ZEW policy brief

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Global Influence of Inventions and Technology Sovereignty

The global economic landscape has fundamentally shifted from the paradigm of globalization to renewed concerns regarding the risks and rewards of technological interdependence. This shift has sparked a critical discussion on technology sovereignty. This concept refers to a country's ability to provide essential technologies for competitiveness and welfare, and to develop or acquire them from other geographic areas without being unilaterally dependent on any particular one. We analyze the technology sovereignty of the world's leading innovators, including Europe, the US, China, Japan and Korea. By examining citation data from the universe of PCT patent applications, we determine the strength and direction of inventions' influence at global and bilateral levels to assess each geographic area's technology sovereignty. Our analysis shows that the US holds substantial technology sovereignty due to its leading global and bilateral influence. Despite ongoing US-European integration, their global positions differ, as Europe is dependent on all other areas except China. Although China has globally filed the most patent applications in recent years, bilaterally it remains dependent on all other geographic areas. Moreover, only Japan and Korea show a recent decline in their global influence.

KEY MESSAGES

- We analyze the technology sovereignty of Europe, the US, China, Japan and Korea by measuring their inventions' global influence and dependence using patent applications between 2000 and 2020.
- The US shows superior technology sovereignty. Despite US-European integration, their global positions differ as Europe is dependent on all other geographic areas except China.
- Although China has filed the most patent applications in recent years, it remains bilaterally dependent on all other geographic areas. Only Japan and Korea show declining global influence, despite previously holding leading positions.

TECHNOLOGY SOVEREIGNTY MITIGATES GEOECONOMIC DEPENDENCE

Technology sovereignty is distinct from self-sufficiency

The global economic landscape has fundamentally shifted from the paradigm of globalization to renewed concerns regarding the risks and rewards of economic interdependence. This shift has sparked a critical discussion of technology sovereignty, a concept at the crossroads of geoeconomics and innovation studies. Technology sovereignty differs from national autarky and technological self-sufficiency. It refers to a country's capacity to provide essential technologies for the sake of its competitiveness and welfare and to develop these technologies domestically or acquire them from abroad without being unilaterally dependent on any particular country. Since new innovations and technological regimes develop globally, technology sovereignty and international cooperation are not antagonistic, but mutually dependent. However, if there is no reciprocal interdependence ensuring access to foreign knowledge, unilateral structural dependence can erode the technology sovereignty of more dependent countries.

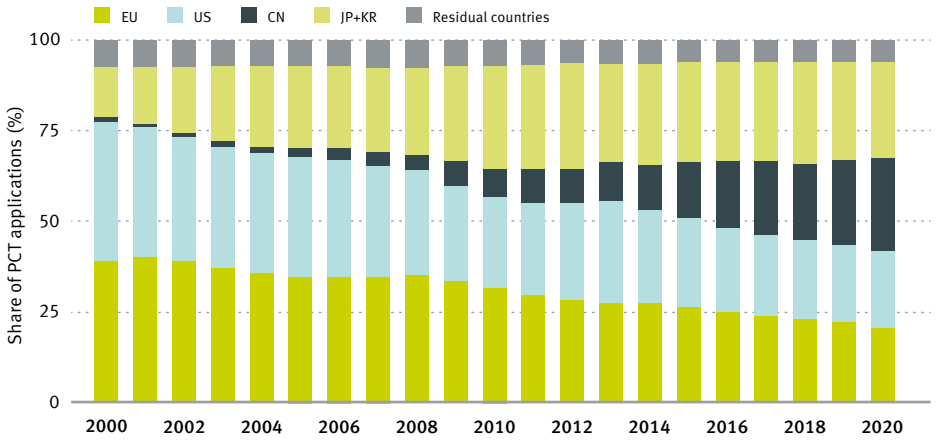
Cooperation with geo-economically reliable partners

Recent technological competition and geoeconomic disputes, particularly between China and the West, have compelled policymakers to balance efficiency with risk reduction strategies. In general, countries aim to collaborate with like-minded and geoeconomically reliable partners while reducing unilateral dependence on less reliable countries. Therefore, it is increasingly necessary for policymakers to develop measures of economic influence and dependence that allow for evidence-based decision making. Because understanding the bidirectional nature of knowledge flows is essential, this requires increasingly nuanced measures to assess how countries mutually influence one another's innovations. In a new study, we present a novel approach to measure the influence and dependence of the leading global innovation regions, rendering the concept of technology sovereignty empirically assessable.

East Asia files the majority of PCT patents

This is achieved by analyzing patent applications filed through the Patent Cooperation Treaty (PCT). The PCT system, which is administered by United Nations' World Intellectual Property Organization, allows applicants to protect intellectual property in up to 157 countries simultaneously. Use of the PCT system has significantly expanded throughout the years, increasing from 97,414 filings in 2000 to 254,008 filings in 2020. This growth is largely influenced by East Asian countries, with China being the top-ranked PCT filing country since 2019. The shift in innovation activity from the West to East Asia is outlined further in Figure 1. In 2000, more than three-quarters of PCT applications came from the US and Europe[1]; however, Western dominance gradually

FIGURE 1: SHARE OF PCT APPLICATIONS BY GEOGRAPHIC AREA (2000 – 2020)



1 We consider Europe as a whole as the European Union is increasingly governing geoeconomic and innovation-related topics of their member countries. In our study, Europe includes 30 countries: the EU-27 plus Norway, Switzerland, and the United Kingdom – which was an EU member country until January 2020.

decreased in the following two decades. By 2020, more than half of the global PCT applications originated from China, Japan, and Korea.

Measuring the quantity vs. influence of patents

The rise in patent quantity is only one side of the story, although the actual influence of inventions is not readily observable. In our study, we develop a measure that uses citations generated by International Search Reports (ISRs) during the international phase of PCT applications. This allows us to compute the extent to which inventions in one geographic area provide the basis for inventions in other areas. We only consider non self-citations from abroad to ensure that our measures are unbiased and independent of potential domestic policy distortions, such as China's patent subsidy programs.

Infobox: Measuring the global influence of inventions

Our analysis is based on the universe of global PCT filings between 2000 and 2020. We initially allocate all patent applications to one of the top four global innovation regions: (1) Europe, (2) the US, (3) China, and (4) Japan and Korea (residual countries account for a small remainder). Subsequently, we compute the number of ISR citations that a geographic area obtains from another area. For example, this data allows us to analyze US technological influence in China.

We first analyze the overall **strength of global influence** at the patent level for each geographic area. Second, we examine the **geographic direction of global influence** and how it changes over time. Third, to calculate **bilateral influence**, we add up all inventions from each geographic area and determine if the focal area shows reciprocal dependence on the other area or whether its situation is characterized by either independence or dependence. We also compute the **average bilateral influence** for each area in comparison to all others and again analyze changes over time.

THE US SHOWS SUPERIOR TECHNOLOGY SOVEREIGNTY

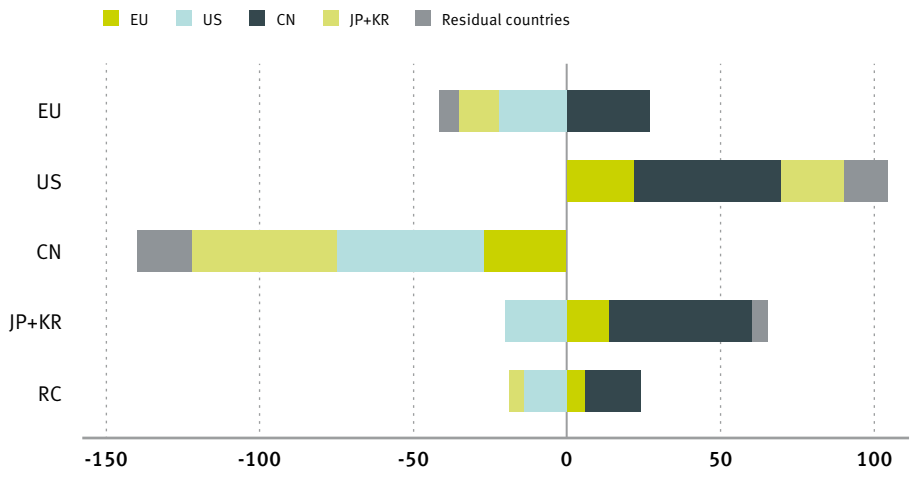
Strengths of global influence. Compared to Europe, US patents receive significantly more ISR citations. In contrast, Chinese patents are associated with fewer citations. This imbalance between the countries has persisted since 2000, with the gap becoming a bit more pronounced over time. Patents from Japan and Korea, on the other hand, started out slightly stronger compared to Europe, but have weakened over time. In addition to receiving more ISR citations, US patents also have a stronger influence across geographic and technology areas.

Geographic direction of global influence. A notable and stable integration has occurred between Europe and the US. The share of ISR citations coming from other geographic areas to Europe and the US roughly doubled over time. The reason for this increase is that the number of PCT applications strongly increased in East Asia. As a result, these countries produced more inventions based on Western inventions, illustrating the continued global influence of Western technology. From 2012 to 2017, only 21% of ISR citations in Japan and Korea and 8% in China came from abroad, compared to 38% in the US and 32% in Europe.

Bilateral influence. In Figure 2, a value of 0 indicates full reciprocity between the two areas, while an upper (lower) bound of 100 (-100) implies full independence (dependence) of the focal area in relation to the other area in question. Because we are quantifying the stacked bilateral influence across all four partner areas, upper and lower bounds extend to 400 and -400. Notably, the US is the only country with consistent bilateral independence, amounting to 104, while China is the only country with consistent dependence, amounting to -140. Both Europe and Japan and Korea have

rather mixed accounts of stacked bilateral influence, with more moderate upper and lower values of 27 and -42 and 65 and -20, respectively.

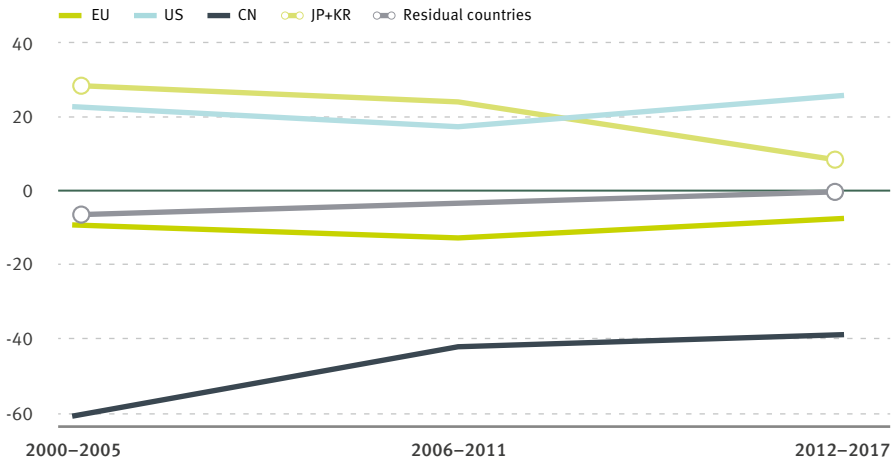
FIGURE 2: STACKED BILATERAL INFLUENCE (2012 – 2017)



For each focal geographic area the bar shows the bilateral influence of that area with respect to the other four areas. 0 refers to reciprocity between the focal area and all other areas, 400 refers to full independence, and -400 refers to full dependence.

Average bilateral influence over time. Figure 3 shows the average bilateral influence for each geographic area relative to the aggregate of all other areas. Again, a value of 0 indicates reciprocity, 100 indicates full independence, and -100 indicates full dependence. Notably, Europe and the US remain relatively stable and exhibit similar trends over time. Specifically, the US fluctuates between 17.6 and 25.8, whereas Europe ranges from -12.9 to -7.5. The position of Japan and Korea has weakened over time, declining from 28.5 to 8.2. In contrast, a continuous increase in the bilateral influence of China from -60.7 to -38.9 is shown, which still positions China below other areas.

FIGURE 3: AVERAGE WEIGHTED BILATERAL INFLUENCE OVER TIME (2000 – 2017)



For each focal geographic area the average bilateral influence with regard to all other areas is displayed. 0 refers to reciprocity, 100 refers to full independence, and -100 refers to full dependence.

IS CHINA CATCHING UP WITH THE WEST?

US remains the world's technological superpower

Across all results, it is evident that the US has maintained its influential position as the world's technological superpower. However, this conclusion is far from obvious. Since 2019, China has overtaken the US, Japan, Korea and Germany as the leading PCT patent applicant. Nevertheless, our analysis suggests that China's focus on quantitative patent targets combined with industrial and innovation policies has not yet amounted to inventions with an overwhelming global influence. In contrast, our findings reveal China's continuous dependence on all other geographic areas, which is evident across all technologies and future-oriented Key Enabling Technologies (KETs). Although China improved its average weighted bilateral influence during the first decade of the millennium, its recent growth trend is similar to that of the US and Europe, albeit at a lower level. Thus, our results do not suggest that China is primed to overtake the US.

China made significant progress but remains the most dependent on others

Several policy implications emerge. Despite ongoing US-European integration, their respective global positions differ. Therefore, it is crucial for European policymakers to address this dependency. A related policy approach could focus on promoting KETs, as Europe has already obtained relative advantages in these future-oriented technologies, while also avoiding future dependence on Chinese innovation. Japan and Korea have made important contributions to global innovation; however, recent inventive activity has not yet been adequately translated into international influence. Finally, the geoeconomic climate is characterized by a systemic rivalry, which partially originates from China, and the push for technological sovereignty by other countries could be seen as a response to this. The timing of these events poses a challenge for China, as it has made significant strides in terms of the quantity and influence of inventions, but remains more dependent on other geographic regions than vice versa.

REFERENCES

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