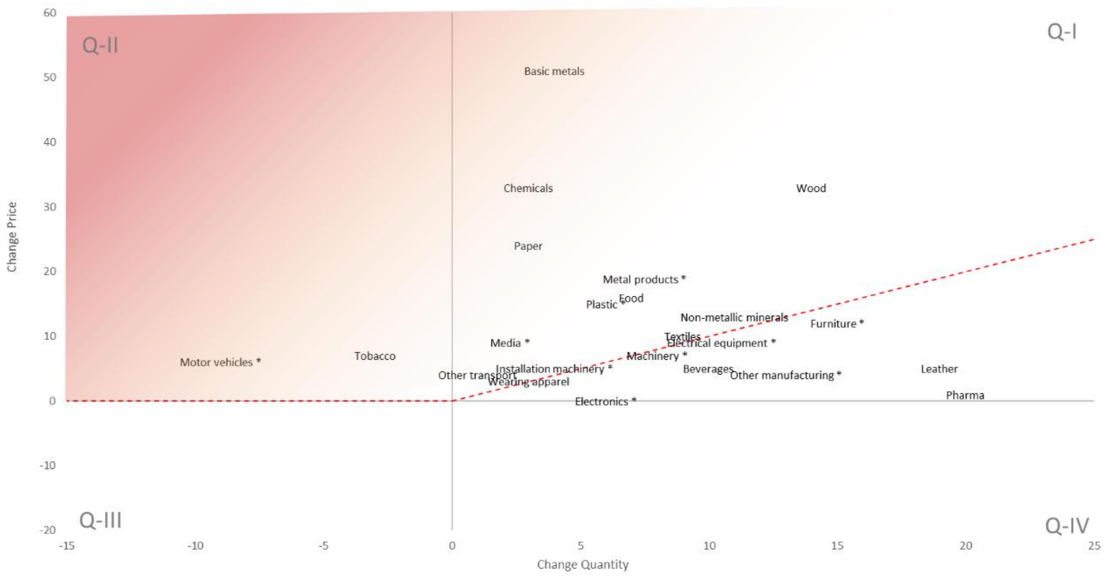
[26] The median is used to highlight in relative terms the most distressed sectors.

Table 3: Illustration of the sectoral SCAN

Nace rev 2		Last three month average (2022 compared to 2021, 2019, 2018)			Answers provided during Q1 2022				
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Producer prices (sts_inpp_m)	Import prices (sts_inpi_m)	Production (sts_inpr_m)	Labour (% s.a.)	Shortage of material and/or equipment (% s.a.)	Other (% s.a.)	Financial (% s.a.)	Shortage of material and/or equipment (> median)
C10	**Food**	16%	15%	7%	27%	41%	18%	7%	
C11	**Beverages**	5%	3%	10%	15%	33%	16%	7%	
C12	**Tobacco**	7%	1%	-3%					
C13	**Textiles**	10%	10%	9%	22%	29%	26%	8%	
C14	**Wearing apparel**	3%	4%	3%	14%	26%	20%	9%	
C15	**Leather**	5%	5%	19%	19%	19%	16%	4%	
C16	**Wood**	33%	31%	14%	27%	41%	15%	7%	
C17	**Paper**	24%	20%	3%	21%	37%	18%	6%	
C18	**Media**	9%		2%	29%	55%	16%	8%	*
C19	**Petroleum**	81%	62%	3%	3%	33%	17%	1%	
C20	**Chemicals**	33%	32%	3%	13%	42%	12%	5%	
C21	**Pharma**	1%	6%	20%	24%	38%	8%	2%	
C22	**Plastic**	15%	11%	6%	33%	45%	19%	5%	*
C23	**Non-metallic minerals**	13%	9%	11%	25%	36%	25%	6%	
C24	**Basic metals**	51%	49%	4%	18%	33%	30%	8%	
C25	**Metal products**	17%	14%	7%	32%	48%	21%	7%	*
C26	**Electronics**	0%	2%	6%	29%	65%	17%	7%	*
C27	**Electrical equipment**	9%	9%	10%	27%	68%	13%	4%	*
C28	**Machinery**	7%	6%	8%	29%	66%	16%	3%	*
C29	**Motor vehicles**	6%	6%	-9%	22%	69%	14%	4%	*
C30	**Other transport**	4%	7%	1%	12%	42%	20%	2%	
C31	**Furniture**	12%	9%	15%	27%	44%	17%	8%	*
C32	**Other manufacturing**	4%	4%	13%	32%	46%	11%	4%	*
C33	**Installation machinery**	5%		4%	29%	56%	13%	6%	*

Source: GROW A1 calculations based on Short-Term business statistics (Eurostat) and Business and Consumer Surveys. Note: For indicators in Block 1, we rely on monthly short-term business statistics and we compare the average for March/April/May 2022 with the average of the same period of 2021, 2020 and 2019. For the data in Block 2, we use the most up-to-date information using Business and Consumer Surveys. Indicators in Block 2 allow to identify problematic sectors by identifying those sectors where firms are reporting particularly important production constraints. Sectors situated above the sectoral median in terms of number of firms reporting shortages of material and/or equipment are highlighted with an asterisk (*).

Graph 3: Identification of distressed sectors through the sectoral SCAN



Source: GROW A1 calculations based on Short-Term business statistics (Eurostat) and Business and Consumer Surveys. Note: For indicators in Block 1, we rely on monthly short-term business statistics and we compare the average for March/April/May 2022 with the average of the same period of 2021, 2020 and 2019. Changes in import prices are captured by the Y axis and changes in production are captured by the X-axis. This information is complemented with the indicators in Block 2, which allow to identify sectors where there is a particularly high self-reporting firm response in terms of constraints. For illustration purposes, sectors above the industrial median in self-reporting input constraints are highlighting with an asterisk (*).

4. Conclusion

In this note, we proposed a frequently updated quantitative monitoring tool to detect possible supply chains disruptions.[27] More precisely, the SCAN monitoring tool offers insights to policy makers on the potential supply chain disruptions at two levels of aggregation, namely products and sectors. The core indicators included in the SCAN can be updated twice per month for products (with a lag of two weeks) and monthly for sectors (with a lag of up to two or three months).

Given the high-frequency of the customs data, the SCAN monitoring tool allows to detect supply chain disruptions at the product level almost as soon as they materialise. While this data-driven exercise cannot forecast non-materialised disruptions, the use of structural indicators can give an indication on ex-ante vulnerabilities that can materialise in supply chain disruptions if specific events occur. In addition, the ongoing monitoring of the situation allows to infer whether the observed product disruptions are transitory or persistent. If the same types of disruptions occur in successive updates of the SCAN, this suggests that the problem is persistent and particular attention might be required on the identified issue.

[27] Some indicators can be updated twice a month (i.e. evolution of import prices and quantities at the product level), while other indicators could be updated monthly (i.e. evolution of producer prices and production at the sectoral level) or quarterly (i.e. production constraints faced by firms). While structural indicators do not vary significantly in the short-term, structural indicators can be updated on a yearly basis.

Moreover, based on the product-level SCAN, which is updated in almost real time, one can already predict the more aggregated sectoral implications of product-specific disruptions which might materialise at a later stage. Then, the sectoral SCAN allows to get a better understanding of the sectoral situation.

While the SCAN at the product level focused on the pilot example of solar panels, the same type of exercise can in principle be performed for other strategic products, including semiconductors and other green transition technologies such as heat-pumps, electrolysers or wind-technologies. Expanding the implementation of the SCAN monitoring tool to other products would provide additional insights as to which products are more vulnerable to supply chains disruptions so as to motivate policy intervention when justified.[28]

To sum up, the SCAN collects highly relevant indicators with the objective of monitoring supply chains disruptions in the EU. However, given the intrinsic international nature of the problem it aims to address, as well as the similarity of the challenges faced by other regions in the world, this methodology can be a starting point for discussions with other partners sharing similar objectives.

[28] In order to be able to analyse disruptions in supply chains more systematically, without relying on particular case studies, firm-to-firm level data would be needed for the EU as a whole. This type of data is not available at the moment of publication of this paper.

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Annex

The correspondence between each raw material and the codes in the trade data (CN8 codes) and the production data (PC8 codes) is done as follows.[29] First, we associate each raw material to the CN8 codes, based on existing European Commission documents.[30] Then, we associate the PC8 codes to CN8 codes, based on the correspondence table for CN2021 and PRODCOM 2019 from Eurostat RAMON. Table A1 summarizes the corresponding CN8 and PC8 codes for the raw materials of silicon-based designs of solar panels.

Table A1: CN8 and PC8 codes for raw materials relevant to solar panels

Prevailing designs materials	CN8 code	PC8 code
Silica	25051000	08121150
Gallium	81129289	24453073
Phosphorus	28047010	20132181
Boron	28045010	20132141
Tin	26090000 & 80011000	7291530 & 24431330
Lead	26070000 & 78011000	7291510 & 24431130
Silver	26161000 & 71061000	7291410 & 24411030
Indium	81129281	24453070
Molybdenum	26131000 & 2613900& 28257000 & 72027000 & 81021000	7291925 & 7291926 & 20121973 & 24101275 & 24453017

[29] CN8 stands for Combined Nomenclature at 8-digit level. PC8 stands for 8-digit Prodcom.

[30] European Commission, “Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability” COM(2020)474 final.

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