# **Geopolitical supply risks in the solar industry and Europe’s incentive policies**

# Introduction

Europe is heading from a reliance from the Middle East and Russia for fossil fuels to a dependency on China for green energy technologies, posing again challenges for energy security through geopolitical risks.  
  
Supply chain disruption during the pandemic, Russia invasion of Ukraine and the subsequent high energy prices, price volatility of raw material and concerns about the inadequate supply of critical minerals to meet the future demand have sparked a debate and awareness on supply chain risks and on concentrated import dependence from industries and regulators, particularly the reliance on authoritarian countries and strategic supply chains.

Policies to incentives renewable energy sectors are often accompanied by the argument of energy security, supply diversification and energy independence, seldom they note the high import dependence of renewable technologies and raw materials which can again create geopolitical risks to the energy security (although to a lesser extent since the technology is imported not the energy itself)  
  
Solar Photovoltaic (PV) is recognized as one of the main technologies required to achieve the transition goals set by the EU, and beyond. For that the EU is subsidising domestic application and manufacturers, but the production capacity in Europe is very low in comparison to other countries and the EU has a huge trade deficit across the solar PV supply chain.  
With China’s dominating position, trade partners are highly vulnerable to geopolitical risks and are susceptible to abuse of market dominance by China as a bargaining power, to further political, economic, or social interests and exploit others reliability.

The main instrument of the European Union to promote renewable energy was for long Feed in Tariffs, which are long-term contracts for renewable energy producers with the goal to promote their application by reducing the financing risks for investors.  
The effectiveness of Feed in Tariffs in promoting domestic photovoltaic industries can potentially influence the concentration of imports by either reducing dependence on foreign technology, if domestic production is boosted, or by increasing it, if demand outstrips local supply.

The main purpose of feed-in tariffs is to accelerate investment in renewable energy technology, depending on their application the effectiveness in achieving this goal varies. The pertinent question is if they also create enough incentives for domestic or foreign producers to enter the market or if they have just consolidated the Chinese dominance and the rapid demand growth favoured large-scale, low-cost manufacturers. If so, how sustainable are demand incentives?

From this reflection my research questions are formulated:

Have incentive policies an impact on the diversity of suppliers and import dependency?  
Can Europe’s renewable incentive policies hedge against the geopolitical risk of China’s supply chain dominance of solar photovoltaic products?

# Solar energy as a strategic sector for EU’s renewable ambitions

The EU's energy policies are encapsulated in the European Green Deal, which aims to make Europe climate-neutral by 2050.   
The energy sector accounts for over 75% of the EU’s greenhouse gas emissions, thus the sector is crucial to the objective of reducing net greenhouse gas emissions by at least 55% by 2030 and becoming climate neutral by 2050. Thus, a central component of this strategy is the expansion of renewable energy, the target is set of at least 42.5% but aiming for 45% share of renewables in EU energy consumption by 2030, which means almost doubling the existing share of renewable energy in the EU, which was 23% in 2022.  
  
REPowerEU plan published by the European Commission in May 2022 entails measures to accelerate the clean energy transition and reduce dependence on Russian fossil fuels. The plan focuses on energy efficiency, clean energy production and supply diversification.   
(European Commission, kein Datum)

In the EU, as part of the Green Deal Industrial Plan, the net Zero Industry Act, with the objective of increasing the manufacturing capacity of net-zero technologies, was formulated. Special focus should be made on technologies that are already commercially available and rapid expansion are feasible.

The study by (Ansarin, et al., 2023) evaluates the strategic importance of each technology based on factors such as level of maturity, contribution to reducing greenhouse gas emissions, competitiveness and security of supply.  
As indicators for the security of supply they look at the EU manufacturing growth needed to meet the required internal market demand and at supply chain vulnerabilities, like competitiveness threats and market concentration.

The solar PV supply chain is considered as highly strategic, as well as wind energy and batteries. Solar PV is crucial to achieve the share of renewable electricity proposed under REPowerEU, and so to realize the EU Fit for 55 goals in 2030.

Solar PV refers to any technology that uses semiconductor materials to convert light into electrical energy. The semiconductor material creates electrical voltage and electrical current upon exposure to light, this effect is known as the photovoltaic effect.  
Solar cells are the individual devices that convert light into electricity. An array of many solar cells forms a solar PV module. One or more solar modules, together with additional components including cables, inverters and supporting structure make up a solar PV System.

The production process can be summarized as follows: crystalline silicon is purified, afterwards this silicon is crystallised into ingots, which are then sliced into wafers. By adding chemicals and materials the wafers are transformed into solar cells. The cells are covered by glass or other materials, framed, and assembled into a solar module.

There are different types of solar PV technologies, which are often distinguished by the semi-conducting materials used for the modules. The most common forms are monocrystalline crystalline silicon.

According to the REPowerEU plan, 592 GW of installed solar PV capacity will be required by 2030 to reach the 69% proportion of renewable electricity. In 2021, total solar capacity across the EU exceeded 200 GW. To reach the goals by 2030 adding about 45 GW of solar PV each year is necessary.  
The EU suggests that the domestic manufacturer should aim to reach at least 30 GW of operational solar PV manufacturing capacity by 2030 across the full PV value chain.  
The manufacturing capacity in Europe is currently very low compared to other countries. EU’s goal of 30 GW of operational domestic solar PV manufacturing capacity seems very ambitious.  
(Ansarin, et al., 2023)

In the Net-Zero Industry Act, the EU stabilized a self-sufficiency benchmark of 40%, this import substitution approach sends a protectionist signal and turns the back on cheaper imports. (McWilliams, Tagliapietra, & Trasi, 2024)

# History of solar industry

Over the years, solar photovoltaic technology has undergone significant development, with various countries implementing incentive policies to promote its production and adoption. The timeline that follows traces the evolution of solar PV technology, from the early discoveries of the photovoltaic effect to today’s solar panel installations, highlighting significant government initiatives that have shaped its trajectory and underlying changes in the geographic epicentre of the industry. The focus is here on the key players of the industry’s history: USA, Japan, Germany, and China.

The first solar cell capable of producing an electric current form light was created in 1839 by French physicist Alexandre Edmond Becquerel.   
In 1883, the American Charles Fritts produced the first solar panels with solar cells made of selenium wafers, these panels only had a mere 1% energy conversion rate.  
In 1922, Albert Einstein won the Nobel Prize for his paper on the theory underlying the “photoelectric effect”, which demonstrates the process of how the sun generates energy through solar cells.   
  
The physicists Gerald Pearson, Daryl Chapin, and Calvin Fuller presented in 1954 the first high-power solar PV cell, which used silicon wafers rather than selenium wafers to increase energy conversion efficiency.  
  
In 1963 the Japanese Sharp Corporation started to mass-produce solar panels made of silicon solar cells.

In the USA, the 1973 oil crisis spurred efforts to develop PV terrestrial applications, following the successful aerospace application in the previous decades.   
The American solar industry, mainly located in California, was till now focused on the space market and their characteristics, small volume, price-insensitive market, high efficiency, high-cost cells optimized for the conditions of space. It was now called to adapt to a high volume market to replace conventional electricity in homes and businesses, which was much more cost sensitive (West, 2013)  
In the late 1970s, PV module factories were prompted to established by the demand from research associations and the tax credits offered by the “Public Utility Regulatory Policy Act of 1978” for residence who invested in solar energy. Research reduced PV costs by 80%, enabling testing and adoption of various solar panel applications, primarily off-grid.   
The grid-connected solar generation experiments were economic failures, due to the sharp reduction in oil and natural gas costs that occurred after 1982, while the projected decline in PV prices was not realized. Even though, the USA had the largest grid-connected solar facilities and largest US solar technology suppliers with Luz and Arco Solar in the world, declining fossil fuel prices nullified American commercial and utility demand and government subsidies. Thus, American firms remained focused on their niche markets. (West, 2013)

In 1976 the Japanese Kyocera Corp kept simplifying the manufacturing process, by producing thin-film silicon crystal solar modules.

From 1960s to the 1990s, the United States lead the PV technology industry.   
PV investment costs decreased because of R&D breakthroughs and manufacturing process improvements. Lower costs as well as incentives facilitated the growth of more niche markets in the USA (Norberg-Bohm, 2000).

As solar energy disappeared from the public interest in the US during the 1990s, Japan and Germany became the leading countries in solar deployment and development efforts of photovoltaics as a conventional energy substitute migrated to countries with higher energy prices, higher environmental awareness, and active governments. Through internal initiatives, many large Japanese corporation expanded into the solar industry. Meanwhile, Germany heavenly supported the purchase of renewable energy (West, 2013) In 1999, the German government launched a “100.000 Rooftops Program”.   
Around the same time, the “Feed-in Tariff Law” was implemented, a demand-sided policy that guaranteed the price for 20 years, further strengthened the formation of the German PV market by diminishing the risk associated with investments when financing purchases. (West, 2013)

Vast early R&D investment allowed USA and Japan to obtain a technology and price advantage in PV modules, they controlled most of the market for PV production in the early 2000s. At the time Japan was the main PV producer worldwide. The country contributed to more than 40% of the worlds production capacity until 2006.  
  
After 2000, the German PV market grew quickly and the country became the demand leader, according to (Blankenberg & U., 2013) the growth was mainly provoked by the feed-in tariff. In 2005, Germany installed more than 60% of the world PV capacity.   
Public R&D subsidies and demonstration initiatives encouraged private firms to enter the market and invest in PVs. Regardless of that, the development of the PV market was limited by the high cost of solar energy and investments into new production facilities could not be justified.  
  
In the US, after 2000 environmental concerns increased and this brought new US venture capital investment, especially in Silicon Valley. But also renewed public financial support. (West, 2013) blame inconsistent public and policy support, with fluctuations between and within administrations and claim that Californian firms lost the lead to Japan, Germany and later China because they were supported by longer-term policies, inability to create sustained technological advantage, clash of premature entry and slow industry growth, absence of an intermediate niche market to go from small price insensitive markets like space satellites and remote communications to mass consumer markets and lack of capital necessary to achieve scale economies. (West, 2013)

In China, in the “Five-Year Plan” for 2001-2005 renewable energy was recognized as essential to optimize the Chinese energy structure. From 2004, China’s PV production rose remarkably, benefitting from free land for factories, tax breaks and low-interest government financing.

In 2005, the USA introduces a 30% [investment tax credit](https://www.solarreviews.com/blog/federal-solar-tax-credit), accompanied by an accelerated depreciation, it reduced the system costs dramatically for residential and commercial use.

In China, the five-year plan (2006-2010) included guidelines for the development of strategic technologies for renewable energy were formulated and the public funds for PV R&D increased to USD 6 million per year. In 2006, China began to enact the “Renewable Energy Law” to stimulate domestic demand, which revealed itself later very imported for the Chinese PV industry.

In 2007 the global investment in clean energy exceeded USD 100 billion, with solar energy as one of the leading clean energy technologies.

For a long time, China imported most of the technology, mainly from western countries and invested much less in R&D then others. Chinese policies prioritized production efficiency above technology advancements, in contrast to Germany, Japan and the USA.   
But still Chinese PV manufacturers beneﬁted from support measures offered by the central government. Over time, China has started to dominate the worldwide PV production with high-volume, low-cost manufacturers, and the production of Japan, Germany and the USA decrease due to the rapidly declining PV prices as a result of global competition.

In 2009, China exported more than 90% of its PV products to the USA and Europe.   
Since then, the Chinese government implemented a variety of policies to support the development of the domestic PV market, such as special funds, feed-in tariffs subsidies, preferential income taxation, financial assistance, and demonstration projects.

In 2011, over 66% of PV products produced worldwide came from China. Subsequently, USA and the European Union imposed countervailing and anti-dumping charges on Chinese photovoltaic products. To offset the sudden export restrictions, China adopted a nationwide FiT scheme, to further stimulated the local PV market. Through the market incentives the domestic PV demand expanded significantly, and the Chinese PV sector kept growing.   
In the early 2010s large automated solar cell and solar module production factories were built, which further reduced the cost of modules.  
(Huang, Negro, Hekkert, & Bi, 2016)explain the rapid rise of the Chinese PV industry by the interaction of institutional changes, technology transfer, and large European selling market.  
  
During the Five-Year Plan between 2011-2015, the support for PV covered the complete manufacturing chain. During that period, the government invested an average of approximately USD 75 million in R&D per year.  
The demand-side pull policies boosted China’s PV market development. In 2017 PV installed capacity in China accounted for more than 50% of the global PV installed capacity.

(Almerini, 2023) (Daoyuan, Weijun, Fanyue, Qunyin, & Jianxing, 2021)

In 2022 the share of China manufacturing exceeds 80% in all stages, more than the double of its 36% share in global PV deployment.   
In all countries except China, demand for solar PV exceeds manufacturing capacity.  
North America and Europe have significant module-manufacturing capability but depend almost entirely on China and Southeast Asia for key components. (Agency, 2022)

The Inflation reduction act was implemented in the USA in 2022, it provides almost $400 billion of federal funds to clean energy over the next decade, it includes a mix of tax incentives, grants, and loan guarantees and aims to incentivizing domestic production of critical supplies or from free-trade partners. Main components of particular interest for the solar industry are the Production Tax Credit and Investment Tax Credit programs*.* (Badlam, et al., 2022)(RWDI, kein Datum)

In 2022 and 2023, new policies and targets in the EU were outlined, mainly the RePowerEU Plan and the Green Deal Industrial Plan. They are anticipated to play a significant role in driving solar PV investment the next years. The RePowerEU sets a target of 45% renewable energy by 2030 (which would mean 1236 GW of total installed renewable capacity, of which 600 GW of solar PV). As a response, many nations increased their solar PV support systems aiming to increase their capacity. The goal of the Green Deal Industrial Plan is to encourage the growth of the production of renewable energy technologies, such as solar photovoltaic. (Bojek, 2023).

The initial stage of the solar PV industry was concentrated in the United States, with major inventions that contributed to the development of the technologies. Then Germany and Japan build buyers’ market and made it commercially viable, they were the main demanders and important producers of PV in the early 2000s. China took then over and is now dominating the production of solar PV technology.

It is neither possible nor desirable to completely decouple China out of the supply chain. Completely restoring production would be economically inefficient given the limited access to critical raw materials and high production costs.  
The energy supply chain is more reliant if the origin of supply is diversified and not concentrate in one country or region, so the aim should be to reduce the dependence on China and minimize the vulnerability of overdependence on one supplier country.  
Europe has to find a balance between managing the risks associated with dependency on China and continuing to capitalize the advantages of Chinese suppliers in order to guarantee economic efficiency and to implement EU´s transition plan to a low-carbon economy. Thus, it must find an equilibrium between efficiency and resilience.

# Supplier concentration

Countries’ specialisations are determined by competition based on comparative advantages, which also impacts the geographic organization of global value chains. Because of comparative advantage, specialisation, and economies of scale, the organisations of production are frequently highly concentrated.Relying on a small number of geographically concentrated suppliers heightens supply shock risks and while some hubs’ high centrality in global value chains might accelerate the spread of shocks, these hubs are also essential in driving the benefits of these chains, particularly knowledge spillovers.   
When facing disruptions, downstream firms that depend on specific inputs (such as inputs with high knowledge capital or certain natural resources) are less able to quickly switch to other suppliers, plus rearranging the supplier base is expensive.  
Certain supply chains and sectors are more susceptible and vulnerable to shocks than others due to their high reliance on foreign value-added in production and supplier concentration.  
Concentration brought about by anti-competitive behaviours can undermine the initial efficiency gains and increase volatility.  
(Arriola, et al., 2021)

The concentration in the solar PV sector is heavily focused around China. Over the past decades, global solar PV manufacturing capacity has increasingly shifted to China, which now dominates the market. China controls a significant portion of the supply chain, including the production of polysilicon, wafers, cells, and modules. China’s share in all the manufacturing stages of solar panels exceeds 80%. In addition, the most important suppliers of solar PV manufacturing equipment are Chinese. (Agency, 2022)  
Five countries produce more than 90% of the world solar modules. China produces solar modules with a yearly output of over 500 GW, corresponding to 80% of world manufacturing capacity. Followed by Vietnam (5%), India (3%), Malaysia (3%) and Thailand (2%).  
The European Union produces around 1%. In 2022, 40 GW of solar PV modules were added in the EU, only around 10% of them were manufactured in the region.  
(IEA, 2023)  
As can be seen in the graph, the geographic concentration of production for polysilicon, wafers and cells is even higher.

Inherently, the EU has a huge trade deficit across the solar PV supply chain, mainly with China.   
While Europe has some high-grade silicon production, it has very little ability to produce ingots and wafers. Additionally, Europe is not competitive in the cell manufacturing and its production is therefore extremely reduced. China accounts for about 85% of world’s cell manufacturing, with other Southeast Asian countries producing most of the remaining cells. (Agency, 2022)

This high geographical concentration in global solar PV supply chain by China, as the biggest manufacturer of solar PV products and especially it´s Jiangsu province, exposed during the Covid-19 pandemic some vulnerabilities of the supply chain by creating severe disruptions in Europe, mainly because of component manufacturers and other suppliers and logistics problems reported by SolarPower Europe.

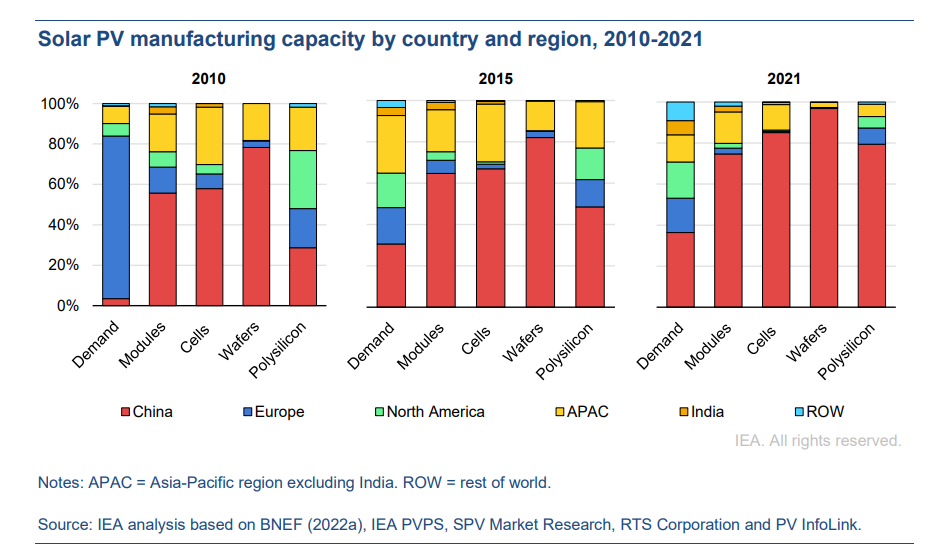
Thus, although China was instrumental to bring down the costs of solar PV, this concentration poses several risks, including supply chain disruptions, price manipulation, and geopolitical vulnerabilities. For instance, any political or economic instability in China could have far-reaching impacts on the global solar PV industry.  
(Ansarin, et al., 2023)

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Two significant issues related to China’s solar PV sector are not further discussed in this work:  
  
Firstly, the subsidization by China of the establishment of manufacturing facilities in other countries, such as Cambodia, Malaysia, Thailand, and Vietnam (all within their Belt and Road Initiative). Chinese companies can through their facilities in third-party countries avoid targeted trade enforcement actions. (Dayen, 2022)

Secondly, through the rapid production expansion in China supported by subsidies and state-backed investments, there is a significant overcapacity, which resulted in dramatic decrease in price and thus facilitated the widespread adoption of solar energy but also increased concerns about market destabilization. (Writer, 2024) The utilization rate of solar manufacturing decreased from almost 60% to less than 40% in 2022 as a result of the increase in manufacturing capacity. This is far less than the 70%, a level normally considered healthy for a mature industry. (IEA, 2023)



https://iea.blob.core.windows.net/assets/d2ee601d-6b1a-4cd2-a0e8-db02dc64332c/SpecialReportonSolarPVGlobalSupplyChains.pdf

Import concentration according to TradeMap

# Supply chain risk/Geopolitical risk

Through specialisation and economies of scale global value chains rise productivity and lower production prices. (Andrews, Gal, Witheridge, & William, 2018). Global value chains unable also smaller firms and businesses from developing countries to participate, as they do not have to master all production stages. (Arriola, et al., 2021)

But, recent years have demonstrated the risks and adverse effect of segmented and non-diversified critical supply chains.  
Complex global supply chains have a lengthy process of establishment, during that their integration deepens and they become rigid and difficult to alter.  
Supply disruptions may originated from [natural](https://e360.yale.edu/features/how-climate-change-is-disrupting-the-global-supply-chain#_blank) or fabricated disasters, geopolitical unpredictability, conflicts and tensions between states or within, [cyberattacks](https://www.ncsc.gov.uk/news/ncsc-issues-fresh-guidance-following-recent-rise-in-supply-chain-cyber-attacks#_blank), [health crises](https://www.chathamhouse.org/2022/02/next-pandemic-when-could-it-be#_blank), [labour shortages](https://www.ecb.europa.eu/pub/economic-bulletin/focus/2022/html/ecb.ebbox202108_01~e8ceebe51f.en.html#_blank), [new technologies](https://cepr.org/voxeu/columns/between-deglobalisation-and-slowbalisation-where-europe-stands#_blank), macroeconomic developments like [inflation](https://www.forbes.com/sites/sap/2022/10/28/3-major-impacts-of-inflation-on-global-supply-chains/?sh=5df3a2121614#_blank) or [recession](https://www.linkedin.com/pulse/how-recession-could-impact-supply-chains-eskander-yavar?trk=public_profile_article_view#_blank), or [deliberate actions](https://www.oecd.org/trade/resilient-supply-chains/identify-potential-risks/#_blank) such as terrorist attacks, sabotage, or activist blockades.  
The risks are also exacerbated by the evolving wider environment, such as US-China trade war, challenges to multilateralism, rise of protectionism, weaponisation of energy dependencies, rising demand, and the growing use of economic tools to further geopolitical goals.  
Furthermore, unanticipated events may unfold rapidly, leading to sudden materialisation of supply chain risks.  Simultaneously, policy responses typically take a while to implement.   
In addition, private companies are normally controlling key supply chains and may not share the objectives or risk assessment of the public actors. They are more prone to prioritize short-term economic factors over geopolitical concerns.   
According to an OECD assessment of supply chain risks, the loss of a significant supplier has a high probability and severe impact. As can be seen in the graph.  
(Szczepański, 2023)

A diagram of a disaster

Description automatically generated

https://epthinktank.eu/2023/08/18/future-shocks-2023-de-risking-europes-global-critical-supply-chains/supply-chain-risks/

The increasing relevance of geopolitical risk brought out the need to quantify it.   
One of the most common methods is the Index developed by (Caldara & Iacoviello, 2022). They employ a newspaper-based measure of adverse geopolitical events and associated risks. They use the ratio of the number of articles related to geopolitical tensions to the total amount of articles of certain newspapers as the index of geopolitical risk. It must be acknowledged that word selection can bias the results.  
The results demonstrate how the threat and realization of adverse geopolitical events increase the probability and magnitude of downside risks to GPD and foretell lower investment and employment. High firm-level geopolitical risk is associated with lower firm-level investment and negative implications of geopolitical risk are more pronounced for firms in more exposed industries.  
 (Caldara & Iacoviello, 2022)

Numerical methods are employed less frequently.(Engle & Campos-Martins, 2023) examine and developed a estimation technique of the so called global common volatility, which is a measure of all types of global financial risk and are shocks that affect financial markets and thus asset prices across geographical regions and across asset classes at the same time.   
 (Engle & Campos-Martins, 2023)

# China Geopolitical risk

China’s dominant role in global supply chains, particular in sectors like technology, solar PV, and rare earth elements, makes it a critical node in the global economy and partners vulnerable to its geopolitical risks.   
Any disruption in China’s supply chain, whether due to geopolitical tensions, trade disrupts, or domestic issues, could have far-reaching consequences for the global solar PV market. With notable challenges in securing alternative suppliers.  
Another risk factor is China’s political system with the centralized control by a single party, which can incite sudden policy shifts, regulatory changes, and government intervention in the economy. The unpredictability of such intervention increases the risk for trading partners.  
China’s territorial claims in the South China Sea, its stance on Taiwan, and its border conflicts with India contribute to regional instability. These disputes heighten the risk of military conflict and tensions with western countries.  
China’s growing influence in international organizations and its Belt and Road Initiative have raised concerns about its geopolitical ambitions. The strategic competition between China and other major powers, adds to the global geopolitical risk.

# Hedging strategies

To prevent overdependence on other countries, especially on coercive or oppressive authoritarian states, Europe wants to reduce the risk in its supply chain. The EU´s aims to enhance supply chain resilience and strategic autonomy through boosting domestic production, gaining more control over critical raw materials, utilizing trade instruments, and collaborating.   
The overdependency is especially evident for green and digital technologies, for instance China supplies all the EU´s heavy rare earth elements, which are essential for electric vehicle’s motors and wind turbines.  
(Szczepański, 2023)

Hedging against supplier concentration involves strategies that mitigate the risks associated with relying heavily on a limited number of suppliers.

One of the most straightforward approaches, and the one of interest for this work, is the diversification of suppliers. To prevent over-reliance on any single supplier, identifying and building relationships with multiple suppliers- ideally located in different geographical regions- is beneficial.  
Other hedging approaches are forward contracts that help manage price volatility and supply risk, strategic partnerships that can offer stability in supply chains, maintaining a higher level of inventory and regular auditing and monitoring of suppliers to allow proactive measure before a disruption occurs.

It could be argued that also domestic production capacities lower the exposure to foreign geopolitical risks and global supply chain disruptions.   
This incites the debate on [efficiency vs resilience](https://link.springer.com/article/10.1007/s10100-021-00766-1#_blank) of supply chains: efficiency is essential to survive in a highly competitive business environment, whereas resilience is needed to protect the supply chain from unanticipated disruptions. (Szczepański, 2023)  
  
Given the discussion about the spreading of economic shocks across various sectors and regions through global value chains and how to improve their stability and resilience to shocks while capturing efficiency gains brought about by specialisation and comparative advantage.  
In an OECD paper, (Arriola, et al., 2021) study the effects of a stylised re-localization policy scenario on stability and economic efficiency using a global trade model. They conclude that while countries may be less exposed to shocks from abroad, the negative effects of a policy-induced reshoring of global value chains on efficiency and their ability to absorb shocks through trade tend to dominate.  
In comparison to the interconnected regime, the model´s localized regimes have lower GDPs, and it does not significantly affect the stability of GDP, production, and consumption. Some countries, especially downstream economies could gain on stability in the localised regime but lose the most in terms of efficiency, real GDP. Overall, the loss of income level and stability in upstream nations within global value chains would be greater upon transitioning to a localized regime.   
They conclude that economically policy-induced reshoring of global value chains is not reasonable.(Arriola, et al., 2021)

According to the analysis by (Bettoli, Nauclér, Nyheim, Schlosser, & Christian, 2022) even if scale and excellence effects are realized in Europe, the costs of manufacturing PV panels will be 20-25 % higher than the current lowest level costs. High labour, material, utility, and capital costs will continue to be a competitive disadvantage for European companies. To reduce the difference in cost technology development and EU Carbon cost could be facilitating. (Bettoli, Nauclér, Nyheim, Schlosser, & Christian, 2022)

Long and complex global supply chains are more vulnerable to business disruptions, because they are normally slow to respond to change.  
While managing a small number of suppliers is more efficient, it can increase supply risks.  
Supply risks include the risks associated with supply cost, supply quality and supply commitment.  
To measure the risk two methods are use, the likelihood of the occurrence of an event, and the negative implications of the event. To mitigate the risk both aspects can be addressed.  
The paper from (Tang & Brian, 2008) looks how different flexibility strategies can be used to manage supply chain risks, it illustrates that most of the benefits are obtained at low levels of flexibility.  
(Tang & Brian, 2008)

The article by (Gehrig & Stenbacka, 2023) discuss the importance of dual or multi sourcing as a mechanism to enhance the resilience of supply chains. Dual sourcing helps mitigate risks associated with dependency on a single supplier by reducing the switching costs in the long run, especially in the context of essential resources and geopolitical risks. It argues that dual sourcing can serve as an insurance mechanism to prevent monopolistic behaviour and price manipulation by dominant suppliers.  
The study looks at the gas market and emphasizes the need for long-term investments in infrastructure, such as LNG terminals, to enable dual sourcing. Such investments, though costly upfront, provide long-term benefits by reducing exposure to geopolitical risks and ensuring supply security. The analysis suggests that public infrastructure investments or subsidies may be necessary when private firms do not have sufficient incentives to invest in dual sourcing. These investments can enhance consumer welfare by ensuring access to essential resources at competitive prices.  
(Gehrig & Stenbacka, 2023)

Some arguments from the paper can be also transferred to the solar industry. As China dominates the global manufacturing of solar PV equipment, importers could benefit from diversifying their supply chains to reduce risks associated with geopolitical tensions or market disruptions. Investments in manufacturing capabilities across different regions could reduce dependency on any single supplier or region for solar PV components.  
The solar PV industry could implement multi sourcing strategies to avoid potential supply chain bottlenecks or price increases, ensuring that production remains stable and competitive.

Multi sourcing can be also affective against predatory investments, which are strategic investments made by dominant players to undercut competitors, gain market share, or establish monopolistic control, often at the expense of long-term market stability.   
In China, the solar PV industry has seen significant growth driven by massive government subsidies and investments, allowing Chinese firms to dominate the global market.   
These investments by China led to concerns about overcapacity and the potential for predatory practices, where Chinese manufacturers drive out competition by flooding the market with cheap products. In fact, the price for solar PV products dropped globally and created challenges for competitors in other regions, particularly in Europe and the United States. The concern is that this market domination is supported by state interventions that distorts global trade and create a market overly dependent on Chinese suppliers. (Gehrig & Stenbacka, 2023) (Writer, 2024)  
These accusations led to the anti-dumping and anti-subsidies trade measures in 2012 to protect the European and American manufacturers, also more recently some investigations on excessive Chinese subsidies incited by the EU and USA took place. (Bradsher & Cardwell, 2012) (Commission, 2013) (Liboreiro, 2024)

# Incentive policies in Europe

Two different approaches can be employed to tackle the challenges arising from increased energy consumption and the impacts of continued fossil fuel combustion:  
  
The first is market driven and relies on rising energy prices to compel behavioural and technological improvements in the production and consumption of energy. Increases in prices rise spread quickly throughout the economy and effectively encourage innovation.   
However, unexpected price increases disproportionately affect the poor and result in economic dislocations and inequities. Furthermore, even if fossil fuel prices are momentarily high, it is not said that they continue to rise or even stay high given that the resources are not that scarce as often argued.  
Furthermore, energy prices frequently do not account for all social costs associated with energy production and consumption. The burning of fossil fuels is generally underpriced if there are no substantial taxes or other policies to discourage it.   
Because energy from fossil fuel is priced too low relative to its total social costs, dependence on markets results in excessive energy consumption. (Haas und Hird 2013)   
On top of that, carbon intensive industries not only produce negative externalities that are not considered by prices but are also subsidised.   
To support consumers and businesses with the pressure of high energy prices brought on by conflicts and economic recovery from the pandemic, many states increased fossil-fuel subsidies. In 2023, they reached a record $7 trillion. The amount of subsidies for natural gas, coal and oil was equal to 7,1 percent of world´s GDP (Black, Parry und Vernon 2023).

The second approach relies on governmental intervention to stimulate innovation and redirect investments.  
Energy subsidies are motivated with the need to provide affordable energy for low-income members of society, correct markets for unpriced externalities, induce technology innovation and drive down the costs of new technologies, reduce import dependence and enhance energy security and create new economic activity and jobs. (Taylor 2020)  
There exist valid economic rationales for some subsidies: the tendency to underinvest in research and development (R&D) because of disparities between the private and social return of R&D. Moreover, R&D investments are financially restricted, because of the inherent risk involved. Increasing R&D and getting closer to the societal optimum can be facilitated by government support (Strobl und Görg 2006) (IMF, et al. 2022). Besides the policy objective to correct market failure, subsidies can be motivated to respond to national emergencies, from health to climate change. (Van Heuvelen 2023)

It could be argued that both of this rationales, market failure and severe crisis, apply to subsidies for the renewable energy sector.

Nevertheless, it is important that support is proportionate, non-discriminatory, well targeted, time- limited (ideally with an announced phase-out plan) transparent, and non-discriminatory. (IMF, et al. 2022)

The existence of cost gaps between clean energy technologies and fossil fuels strengthens the argument for incentives to accelerate the adoption of crucial clean energy measures. This cost gaps between clean energy technologies and fossil fuels can be reduced by lowering the upfront and operating cost of clean options, that can occur through technology and financial innovation or government intervention. Cost gaps can also be narrowed by changing pricing, tax and subsidy frameworks for fossil fuels, e.g. by removing fossil fuel subsidies or by including environmental costs. (IEA 2023)  
To address market failures and distortions while efficiently meeting emissions reduction targets, governments should seek to optimise the balance between direct subsidies for low-carbon alternatives and carbon pricing applied to fossil fuels. (Curran, et al. 2017)

Investments in energy efficiency, renewable energy and other mitigation measures help to move away from fossil fuel-dependent energy systems.  
The declining cost of renewable energy prices, especially in the electricity sector, raises the possibility that regulations impeding the shift to more affordable energy sources could harm economic competitiveness. However, tariff hikes resulting from reform of consumer subsidies are unpopular. Future cost savings and better air quality are less tangible and may take years to manifest. This provides an opportunity for populist stances against price hikes, subsidy reform and the clean energy transition.   
These concerns might be legitimate in some circumstances. Inadequate mitigation of price shocks by poorly designed reforms may cause unreasonable hardship for consumers. Similarly, it could be challenging to persuade businesses and workers who have enjoyed low prices that the reforms will benefit them or the economy as a whole.  
A swap that relocates a portion of the savings from fossil fuel-subsidy reform to finance the clean energy transition has the potential to increase the long-term, permanent emission reductions and yield further economic and social advantages.  
Governments can use swaps to redirecting support to large-scale on-grid renewables energy projects and put in place systems to leverage private investment for clean energy initiatives.  
 (Bridle, et al. 2019)  
Even so, shortcomings of new energy, such as underperformance, technical difficulties, large land requirements, competition with food inputs, intermittency and pollutants, should not be rationalized. Not all pollution does the same level of environmental harm, comparisons of the relative costs and benefits are important to use scarce financial resources efficiently. (Haas und Hird 2013)

Certain subsidies are primarily a reaction to political pressure or lobbying efforts, lack a clear economic rationale, or go beyond what is required to accomplish that rationale or have outlasted it. (IMF, et al. 2022)  
The use of renewable energy has increased significantly as result of subsides, but they should be time-bound and phased out once the relevant market failures have been overcome. (Curran, et al. 2017)

In the EU, support for renewable energy sources is still growing, mostly through market-based instruments like feed-in premiums, contracts for difference and RES quotas with tradable certificates. The highest financial support goes to solar, followed by wind and biomass. (Enerdata 2022)

Previous studies have looked at the relationship between subsidies and innovation and investment.

A Chinese study using fixed effects and difference-in-difference models investigates the impact of subsidies on innovation investment. It found an inverted U-shaped relationship between new energy subsidies and enterprise innovation investment through the incentive effect and the crowding out effect. Higher subsidy levels can have crowding out effect on research and development investment due to managerial myopia. The paper claims there is an optimal choice of government intervention to avoid undesirable effects on R&D investments. (Wu, et al. 2022).   
The background of industries and country characteristics effect the relationship between subsidies and private R&D investment, as well as the enterprise owner´s characteristics. (Yu, et al. 2016) A study on the manufacturing sector in Ireland claims that for foreign establishment, subsidies do not cause crowding out effects nor additionality on private R&D financing, regardless of the subsidy size. (Strobl und Görg 2006)  
Government R&D subsidies increase R&D investment by reducing the degree of uncertainty in the product market. (Czarnitzki und Toole 2007)

Through the construction of a panel threshold model the paper of Yang et al. studies the threshold effect of government subsidies on investment in China, looking at the effect of different types of subsidies and enterprise sizes on the threshold. The main result is that government subsidies have a positive threshold effect on renewable energy investment, particularly in areas with high energy consumption intensity, low economic development, and high bank credit.   
They conclude that tax incentives have a more significant effect on promoting renewable energy investment. Government subsidies play a crucial role in supporting the development of medium-, small-, and micro-sized renewable energy enterprises, given their financing difficulties. On large-sized companies, subsidies have less effect on investment behaviour, considering that they can attract bank loans. The authors suggest that for large companies the government should limit itself to encourage investment. (Yang, et al. 2019)  
Also, Du et al. look at the threshold effect of government subsidies on the development of the renewable energy industry. The results show a U-shaped relationship between subsidies and enterprise output. They emphasize that the effect and efficiency of subsidies on investment depend on the industry. (Du, et al. 2023)  
In line with that, Huiming et al. state that different energy sectors have different subsidy thresholds and there is a nonlinear relationship between government subsidies and capacity utilization (Zhang, Zheng und Li 2016).   
The study by (Milanés-Montero, Arroyo-Farrona, & Esteban, 2018) finds that higher FITs are associated with greater return on investment in European companies. But there are some country specific differences in profitability, for example even though Germany has lower average FITs then other countries, it experienced significant growth in installations due to its stable support mechanism, strong stakeholder confidence and streamlined procedures. The study also recognizes the risk that of long-term fixed tariffs could result in high system costs and potential misalignments with market prices. (Milanés-Montero, Arroyo-Farrona, & Esteban, 2018)

Sendstar et al. highlight the importance of a stable policy environment with credible policy commitments to incentivize investments by private firms. Sudden unexpected policy changes deter further investment activity in affected countries. (Sendstad, et al. 2022)  
Also, Dijkgraaf and al. study the effect of FIT policies on the development of the solar sector, considering structure and consistency of the policy. They show that tariff and consistency is very important and can multiple the effect of FIT. (Dijkgraaf, van Dorp, & Emiel, 2014)  
Too rapid subsidies removal can be fatal to industry development, especially for emerging industries. Du et al. conclude that subsidies contribute to the positive development of the industry but also highlight the necessity and inevitability of a subsidy retreat policy. (Du, et al. 2023)  
Unreasonable subsidy policies disrupt the market and make companies overly dependent on them. Blind production can then lead to overcapacity. Governments should adjust the target of subsidies to ensure that enterprises have sufficient independent development capacity.   
Excessive subsidies can lead to resource waste and inefficiency. Removing subsidies will have an effect on macroeconomics, industrial output and individuals’ welfare, but it can effectively increase structural optimization and factor efficiency. (Du, et al. 2023)

The Study by (Hajdukovic, 2022) on the relationship between international trade and the price of solar PV modules finds that an increase in imports of cells and modules leads to a decline in module prices, thus affirms that international trade promotes deployment of solar PV technologies by reducing the price. Also, technological advancements and market expansion are crucial in driving down the prices. Policies such as public funding for R&D in solar PV and the implementation of feed-in tariffs helped to decrease prices. (Hajdukovic, 2022)  
Private R&D, learning-by-doing, and economies of scale were all facilitated by feed-in tariffs, renewable portfolio standards and other market-stimulating policies. The study by (Kavlak, McNerney, & Trancik, 2018) states that public and private R&D, economies of scale, learning-by-doing and of market stimulating policies contributed to an estimate of 60% of the cost decline in PV modules between 1980 and 2012. (Kavlak, McNerney, & Trancik, 2018)  
The study by (Groba & Cao, 2014) finds that Chinese export growth in the solar PV industry was strongly tied to income levels in importing countries, market size and policy environment, especially demand side policies, play an important role. (Groba & Cao, 2014)

Much of the solar PV market dynamic we see today was shaped by the production- focused incentives in China, which were aiming to build a strong manufacturing base by imposing measures to increase the capacity and technological advancement of the manufacturing sector. Whereas European incentives often focused more on deployment and integration into existing energy systems. The emphasis there is on increasing the adoption of renewable energy sources.

# Incentive policies in Europe and supply dependency on China

Have incentive policies an impact on the diversity of suppliers and import dependency?

In the solar PV sector not, looking at the historical development. Europe started promoting installation of solar PV, without the means to meet the increased demand. It looks like China took the initiative, started to incentives the build up of the industry and export competitive products, expanding its dominance and making it for competitors hard to compete.

To address the second research question:  
Can Europe’s renewable incentive policies hedge against the geopolitical risk of China’s supply chain dominance of solar photovoltaic products?  
A panel model analysis was used, where data for the EU countries between 2005 and 2019 was collected. fixed and random effects model.  
What role did feed-in tariffs play in the dominance of China, and if consistency of the policy changed the supply strategy.

The data from 2005 until 2019 was collected. 2005 was chosen because since than solar energy really peaked up and China became an important player, FIT data was only available until 2019 and lost importance in recent years.  
24 countries part of the EU. Luxembourg, Malta and Cyprus were excluded, due to some missing data and their size and importance with regards to solar installation.

The independent variable is the Feed-in Tariffs/Feed-in Premium, which is the most used incentive policy in the EU during the period.   
Feed-in Tariffs are long-term contracts, usually from 15-25 years to renewable energy producers, providing them with a priced price for each unit of electricity feed into the grid. The price is typically above the market rate, ensuring that producers have a guaranteed income and can recover their investment costs over time. FITs are designed to accelerate the deployment of these technologies by reducing financial risk for investors. (Kenton, 2024). In recent years, market-based instruments became more popular, among which Feed-in Premium. Feed-in Premiums provide a premium on top of the market price, intended to compensate for the additional costs associated with renewable energy production. (Energypedia, 2019)

FIT values are provided by OECD, the unit of measurement is current USD/kWh, additional also the length of the power purchasing agreement was collected (measured in years).  
Project with capacity below 1MW and for household use were excluded, if the policy foresees such a distinction.  
The dataset provides the tariffs for different renewable electricity sub-sectors, for this analysis only the solar photovoltaic was considered. If the tariffs vary within a sector, typically across technology type and installed capacity the mean value was stated.   
in the dataset, feed-in premiums are recorded as if they were feed-in tariffs.  
It fulfilled the purpose of the needs of this paper, as an indicator of government support for renewable electricity use, enabling country level comparison.

As the dependent variable, data was taken from the UN Comtrade Database. Imports from the world and from China were available for all 24 countries of interest. So that, the import share from China could be calculated and the absolute number of imports from China were available.  
  
As the study is interested in photovoltaic products, the product group with the HS Code 854140 was chosen: Photosensitive semiconductor devices, incl. photovoltaic cells whether or not   
assembled in modules or made up into panels; light emitting diodes (excluding photovoltaic generators)  
The Harmonized System (HS) is a standardizes method to classify traded goods with numerical codes.

With the HS revision of 2022 the HS codes 854140 was segregated to allow more specific information into the following four categories:

854141: Light emitting diodes "LED"  
854142: Photovoltaic cells not assembled in modules or made up into panels  
854143: Photovoltaic cells assembled in modules or made up into panels  
854149 Photosensitive semiconductor devices (excl. photovoltaic generators and cells)

To control for other variables that influence the variability of import:

to control for income and demand variables:   
- GDP pro capita, to control for the economic strength of the countries as an indicator of the general economic condition

-Energy consumption, to control for total energy needs

To control for the market size:  
- Annual solar capacity Addition (demand for solar products)

-Area, as indicator for the renewable energy potential by controlling for the size of the countries

To control for the production costs:

-Electricity price, taken as an average of industrial and household price measured in kilowatt per hour (EUROSTAT)

-Average Wage Difference, as a proxy for the difference in production costs

-Tech Advancement, more advanced technology might reduce the need for imports from China

-Tech Advancement in China

Controlling for other regulatory, policy indicators:

-Trade Policies EU, to better isolate the impact of FITs from other policy measures that influence the import level, this includes the surcharges on Chinese solar imports from 2013-2018.

-Governmental fixed Asset Investment in China to the “manufacturing of electrical machinery and apparatus” as a proxy to the government spendings to the sector, due to high multicollinearity this indicator had to be dropped.

-Environmental Standard Difference, as a proxy for the difference in environmental standards and regulations

SD Fit and SD Duration to account for consistency of policy, as in the paper (Dijkgraaf, van Dorp, & Emiel, 2014) based on the last five years. In the paper they show that consistency is important for the effectiveness of the policy.  
More reliable and consistent policy could make the market for the producers in the region more attractive.

 **Incentive for Local Production**:

* Feed-in tariffs (FiTs) are designed to incentivize renewable energy production by guaranteeing a fixed price for the energy produced. This can lead to increased local production of renewable energy components, potentially reducing reliance on imports, including those from China.

 **Market Demand and Cost Competitiveness**:

* FiTs increase the demand for renewable energy systems, such as solar panels. Chinese manufacturers, known for their cost-competitive products, may benefit from this increased demand, potentially increasing their market share in Europe.

 **Technological Advancements**:

* European feed-in tariffs might encourage technological advancements and efficiency improvements within the EU, enhancing the competitiveness of local suppliers. This could decrease the market share of Chinese imports if European products become more cost-effective and technologically superior.

Chat Gpt

Main research question:

Can Europe’s renewable incentive policies hedge against the geopolitical risk of China’s supply chain dominance? Have incentive policies an impact on the diversity of suppliers and import dependency?

Panel data 1 with import dependence 2 with 854140 3 with ingots or wafers 4 with a raw material

Subquestion:  
How did China become so predominant in the renewable energy sector and in the solar industry in particular? What was/is the driving force behind it? What role did its autocracy play?

Time series? China 5 year plan

Hypothesis: Higher subsidies reduce import dependence, but do not significantly affect components and raw materials, leading to limited impact on geopolitical supply risk.

Increased subsidies could potentially decrease import dependence (might not have any effect on import concentration). Subsidy-driven shifts in production may incentivize domestic industries and reduce reliance on imports for finished goods and some components. But this may not apply to other crucial components and raw materials. Despite industry-specific incentive policies, some sectors remain vulnerable to geopolitical supply risks due to the complexity of global supply chains, inefficiency of complete reshoring and difficulty of diversifying the suppliers.

Hypothesis: Cost advantage and efficiency is the driving force of China’s dominance in the solar technology supply chain, which was also achieved through early substantial state support that enabled a rapid exploitation of scale-up benefit and lower production costs at the expense of worse working conditions and lower environmental standards.  
lower energy costs

Role of Predatory pricing (2010s)?

To answer the main research question:

Panel data regression with import concentration (indicator for geopolitical risk) as the dependent variable and Feed-in tariffs/European incentive policies as the independent variable.

2005-2019

*CN’s share in ImportEUit*=*β*0​+*β*1​*FITEUit*​+*β*2​*GDPprocapitaEUit*​+*β*3​*RenewableEnergyConsumptionEUit*​+*β*4​*SolarPVcapacityEUit*​+*β*5​*TechAdvancementEUit*​+ *β*66*TechAdvancementCNit +β*77*TradePoliciesEUt*​+ *β*7FixedAssetInvestmentCN*t-1*​+ *β*9​​*(AvgWagesEUit*​- -AvgWages*CNt)+ β*10*(EnvironmentalSt.EUit*​- -EnvironmentalSt.*CNt)+ui*​+*ϵit*

*Energy price not found*

2008-2018

*China’s share in ImportEUit*​=*β*0​+*β*1​*SubsidiesEUit*​+*β*2​*GDPprocapitaEUit*​+*β*3​*RenewableEnergyConsumptionEUit*​+*β*4​*SolarPVcapacityEUit*​+*β*5​*TechAdvancementEUit*​+*β*6​*TradePoliciesEUt*​+ *β*7FixedAssetInvestmentCN*t*​+*β*8​*(EnergyPricesEUit*​- -*EnergyPricesCNt)+β*9​​*(AvgWagesEUit*​- -AvgWages*CNt)+ β*10*(EnvironmentalSt.EUit*​- -EnvironmentalSt.*CNt)+ui*​+*ϵit*

*Subventionen in China*

Golden Sun Program and Top Runner Program,

Fit in tariff

*Einkommen(GDP) nachfrage (Energy Consumption)*

*Technologie, kosten (electricity prices, tech advancement)produktionskosten*

*Regulatorisch( subventionen trade policies und Regulatorikkosten)*

* **Import concentration/Supply diversification as the dependent variable** (HHI Index)   
  China’s Share in country’s imports  
  source: Trade Map/**COMTRADE**/Eurostata/ Figaro (corrects for re-export)

OECD: Trade in Value Added TiVa Database

Question of re-export? Malta, Luxembourg and Cyprus excluding? Final destination

The Harmonized System (HS) is a standardizes method to classify traded goods with numerical codes.

HS Code 854140: Photosensitive semiconductor devices, incl. photovoltaic cells whether or not   
assembled in modules or made up into panels; light emitting diodes (excluding photovoltaic generators)

With the HS revision of 2022 the HS codes 854140 was segregated to allow more specific information into the following four categories:

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854149 Photosensitive semiconductor devices (excl. photovoltaic generators and cells)

Also available import data on components and raw materials, selection of those depending on the availability of the data:

Up to the HS-6 digit level, all countries using the Harmonized System classify products in the same way. HS codes 854140 Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes (excluding photovoltaic generators). Since 2022 HS revision more detailed data, on products with HS codes with more than 6 digits)

* **European incentive policies** as the independent variable.   
  sources: OECD renewable feed-in tariffs. <https://stats.oecd.org/Index.aspx?QueryId=86946>  
  Eurodata, Trinomics, IEA report, IEA policies database  
  Public R&D spending: <https://stats.oecd.org/BrandedView.aspx?oecd_bv_id=enetech-data-en&doi=data-00488-en>

**European commission study:** Energy costs, taxes and the impact of government intervention on investment (data from 2008-2018)

Control variables:   
Solar energy market size in European countries. World development indicators: Renewable electricity output (% of total electricity output)  
Renewable energy share of electricity capacity and generation (%) by Region/country/area, Indicator and Year: IRENASTAT generation weather dependent, not capacity  
Import dependence. Eurostat>Sustainable development indicators> Goal 7  
GPD in China. https://www.imf.org/external/datamapper/NGDPDPC@WEO/ADVEC  
Subsidies in China/incentive policies  
Average tariff faced by China (EU uniform)  
Global production concentration source: Trade Map, China’s share in world exports/imports

Subsidies in China, not disclouse, proxy fixed asset investment… I had to eliminate it then due to multicollinearity in the model

# Conclusions

*Reshoring would full value chain would be extremely costly and very inefficient, and at the cost of taxpayers. Only for areas where Europe has competitive advantage due to the high concentration of skills, access to cheap energy or critical materials, or proximity of related industries.*

*Europe should focus on diversifying their sources of supply, for that targeted incentives and disincentives can be used. It would allow increasing sources of supply while keeping prices down.*

*The impact of the Lieferkettengesetz in the Eu, forced labour allegations in the polysilicon factories in Xinjiang* (McWilliams, Tagliapietra, & Trasi, 2024) *and the inflation reduction act in the USA will be seen in the future. Inflation reduction act clear intention to compete with China and reduce the dependence on them. Feed in Tariffs intention of installation increase.*

*Might be that fit incourage policymaker and industry in China further to be dominant in the area, due to the demand and subsidization in Europe?*

Chinese manufacturers with their cost advantage, technological advancements and production capacity are well positioned to meet the increased demand driven by subsidies, it appears that Feed in Tariffs reinforced the dominance by China.

*No strong economic justification for an import-substitution approach, it would increase the costs of solar panels, slow deployment and create industries that are over-reliant on subsidies. In the Net-Zero Industry Act wants to ensure that 40 percent of the strategic net-zero technologies comes from EU manufacturing, with the only valid justification of mitigating the risk of over-dependence on Chinese imports.* (McWilliams, Tagliapietra, & Trasi, 2024)

How did Europe become so dependent on China? Germanys important role in the early 2000s.

Feed in tariffs less financial risk for the producer of electricity, not said he cares for other risk. Future and not certain it will concern him, Household (too small), miope view,

No argument that import from China is bad, only high concentration creates risk

Seems the concentration of imports was boosted, the demand outstripped local supply, feed in tariffs in Europe, without the capacity of sadisfying it, left the chance for China to fill the needs and become dominant.