# What are the effects of the Korea-Japan trade dispute on Korean and Japanese hydrogen-fluoride and semiconductor industries?

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## 1. Introduction

A trade dispute ongoing since 2019 between the Republic of Korea (henceforth 'Korea') and Japan has been both the cause and effect of strife between the two nations. In July 2019, Japan announced it would remove Korea from its list of "white countries" (preferential trading partners) and restrict exports of hydrogen fluoride (HF), fluorinated polyimide, resist, and their relevant technologies to Korea (METI, 2019). These materials are key to the production of semiconductors and displays, which are industries that are central to the Korean economy.

There is controversy surrounding the reasons behind such measures, ranging from the Japanese claim of security concerns to the Korean argument that it is retaliation for a Korean court decision regarding Japanese forced labour during the colonial era (Tachikawa, 2019). This paper aims to put aside political considerations and analyse what economic effects this trade dispute has had, three years in, on Korea and Japan. This paper will focus on the HF industries of the two countries, as it is directly impacted by export controls imposed by Japan and Korea's attempts to shift away from Japan has had interesting effects that may continue long term. It will also examine the performance of the Korean semiconductor industry, which had its supply chains disrupted by the dispute but has recovered after only a short period of decline.

This paper is structured into five sections. *Section 2*, through a literature review, explores the context of Japan and Korea's economies before the dispute, and, respectively, the measures and countermeasures implemented by each country. In addition, the effect of a country improving technology for a good it has a comparative disadvantage in is discussed. *Section 3,* through data visualizations, examines the direct impact of Japanese measures – reduction in Korean imports of Japanese HF – and Korea's success in localizing production of HF. Furthermore, Korean semiconductor production data is reviewed to show the modest damage it suffered. *Section 4* analyses how this repositions Korea in international trade using the Ricardian trade model. Finally, *Section 5* summarizes the findings and limitations.

## 2. Literature Review

Korea and Japan were closely interlinked as part of the semiconductor global chain. Kim (2021) explains that Korea was dependent on Japan for the three materials that are now subject to stricter export controls. Simultaneously, Japan was dependent on Korea as almost all Japanese semiconductor firms exporting those items had local production subsidiaries based in Korea. This relationship of interdependence meant Korea and Japan could specialize and establish an "efficient division of labour", (Ibid.) but risks inherent to the global semiconductor supply chain (GSC) must be noted. Kim emphasizes the difficulty of replacing suppliers in the industry due to firms' tendency to establish long-term relationships, and the supply chain's exposure to "non-economic variables in the era of economy-security nexus" (Ibid.).

Di Giovanni and Levchenko's (2009) argument that "sectors more open to international trade are more volatile" (Ibid.) supplements this analysis. They demonstrate that countries more open to trade tend to be more specialized, which can lead to higher volatility.

These concerns are indeed realized in the Korea-Japan trade dispute, as the GSC was disrupted by Japan's restrictions. Starting July and August 2019, 857 dual-use items – previously subject to quick and simple licensing – require complex and time-consuming procedures to be exported to Korea. The Korean Ministry of Trade, Industry and Energy employed countermeasures to "stabilize the supply of 20 leading items including the 3 controlled items within a year" (Kim, 2021), providing support to find alternatives and invest in R&D for localization of the production of key items. Interestingly, this put Korea in an advantageous position during the COVID-19 pandemic, during which the global trend for GSC shifted towards regionalization/localization (Ibid.).

Korea's localization of the production of HF can be seen as Korea making technological progress in producing a good it has a comparative disadvantage in compared to Japan. Samuelson's (2004) argument implies that, in this case, Japan will experience permanent lost per capita income.

## 3. Findings

The direct implication of Japanese export controls on HF to Korea can be examined through data on Korean imports of the item. Figure 1 shows a rapid drop in imports of HF from Japan starting 2019, when the trade dispute began. Since Japan was Korea's second largest supplier of HF, this decline is also strongly reflected in Korea's total imports of the item. After 2020, however, it can be observed that more HF is being imported from China, which starts to recover Korea's total imports of the material. It is clear that, following Japan's export restrictions, Korea is far less dependent on Japan for HF.

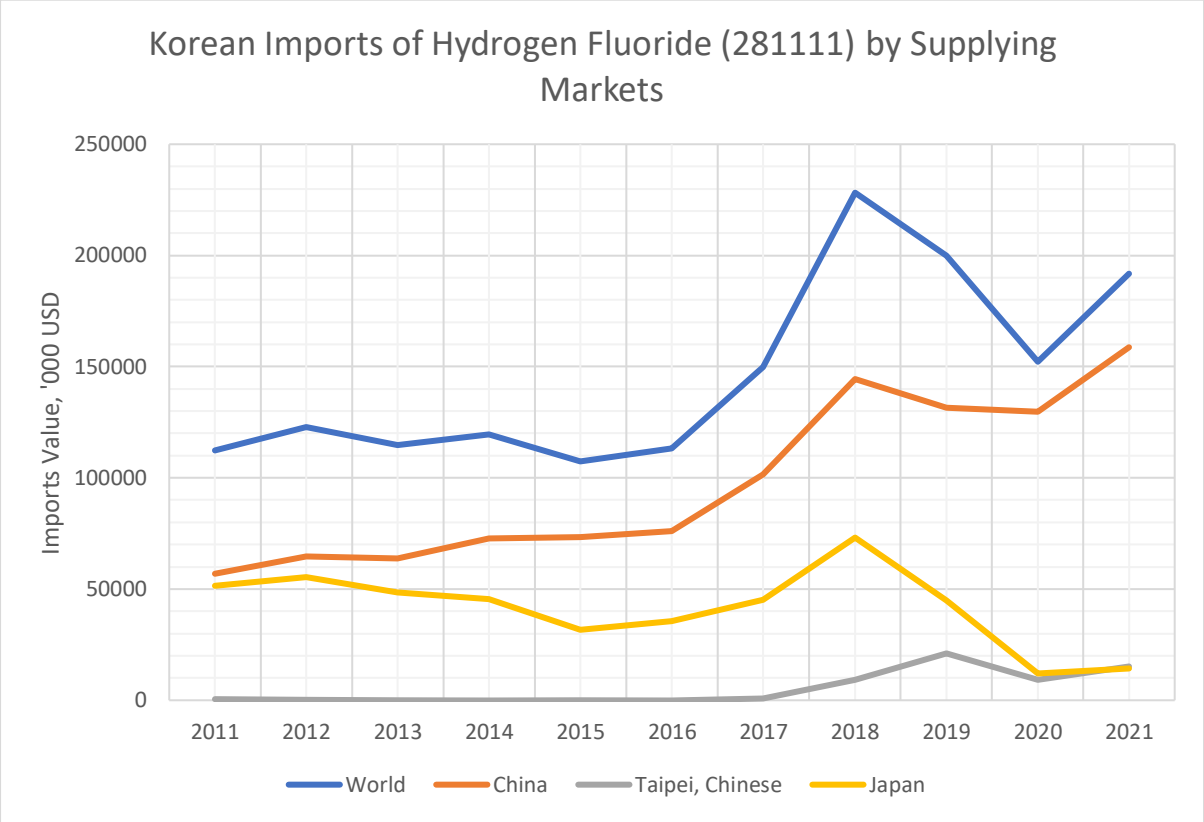


Figure 1. Korean Imports of Hydrogen Fluoride by Supplying Markets (ITC Trade Map, n.d. c)

Observing the data from Japan's side indicates that its measures have damaged its own HFindustry. Figure 2 shows that Korea is by far the largest importer of Japanese HF. Accordingly, Japan's restrictions on exports to Korea have caused Japan's total HF exports to plummet starting 2019. Though exports to all top 4 importers have risen in 2021, this increase is miniscule and far from a

recovery. If Korea successfully becomes independent from Japan in the GSC, this low level of exports may become permanent.

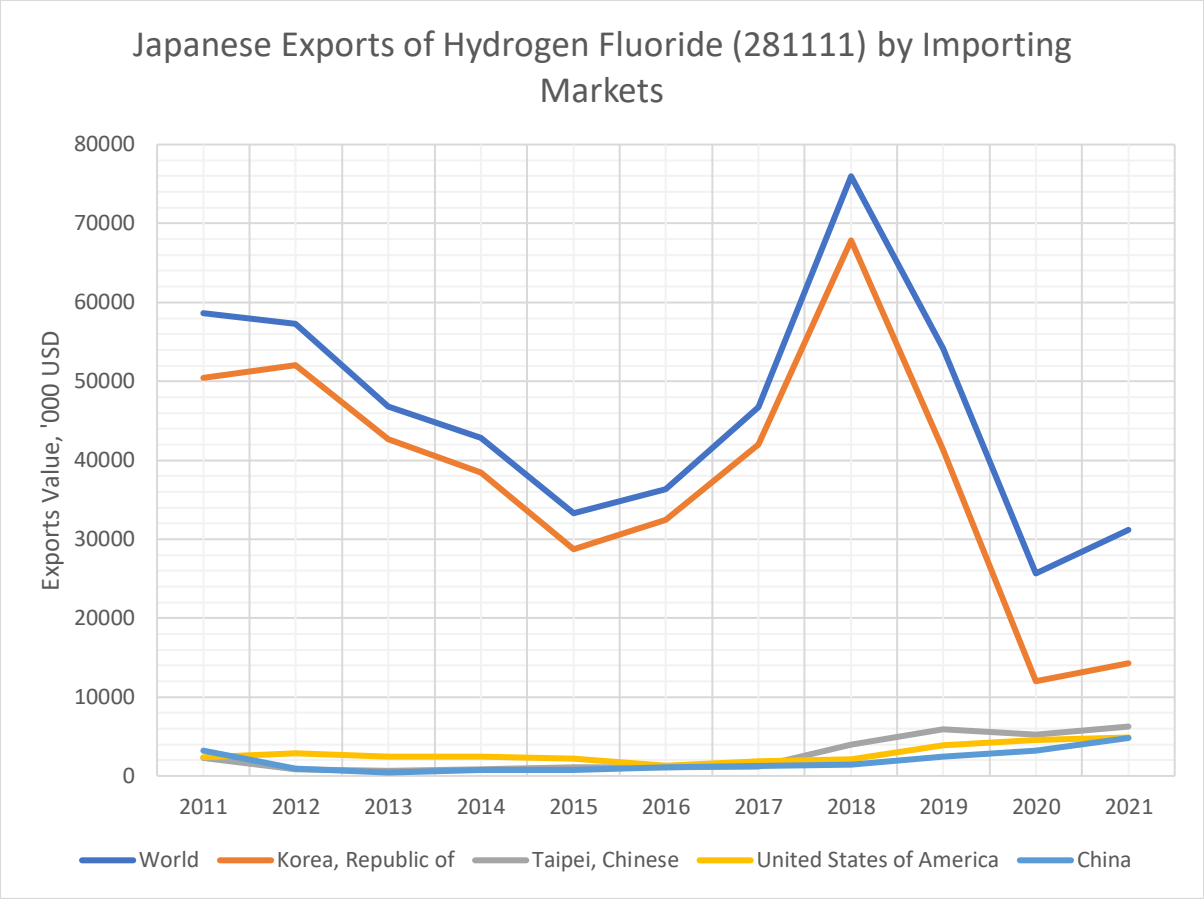


Figure 2. Japanese Exports of Hydrogen Fluoride by Importing Markets (ITC Trade Map, n.d. a)

Examining Korean exports of HF gives an insight into Korea's progress in localizing its production. Figure 3 shows that prior to the trade dispute exports were experiencing slow growth. In 2021, two years after Japan's export controls, a faster increase is observed. While this may indicate that Korea is successfully localizing production, it should be noted that 2021 is the last datapoint and this growth is slower than between 2014-18. Furthermore, Korean exports of HF is still less than a tenth of its imports of the item. Considering that Korea is still largely dependent on foreign imports of HF, it is difficult to assert that localization has already been a success, though the increase in exports indicate progress.

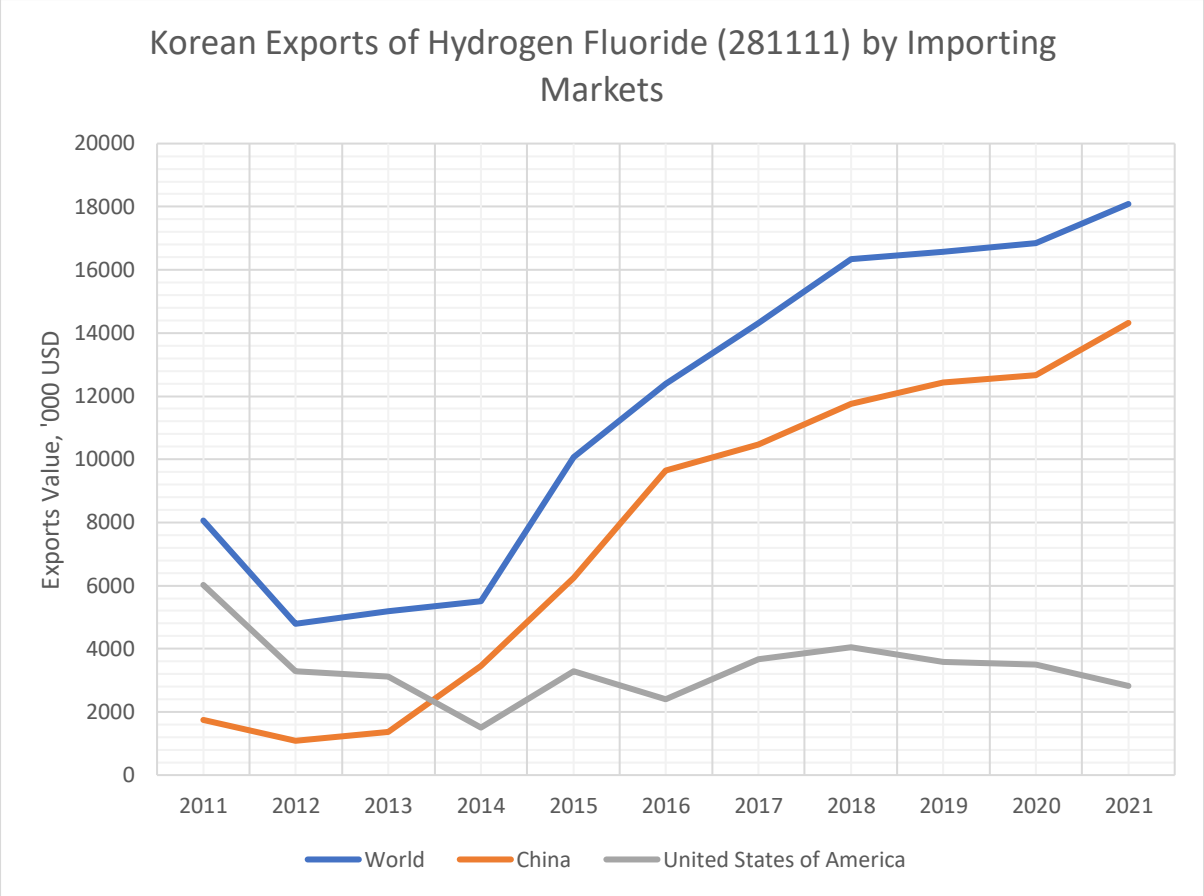


Figure 3. Korean Exports of Hydrogen Fluoride by Importing Markets (ITC Trade Map, n.d. b)

Although the Korean semiconductor industry was heavily dependent on Japanese HF, data on production indicates that damage was modest and easily recovered. Figure 4 reveals that there was no decrease in production until almost a year after the start of the dispute, and this decrease was recovered after only two quarters. Due to the COVID-19 pandemic and global supply chain issues, it is also difficult to conclude that it was the trade dispute that caused this drop.

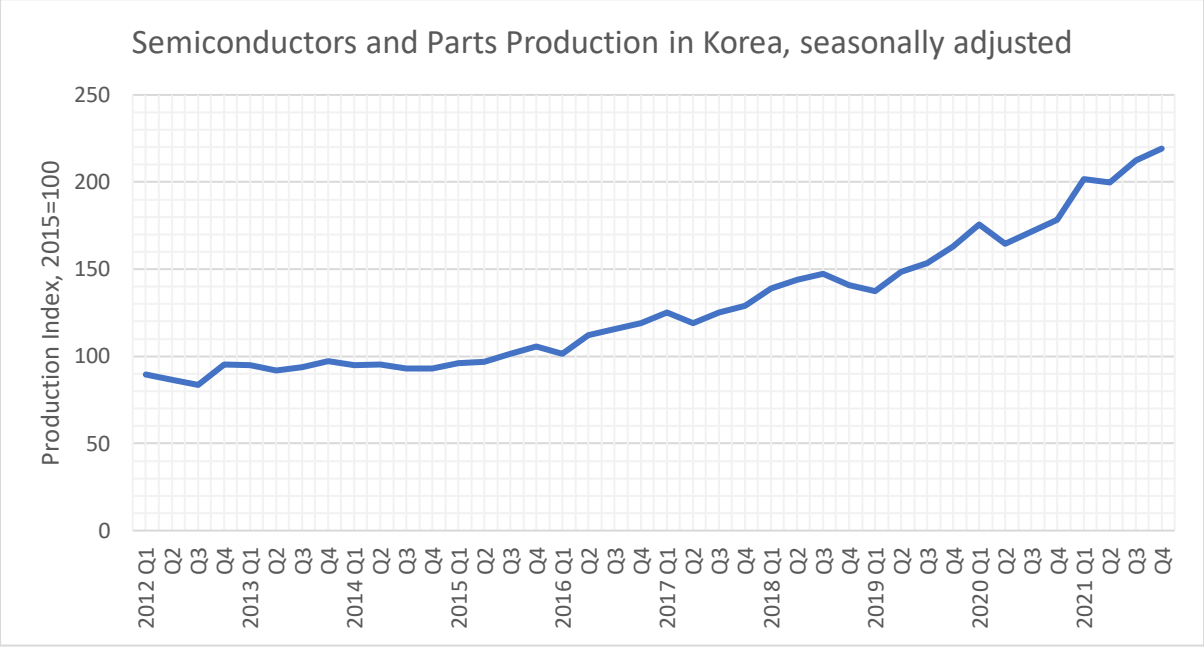


Figure 4. Semiconductors and Parts Production in Korea, seasonally adjusted (KOSIS, 2022)

## 4. Implications

While data to support the argument that Korea has been successful in localizing the production of HF is still limited, there has been notable progress. Corporations such as LG Displays and SK Materials have successfully localized (Jung, 2019) (Song, 2020), while exports of HF, as shown in *Section 3*, have seen an increase.

If localization continues and technical progress is made, Korea's position in the world HF market could change significantly. The Ricardian trade model, although simplified and extreme, can demonstrate the implications. Examine Figure 5 and consider a world with only two goods: good 1 and good HF. Assume that the relative demand curve (RD) crosses the relative supply curve (RS) on the vertical part of the RS, implying complete specialization of home in good 1 and foreign in good HF. As technical progress is made at home in producing HF, the unit labour requirement for producing HF, $a_{LHF}$, falls, causing the left horizontal section of the RS to shift upwards. The RD now intersects the RS on the left horizontal section of the RS, implying incomplete specialization. In other words, home, despite still having a comparative disadvantage in good HF, will produce some HF, competing with foreign. In the real world, where there are many more countries, goods and no complete specialization, this result implies that Korea would produce more HF as its relative cost falls.

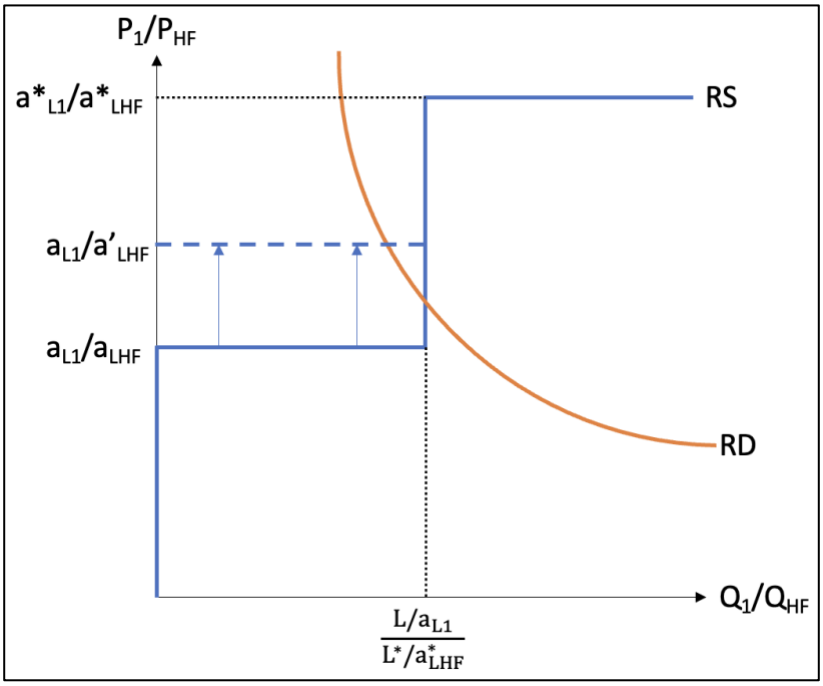


Figure 5. Ricardian Trade Model with two goods

## 5. Conclusion

In summary, the Korea-Japan trade dispute has damaged Japan's HF exports and lost Japan its biggest buyer, Korea. Japan's measures have prompted Korea to localize its production of HF which, if successful, would cause Korea to import permanently less from abroad, especially Japan. Successful technical progress would lead Korea to produce more hydrogen fluoride and cause Japan's per capita income to fall permanently. Meanwhile, Korea's semiconductor industry has remained strong.

It must be noted, however, that optimistic outlooks of Korean localization may not necessarily be realized. Data only covers the first two years of the trade dispute, which may not be long enough for true effects of localization to be observed empirically. The Ricardian trade model in *Section 4* is

dependent on localization, which is another reason, other than its extreme simplification, to be cautious with its results.

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