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This brief examines collaboration and ownership patterns on US patents granted to Chinese inventors from 2000 through 2016. The analysis uses data on inventor residence and owner location from the Patent Examination Research Dataset (PatEx) and PatentsView (www.patentsview.org), a web-based data resource supported by USPTO's Office of the Chief Economist (OCE).

Overview of Findings:

- Chinese residents significantly increased their collaboration on US patents while decreasing their single-inventor patents. The share of Chinese-invented patents that were collaborative grew from 54 to 73 percent between 2000 and 2016.
- Most of this growth is due to greater collaboration among Chinese inventors. However, the share of foreign-collaborative patents with US and European inventors also rose over the past decade. This share decreased for Taiwan, Hong Kong, and Macau collaborators.
- Chinese entities own the largest share of US patents with Chinese inventors. The share of patents (at least) partially owned by the Chinese reached 65 percent by 2016, while the share of patents (at least) partially owned by non-Chinese assignees declined to 40 percent.
- At less than 10 percent, Chinese own the lowest share of US patents issued to teams of Chinese and US-based inventors.
- For patents with at least one non-Chinese owner, the trend over the past several years shows a move away from Taiwan/Hong Kong/Macau-based owners to owners from other regions, especially the US and European Union.

Introduction

Policy makers in the US and Europe are particularly interested in the collaboration and ownership patterns of patents invented or co-invented by Chinese residents.¹ Their interest centers on how to balance the potential benefits from collaboration against the potential risks to innovation and competitiveness. Among the potential benefits are access to new knowledge, enhancements to scientific capabilities, better political associations within China, and improved access to the Chinese markets. The risks include revealing proprietary know-how, losing ownership of patented technologies and strengthening Chinese rivals. For example, China's Technology Import and Export Administration Regulations (TIER) cover any technology transferred into China "by way of trade, investment or economic technological cooperation" and the act of transfer broadly includes transfer "via technical services and other means."² TIER requires that all technological improvements belong to Chinese entities and that foreign entities bear all liability resulting from transferred technologies, including disputes with third party intellectual property owners.

Beyond policy considerations, collaboration and ownership patterns may reveal something fundamental about innovation and economic development. For instance, Jones (2009) argues that innovation becomes more difficult over time due to a "burden of knowledge." That is, the amount and breadth of knowledge necessary to innovate has increased. Under this hypothesis, people must specialize and collaboration emerges as a necessary condition for combining knowledge to create innovations. Of course, increased collaboration may reflect other changes to the inventive process. For instance, improvements in information technologies lower the cost of collaborating (Agrawal and Goldfarb, 2008) and international collaboration may be more efficient for implementing changes or improvements to products marketed overseas (see Kerr and Kerr, 2015). Beyond the inventive process, ownership patterns tell us who reaps the rewards from innovations. In a recent study, Branstetter and colleagues (2015) found the majority of US patents issued through 2010 to Chinese inventors or co-inventors were owned by non-Chinese entities, particularly multinational corporations. Our update shows this ownership pattern has shifted with a greater share of collaborative patents owned by Chinese entities.

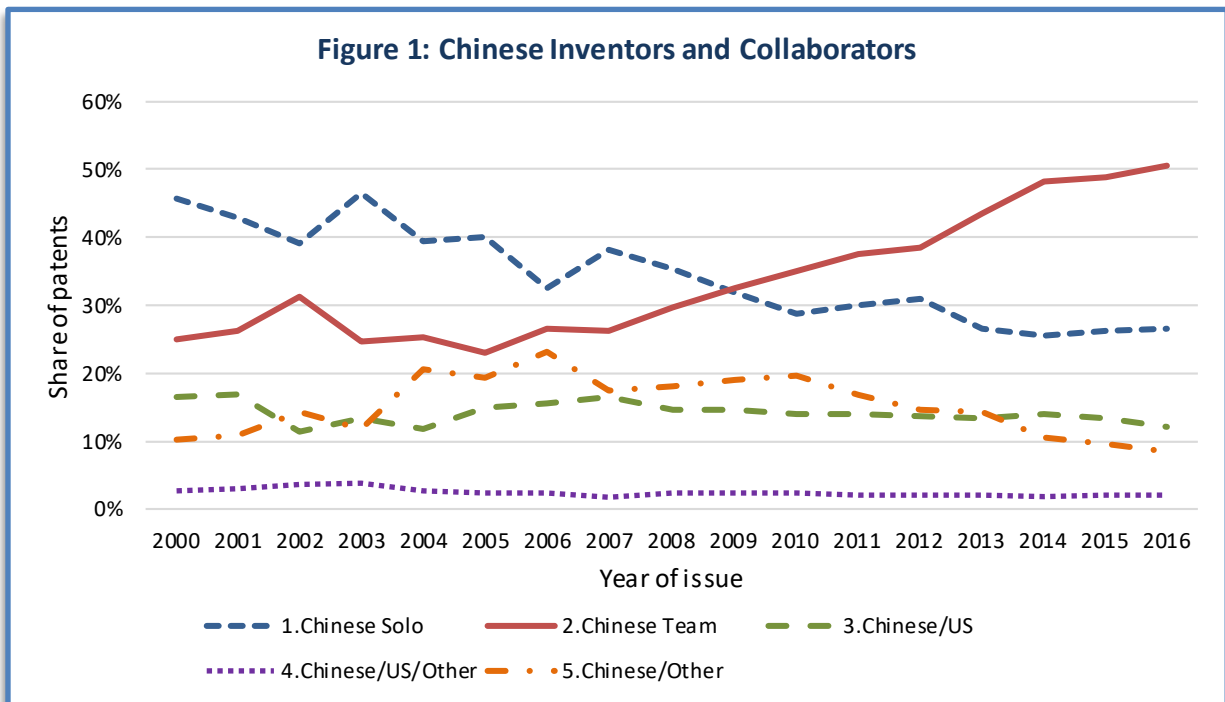
Chinese-only Inventor Teams Show Dramatic Growth

Figure 1 illustrates the trends in collaboration – both domestic and international – of Chinese inventors on US-issued patents from 2000 through 2016. Overall, there was a steady increase in Chinese inventor collaboration over this time period, as the share of patents that were

¹ A USPTO-issued patent is considered Chinese-invented if at least one of the inventors listed on the patent has a residence address in Mainland China. See the Appendix for details.

² See <http://www.wipo.int/edocs/lexdocs/laws/en/cn/cn125en.pdf>. Last accessed on 30 August 2017.

collaborative grew from 54 percent in 2000 to 73 percent in 2016. There was a corresponding fall in the share to patents that were solo-invented.



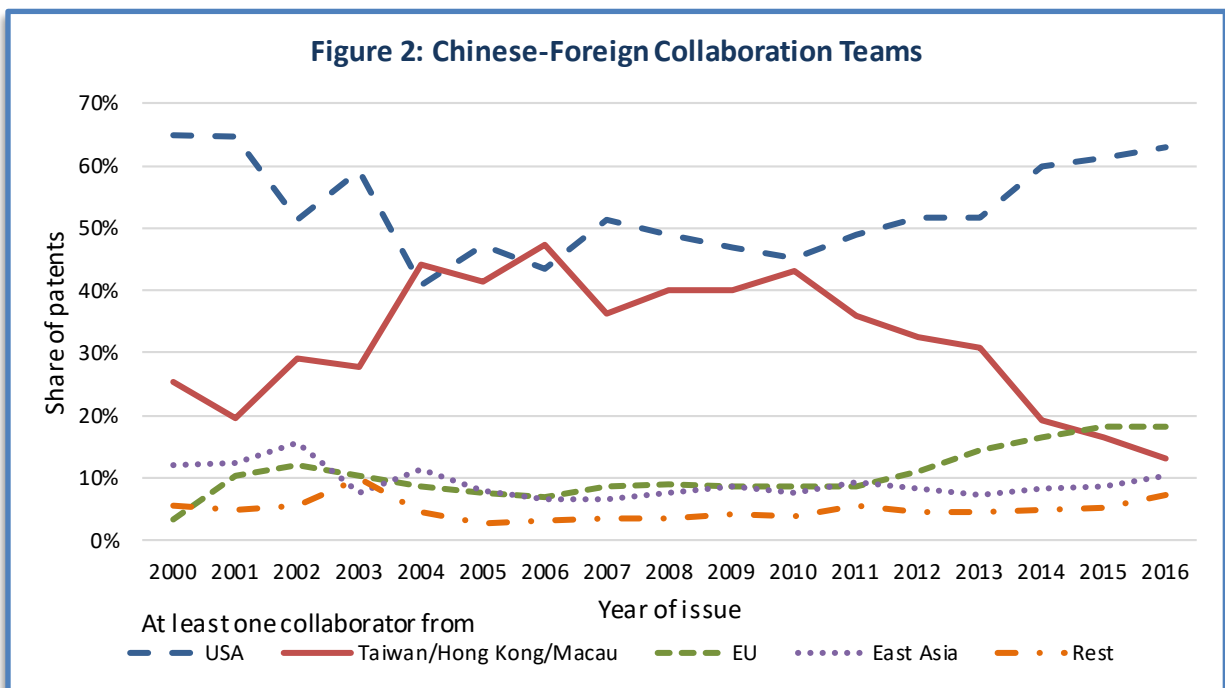
Collaboration exclusively among Mainland Chinese inventors grew most significantly, accounting for much of the displacement of solo patents. Patents issued to Chinese teams represented only 25 percent of the Chinese patents issued by the USPTO between 2000 and 2005, but represented 50 percent of those issued in 2015 and 2016. As the share of patents issued to Mainland Chinese teams grew over the past decade, the share issued to Chinese/US collaborators fell from 17 percent in 2007 to 12 percent in 2016.

As a share of total patents, Mainland Chinese collaboration displaced collaboration between Mainland Chinese and foreign (non-US-based) inventors over the past decade. As recently as 2006, these collaborations represented nearly one-quarter of US issued patents. However, following a steady decrease since 2006, these collaborations account for only 8 percent of Chinese-inventor US patents by 2016.

US Inventors Stand Out Among Chinese-Foreign Collaboration Teams

We also considered the regions of residence of foreigners who collaborated with Mainland Chinese inventors. Figure 2 shows the shares of “foreign-collaborative” patents with at least one inventor from each of the following regions: Taiwan/Hong Kong/Macau (THKM), the remainder

of East Asia (including Japan, South Korea, and the ASEAN countries), the US, the European Union (EU), and the rest of the world.³



The most striking result is an apparent switch from collaboration with inventors from T/HK/M to collaboration with inventors based in the US. The decrease in the share of foreign collaboration patents with at least one inventor from T/HK/M is dramatic, falling from nearly 50 percent in 2006 to 13 percent in 2016. The rise in the share of Chinese collaborative patents with at least one inventor from the US was nearly as dramatic, increasing from 44 to 63 percent over the same time period. Chinese-European collaboration is also notable. The share doubled from 9 to 18 percent over the 5-year period ending in 2016. Those with at least one East Asian collaborator fluctuated between 7 and 10 percent.

The past decade shows a relative rise in Chinese collaboration with inventors residing in western countries and a corresponding decline in East Asia, especially in those jurisdictions that make up the Chinese diaspora. There are a number of possible reasons for this trend. Greater collaboration between Chinese residing in the US and Europe and inventors in Mainland Chinese may reflect the growth in highly trained Chinese scientists and engineers who studied and remained in the US and Europe, or have been attracted back to mainland China.⁴ It may be due to greater scientific and technical capabilities possessed by a new generation of Mainland

³ There can be double counting in these figures. For instance, a single patent can have collaborators from both the US and the EU. Thus, the shares in Figure 2 sum to greater than 100 percent.

⁴ See Xie et al (2014)

Chinese scientists, making them more attractive collaborators.⁵ For both possibilities, the emergence of new communication and work-process technologies have facilitated collaboration over large distances by reducing collaboration costs. Finally, it may reflect growth in advanced technology investments by Americans and Europeans into China.⁶

Significant Rise in Chinese Owned Patents

Figure 3 illustrates the share of patents in each of five international patent ownership categories between 2000 and 2016.⁷ As shown by the solid red line, patents owned exclusively by Chinese entities increased substantially, doubling from 30 percent in 2009 to 60 percent in 2016. Starting in 2006, there was also a somewhat peculiar increase and decline in the share of patents jointly owned by Chinese and non-US-based foreign entities, which peaked at 22 percent in 2012. Overall, the share of patents issued with (at least) partial Chinese ownership rose from about 40 percent to 65 percent over the past decade, with patent ownership being almost exclusively Chinese in the last five years.

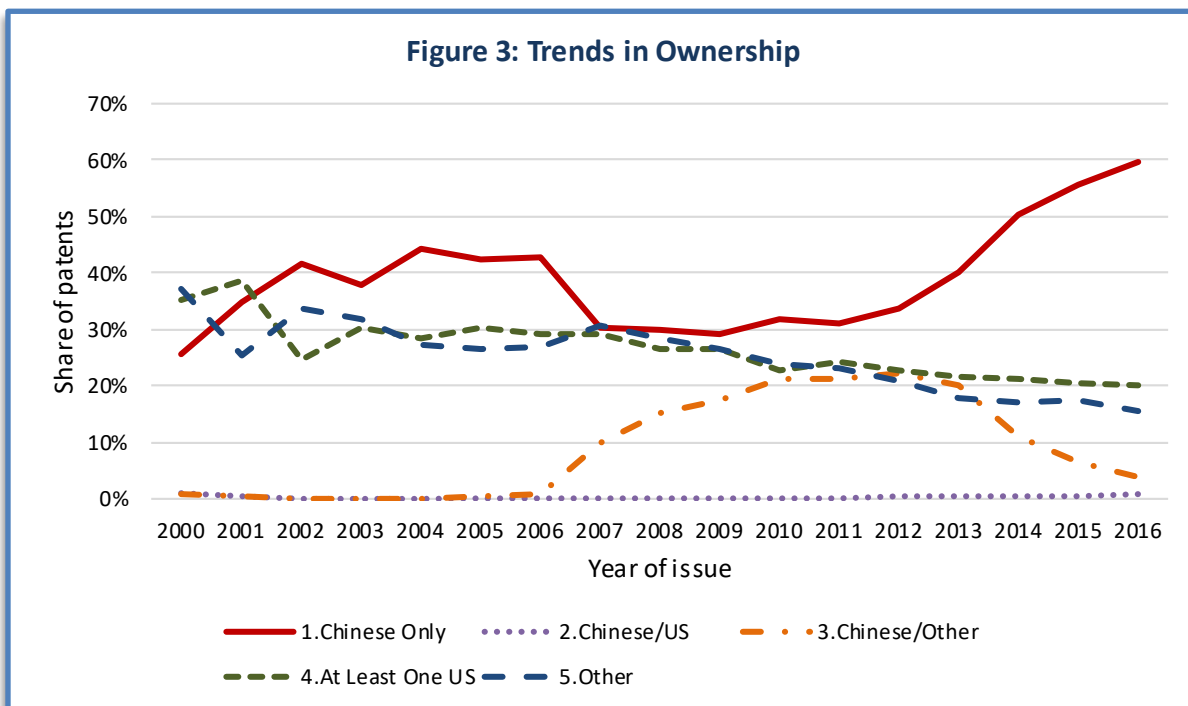


Figure 3 reveals another interesting trend. The share of patents assigned exclusively to non-US-based foreign entities (called “Other” in the figure) fell from nearly 40 percent in 2000 to 16 percent in 2016. The share of patents with at least one US-based owner followed a similar trend,

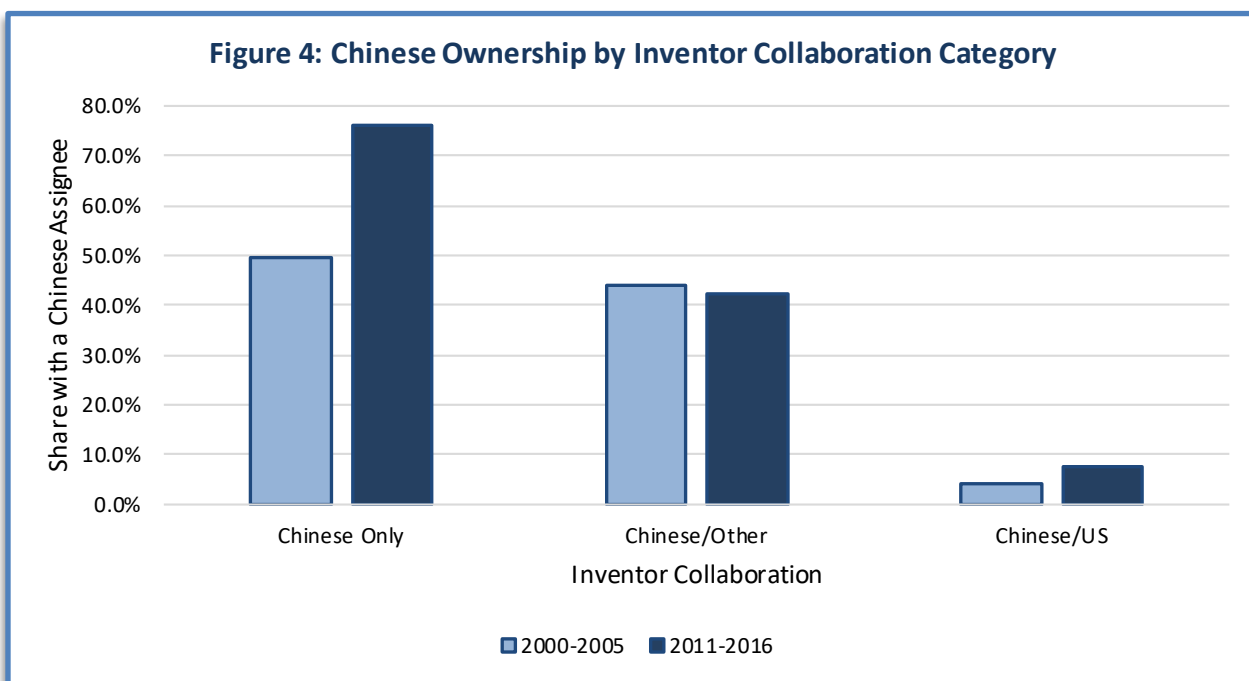
⁵ See Veugelers (2017)

⁶ See, for instance, Marro (2015)

⁷ See the Appendix for detailed definitions of the ownership categories.

decreasing slowly but steadily over the time period. Despite a significant amount of Chinese/US co-invention, the rate of co-ownership of patent rights to Chinese and US-based entities is surprisingly small (less than 1-percent).

Figure 4 shows that the biggest increases in Chinese ownership have been for inventions that were invented exclusively by Chinese inventors. Among the Chinese-only patents issued between 2000 and 2005, the share that were at least partially owned by Chinese entities was roughly 50 percent. By the early teens (2011-2016), this share had increased to roughly 75 percent. The share of Chinese ownership for patents issued to teams of Chinese and non-US-based foreign inventors stayed fairly steady, while the Chinese ownership rate of US patents issued to teams of Chinese and US-based inventors has increase but remains below 10 percent.

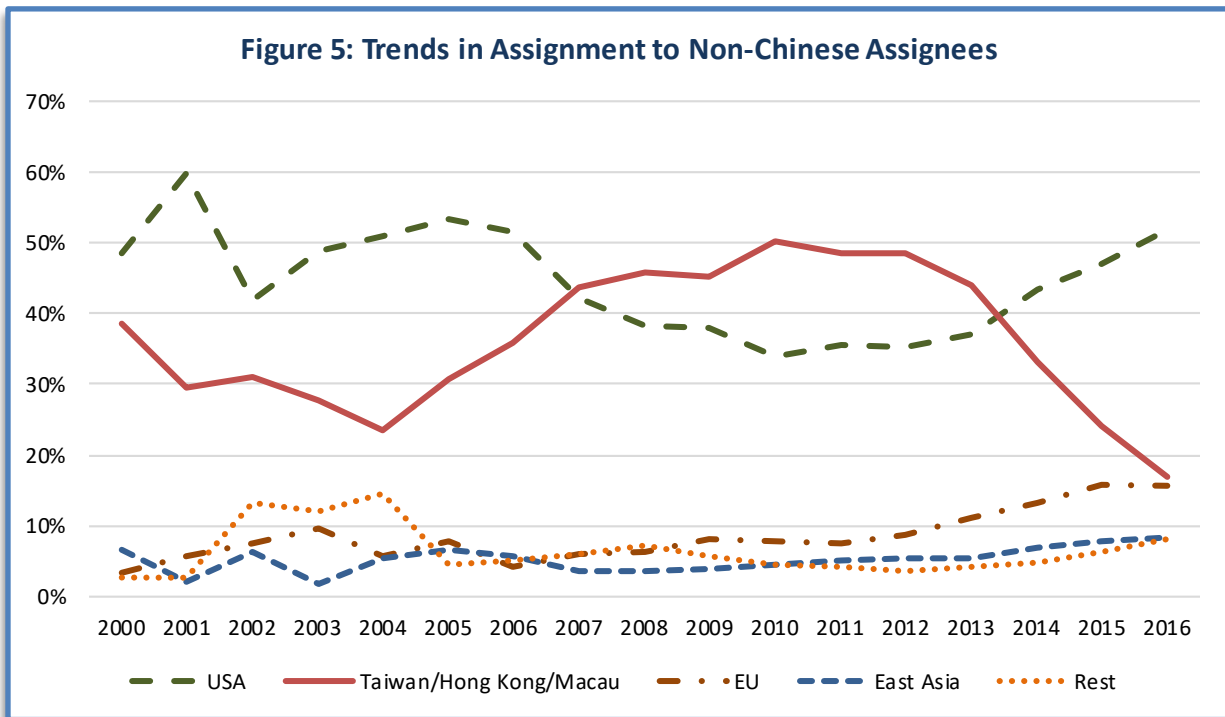


Fall in Patents Jointly Owned by Chinese and Non-US based Foreign Entities

In Figure 5, we consider the population of all Chinese patents granted since 2000 that had a least one non-Chinese owner at grant (all patents not in the “Chinese Only” category). Among these patents, the region most commonly represented has been the USA followed by the Taiwan/Hong Kong/Macau (THKM) region. Each region has had periods where it has been dominant.

However, the general trend over the past several years shows a move away from the THKM-based assignees to entities from other regions. The share of foreign-assigned patents with at

least one THKM-based assignee has fallen from 50 to 17 percent since 2010. At the same time, the share of such patents with at least one US-based assignee has risen from 34 to 52 percent, the share with at least one European Union (EU)-based assignee has more than doubled from 7 to 16 percent and the shares with at least one assignee from the rest of East Asia has also doubled from 4 to 8 percent. These results mirror the results that we found for inventor collaboration.



Appendix: Definitions

Defining “Chinese-inventor” Patents

A USPTO-issued patent is considered Chinese-invented if at least one of the inventors listed on the patent has a residence address in Mainland China. Although the autonomous regions of Hong Kong and Macau are technically part of Mainland China, their residents have had a longer history of patenting in the US and much of the foreign direct investment that has flowed into southern Mainland China has historically originated from these areas. Taiwan is considered separately for similar reasons.

Defining Collaboration Categories

We consider two different forms of international collaboration: collaboration among inventors and the joint ownership of the patent as reflected by the assignment of the patent at issue. Using the information on the inventors for each patent, we classified each Chinese-inventor patent as belonging to a particular inventor collaboration category as follows.

1. Chinese Solo: The patent lists one inventor who resides in Mainland China.
2. Chinese Team: The patent lists two or more inventors, all of whom reside in Mainland China.
3. Chinese/US: The patent lists two or more inventors. At least one inventor resides in Mainland China and at least one resides in the US. None reside elsewhere.
4. Chinese/US/Other: The patent lists two or more inventors. At least one inventor resides in Mainland China, at least one resides in the US, and at least one resides elsewhere.
5. Chinese/Other: The patent lists two or more inventors. At least one inventor resides in Mainland China and at least one resides elsewhere, but none reside in the US.

Using information on the assignees for each patent at grant, we likewise developed five international patent assignment categories.⁸

1. Chinese Only: All of the patent’s assignees are Chinese.
2. Chinese/US: There are multiple assignees. At least one of the patent’s assignees is Chinese and at least one is US-based. There may or may not be assignees from other jurisdictions.
3. Chinese/Other: There are multiple assignees. At least one of the patent’s assignees is Chinese and at least one is from another jurisdiction. There are no US-based assignees.

⁸ We limit our analysis of assignments to patents that were assigned at grant. The results do not change qualitatively if we treat the unassigned patents as owned by their inventor(s).

4. US: None of the patent's assignees are Chinese. There is at least one US-based assignee. There may or may not be assignees from other jurisdictions.
5. Other: None of the patent's assignees are Chinese. There is at least one assignee from another jurisdiction. There are no US-based assignees.

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