Agricultural Biotechnology Policy in China

Hearing of U.S. China Economic Security Review Commission on U.S.-China Food Policy. April 26, 2018

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Introduction

I have conducted economic analysis of Chinese agricultural research and technology since 1994. I look at the growth of Chinese agricultural biotechnology research as an opportunity rather than a threat. Their research, published in American and European-based academic journals, often in collaboration with American scientists, is available to American scientists in the public and private sector. It can be used to develop innovative technologies for American farmers. Chinese technologies such as hybrid rice have been used extensively in the U.S. to increase rice productivity in the U.S. Chinese universities are producing graduates who become graduate students in the US and go on to become the leaders of U.S. and Chinese research. The U.S. needs to ensure that these flows continue through investments in American agricultural research, strong graduate programs and funding collaborations between American and Chinese scientists. In addition, we need to develop policies that can help U.S. biotech industries build on this research to develop new products that can be sold in the U.S., China, and in the rest of the world.

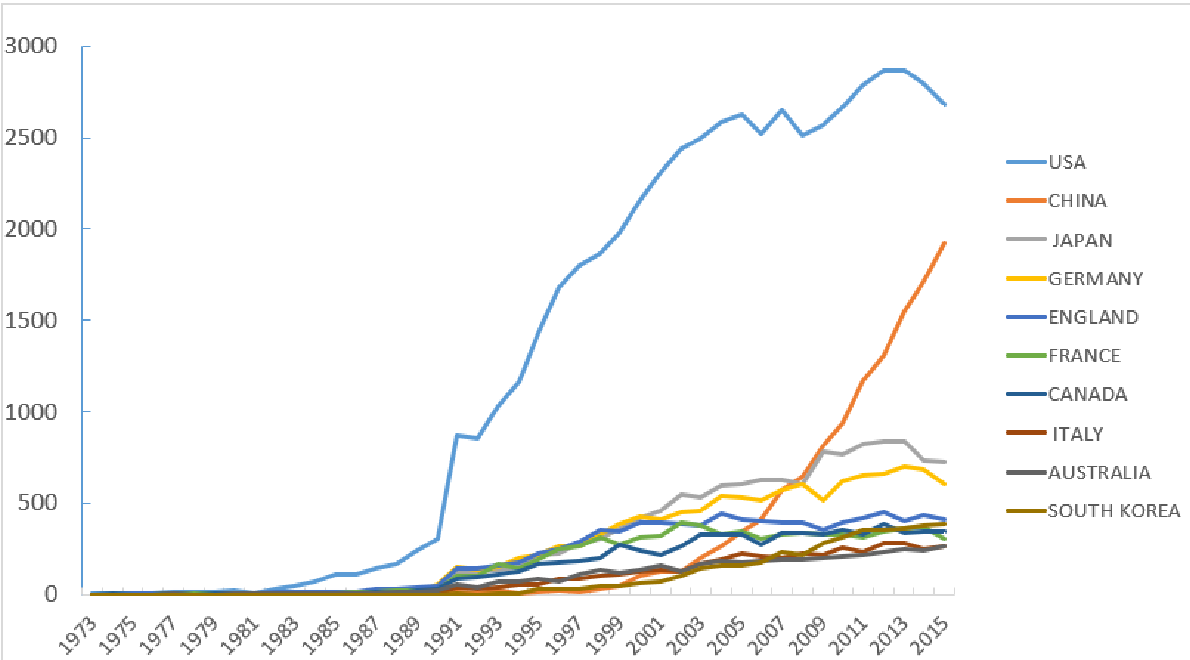
At the same time, the Chinese government protects its agricultural biotechnology industry from competition with American and European-based firms. The breeding and production of transgenic crops is on the list of industries in which foreign investment is prohibited in China. Plant breeding and seed production are on the restricted list which means foreign companies cannot be majority shareholders (China, 2015).

I have organized the rest of the presentation around the questions that the U.S. China Economic Security Review Commission sent me.

1. How competitive are Chinese agricultural biotech research facilities?

Biotechnology laboratories at government research institutions such as the Chinese Academy of Sciences (CAS), the Chinese Academy of Agricultural Sciences (CAAS), China Agricultural University. Provincial Academies of Agricultural Sciences and universities are very competitive in producing globally recognized science. Measured by agricultural biotechnology-related publications in the 10 most prestigious biology journals (*Science, Nature, Nature Biotechnology*, etc.), China has made impressive strides (Figure 1). Publications by Chinese scientists in international journals started at very low levels in the 1990s. They surpassed Germany and Japan in 2007 and were moving towards the U.S. in 2015.

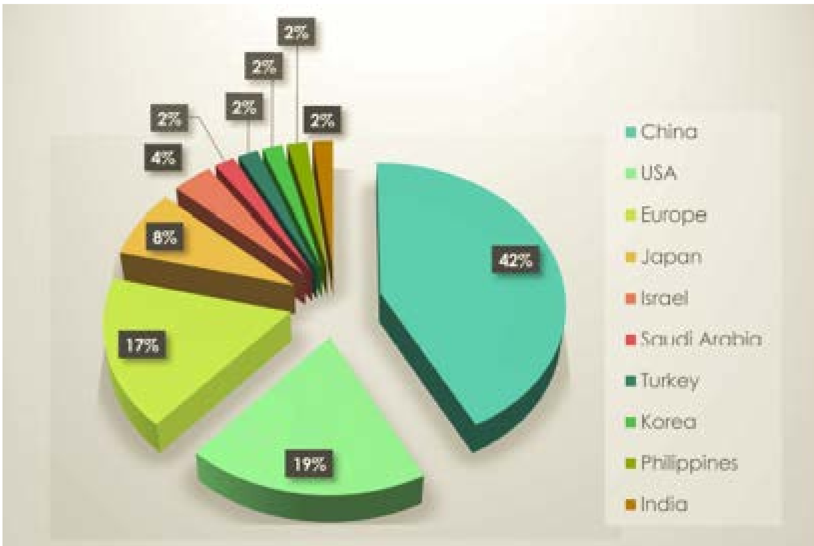
Figure 1. The number of publications in top journals on GMOs 1973-2015



Wang et al 2015

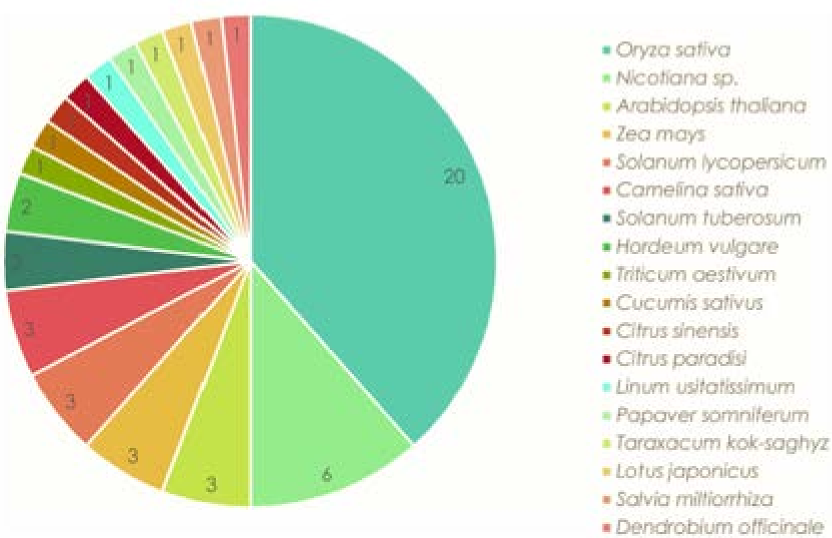
The competitiveness of Chinese research can also be seen by it's publications and patenting of one the latest research tools in biology, gene-editing with CRISPR Cas9 and similar research tools. A recent study of 52 publication using CRISPR to modify plants shows that China is the global leader (Ricroch et al 2017). Forty-two percent of the publications were by scientists in Chinese research institutes followed by 19 percent in the U.S., 17 percent in Europe and 8 percent in Japan (Figure 2). Given the importance of rice in China and Japan and that it is considered a model plant for monocots, it is not surprising that rice (*Oryza sativa*) is the number one subject of the CRISPR studies with 20 of the 52 publications (Figure 3). The commercial crop with the next largest number of publications is corn (*Zea mais*) with three publications.

Figure 2. Percentage of CRISPR publication by country.



Source. Ricroch et al 2017.

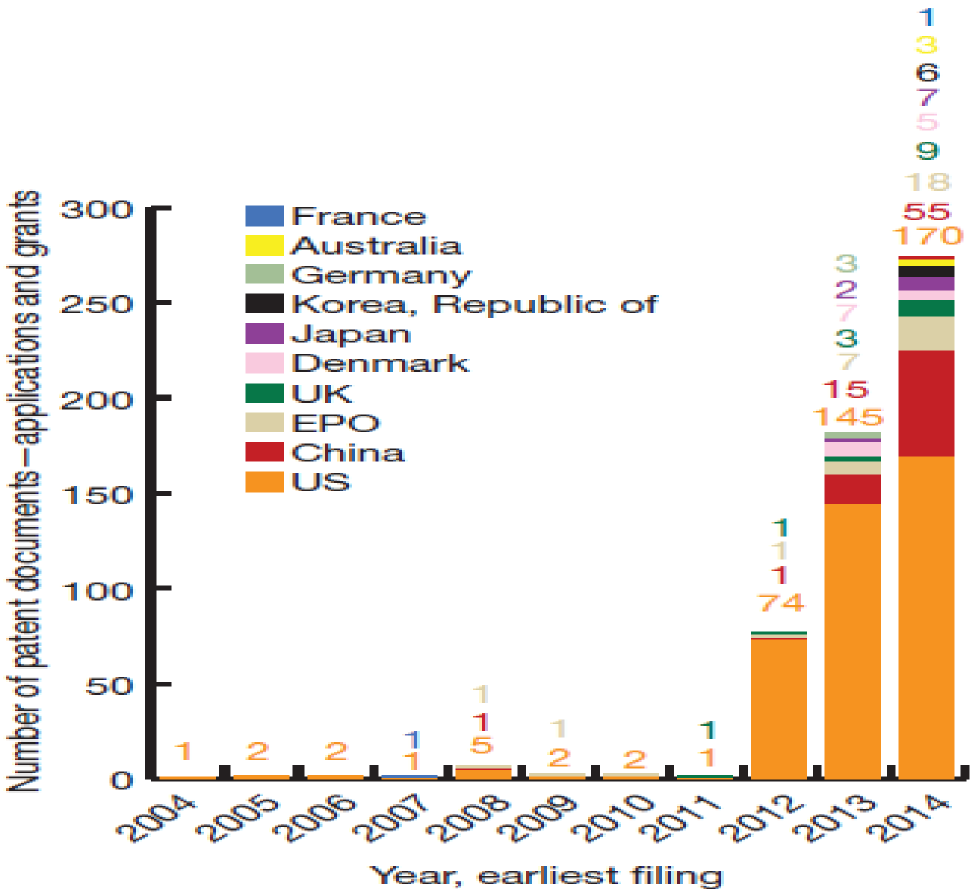
Figure 3. Number of publications by plant species studied



Source. Ricroch et al 2017.

Figure 4 shows the growth CRISPR-Cas patenting. While CRISPR patenting was still dominated by the U.S. in 2014, Chinese patenting has moved into second place. These patents are for tools that can be used for agricultural or biomedical research, but a surprising number of the Chinese patents are for agriculture as opposed to biomedical which dominates in the U.S. For example, the top four organizations globally with CRISPR patent families for plant modification are CAAS 39, DuPont 34, CAS 32 and Dow 15 (IPstudies 2018).

Figure 4. Growth of CRISPR patents



Source: Egelie et al 2017.

Biotechnology research in China has been much more successful at producing journal articles than in developing competitive technology for farmers. Bt cotton traits from CAAS and Monsanto that were released in 1997 are the only genetically engineered (GE) traits of a major field crop that Chinese farmers are allowed to grow. The other GE trait that has been commercialized is a virus resistant trait in papaya from South China Agricultural University. No new GE traits for cotton have been approved for cultivation since 1997, and no new GE technology for major feed and food crops have been approved for cultivation in China.

In 2009 after the world food price crisis of 2007 and 2008, the government approved insect resistant rice (hereafter Bt rice) and high phytase corn (HPM) as safe for consumption and production in China. The Bt rice was developed by Huazhong Agricultural University around 2000 and produced by small local seed companies. HPM was developed by CAAS and Origin Agritech Ltd. Origin has the license to commercialize it. After a firestorm of opposition on social media to commercialization of GE food, especially Bt rice, the government shelved these technologies.

2. Is China's rising competency in genomic sequencing and CRISPR likely to improve their agricultural biotech capabilities?

These important research tools are already improving their capabilities. They are currently in use in most of the major government and university labs in China. They can dramatically reduce the cost of research and plant and animal breeding. China's capacity for genomic sequencing is also improving the efficiency of American and European research since two of the leading suppliers of these services in the U.S. and Europe are the Chinese firms BGI and Novogene.

CRISPR is being used extensively in China. Several new plant varieties such as disease resistant wheat were developed using CRISPR (Wang 2014). The government still has not decided how to regulate plants developed by CRISPR. If they are regulated as conventional breeding techniques, they are likely to be commercialized soon. If they are regulated as GE traits, they may not be commercialized for a while or they may be produced illegally.

CRISPR and genomics eventually will be important to Chinese biotech and seed companies. One of the leading agricultural biotech companies in Beijing, told me in 2017 that it had used BGI's genomics services in its corn biotech research, but no longer use it because the company had to focus its efforts on obtaining regulatory approval of GE traits rather than trying to develop new traits. In interviews with biotech and seed firms in Shenzhen in 2017 it was clear they were networking with BGI scientists and government biotech labs, but so far it has not been very important since these companies did little research to develop new traits. If the government does allow cultivation of GE and gene editing crops, they will probably use these services extensively.

3. What support does the Chinese government provide for agricultural biotech research?

Central, provincial and city governments invest heavily in agricultural biotechnology research. Agricultural biotechnology was an important component of three special research and development programs for key industries. The first focused on applied research in nine industries of which agricultural biotechnology was one. The program was designated "863" because it started in March 1986. The second, the March 1997 "973" program, supported basic scientific research and continued through 2006. It was followed in 2006 by the third program: the National Science and Technology Key Programs. It was a much larger government program which focused on commercializing designated technologies. The agricultural biotechnology component is called the Special Program on New Transgenic Organism Breeding, which started in 2008 and is expected to end in 2020. The goal of this program is to commercialize Chinese GE varieties of five crops and three livestock species and is budgeted to cost U.S.$3.8 billion (RMB 24 billion) over 12 years (Hu et al., 2012).

The Chinese central government also supported the development of the biotech industry by instituting regulations to assure the safety of GE food production and food products. In early 1993, the Chinese State Science and Technology Commission (SSTC) released the first set of biosafety regulations, called the "Safety Administration and Regulation on Genetic Engineering" (Chinese State Science and Technology Commission, 1993). The Ministry of Agriculture (MOA) issued the "Implementation Measures for Agricultural Biological Engineering" in 1996 (MOA, 1996). The first approvals of GE crops for cultivation took place in 1997. In 2001 the State Council decreed a new set of policy guidelines, the "Regulations on the Safety Administration of Agricultural Genetically Modified Organisms" (Huang et al., 2003). MOA also announced new implementation regulations which covered biosafety management, imports and exports of GE foods and crops and mandatory labelling of GE food products, which took effect in March 2002 (Pray et al., 2006).

Government policies also encourage GE development and commercialization by Chinese firms. Government scientists are encouraged to develop, patent and then license GE technology to local firms. The Special Program on New Transgenic Organism Breeding described above subsidized biotechnology research and commercialization by local firms. In addition, these firms were protected from foreign competition by regulations that kept out research on and commercialization of biotechnology by foreign firms. The biosafety regulatory system allowed the importation of foreign GE corn, soybeans and canola for processing and consumption but not for sales as seeds for cultivation in China. Regulations on Foreign Direct Investment (FDI) protected Chinese biotechnology firms by prohibiting research on biotechnology or commercialization GE traits by foreign firms in China (China 2015).

The Chinese government hoped that these restriction on foreign investment in biotechnology in combination with the government research and regulatory policies would allow local firms to develop their own GE traits that would be competitive with foreign traits or commercialize GE traits that were developed by government research academies and universities. These policies have not been successful so far. This is consistent with economics research on foreign direct investment (FDI) which shows that firms in industries where FDI is restricted are less innovative than sectors where FDI is allowed. (Howell 2018).

The Chinese government and Chinese companies recognize the importance of foreign agricultural research and technology which has led the government to encourage state-owned enterprises (SOEs) and large private firms to buy foreign high tech companies with loans from government banks. ChemChina's purchase of Syngenta in 2017 is the biggest example of this, but the Shuanghui Group‘s purchase of Smithfield Foods in 2013 is another because it included one of biggest pork genetics and breeding programs in the world.

4. **How does China’s approval process delay the commercial release of U.S. biotech crops? Is China likely to reform this process?**

I will let the other speakers handle this question.

5. **How do Chinese consumers view biotech crops**?

Until 2012 most urban consumers believed GE food was either safe or they did not know. Between 2010 and 2012 Then the percentage of consumers who considered it unsafe increased from 18 to 45 percent (see Table 1). This change was based on a breakdown in trust in government food safety regulation starting with the poisoning of babies with milk adulterated with melamine in 2008 and regular reports of food safety problems in the press since then. When the government approved Bt rice for cultivation in 2009, the opponents of GE food were able to convince consumers that GE foods could be poisonous. This idea contributed to a social media firestorm of urban consumer opposition to GE food in 2010 (Huang and Peng, 2015).

Table 1. Consumers’ perceptions on GE food safety for human consumption in urban China by year (in %, 2002–2012).

Year	Unsafe	Safe	No idea
2002	13	37	50
2003a	16	35	49
2003b	13	38	49
2010	18	29	53
2012	45	13	42

Source: Huang and Deng 2015

6. **Has the Chinese government sought to manage consumers’ views?**

The Chinese government has sought to manage consumers’ views, but not very successfully. It shut down some of its political opponents’ websites that were saying that GE crops were an American plot to take over the Chinese food supply and weaken the Chinese army. Since President Xi Jinping took power, the government increased its efforts to educate consumers about the benefits of GE food through the government media and by controlling attacks on the safety of GE food in government and social media. It also announced a pathway to cultivation of GE food which starts with commercial crops (cotton), then goes to "indirect" food (e.g. corn and soybeans that are fed to animals) and finally to direct food (rice).

7. What is the state of intellectual property protections for agricultural biotech products in China?

Biotech traits and biotechnology research tools can be patented. The terms of the patents are the same as those in the U.S. It is much less expensive to apply for patents in China than in the U.S. or Europe. Government tax breaks and subsidies support firms that apply for patents. New plant varieties can be protected using either patents or plant breeders' rights. China has special regional courts to handle intellectual property rights issues. It is my impression from talking to a few firms that foreign firms have been increasing successful at protecting their patents in court.

8. How widespread is biotech piracy among Chinese producers?

Enforcement of patents in general is improving. In agriculture, however, it is still weak. U.S. and Chinese biotechnology is extensively copied. Both the Monsanto and CAAS Bt traits for cotton have been used with no royalty payments since 2001 (Personal communication with seed firms in Shenzhen 2016). Bt cotton now covers about 60 percent of the Chinese cotton area. Both Monsanto and Origin Agrotech Ltd., which licensed the CAAS Bt, have given up on the Bt cotton business because they cannot enforce their patents. Recently Bt corn has spread widely in North China. Companies estimate that as much as half of the corn grown there is Bt corn even though it is still illegal. No one I interviewed knew where the Bt trait came from.

9. Does this pose a threat to U.S. businesses?

The current combination of biosafety regulations, weak enforcement of intellectual property rights and the large investments in government biotech research provides opportunities for some U.S. businesses but restricts opportunities for others.

The results of research by Chinese government agricultural research institutes and universities are available in English and Chinese language journal articles. The most sophisticated research is published in prestigious international journals because they give scientists prestige and many universities and institutes provide substantial cash rewards to scientists who publish in *Science, Nature* and other highly ranked journals. Any USDA lab, U.S. university, or biotech or seed firms with sufficient scientific capacity can use these results in their research and technology development.

U.S. firms can use this research to develop new GE crops and profit from them in the U.S. and Latin America. Chinese biotech and seed firms so far cannot use this biotech research because they cannot commercialize GE crops in China. Some Chinese firms have attempted to sell Chinese traits abroad. The CAAS Bt cotton trait was approved for cultivation in India. It could not compete with Monsanto's stacked Bt trait for cotton in India and never has had a large market share (Pray and Nagarajan 2010). Chinese Bt cotton is also being grown in Pakistan, but no royalty payments to CAAS have been made for many years. Several Chinese firms have attempted to sell traits in the U.S. and Argentina, but so far none of them have made their way through the regulatory process.

American farmers have gained from this combination of policies because Chinese soybean and corn producers are less productive than they would be with GE traits. This allows U.S. farmers to sell more soybeans and corn to China.

DowDuPont and Monsanto are two companies that would have made more money in China if restrictions on FDI were lifted, intellectual property rights (IPRs) were enforced more effectively and more GE crops could be cultivated. The purchase of Syngenta by the Chinese state-owned chemical giant ChemChina could increase Syngenta's share of the Chinese seed and biotech market now that it is Chinese firm. Increased access to Chinese science, the ability to conduct biotech research in China and access to Chinese government banks could make it more competitive with DowDuPont and Monsanto outside China also. It's limitation, however, is that it is owned by a massive state owned chemical company which means that it responds less to market pressures for efficiency and innovation and will have to meet government goals such as creating more jobs in China.

10. Does this pose a security risk to the U.S.?

I do not see any obvious security risk in Chinese agricultural biotech research. Agricultural biotech research will continue to be supported. Support for medical biotechnology will grow even faster and will have spillovers into agriculture. I do not see a threat that China will take over the global agricultural biotechnology industry any time soon unless it buys DowDuPont, Monsanto/Bayer or BASF.

The Chinese government's attempt over the last 25 years to develop a home grown agricultural biotech industry that could be competitive in China and globally has failed. The policy instruments used - restrictions on FDI, weak IPRs, major government investments in research and regulations that do not permit planting of GE crops except cotton – ensured that Chinese biotech firms had no market for GE traits in China. Even when GE crops such as Bt cotton was commercialized, Chinese IPRs were too weak for firms to make any profits. The government acknowledged the failure of this strategy by buying Syngenta.

Conclusions

To make the most of Chinese investments in agricultural biotechnology, the U.S. needs to invest in our biotechnology research, our agricultural research and our innovation systems. Encouraging collaboration between Chinese and American scientists encourages more rapid development of new knowledge and technology that can benefit both countries.

Opening Chinese biotech markets for foreign investment, encouraging enforcement of IPRs and the development of transparent biosafety regulations in China will only happen with foreign political pressure. Chinese economic interest groups and companies elsewhere in the world are also pushing for these reforms (Pray et al 2017). The most effective way to move this agenda ahead is to work with these groups and pressure the government for change.

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