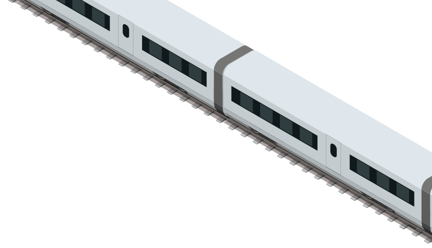


Encouraging innovation is a perennial policy goal – and one common approach is to promote the adoption of foreign technology. **Yatang Lin** and colleagues examine the impact of China's technology transfer policy, which has not only built a huge national high-speed railway system but has also made the country a global leader in the industry.

High-speed rail in China:

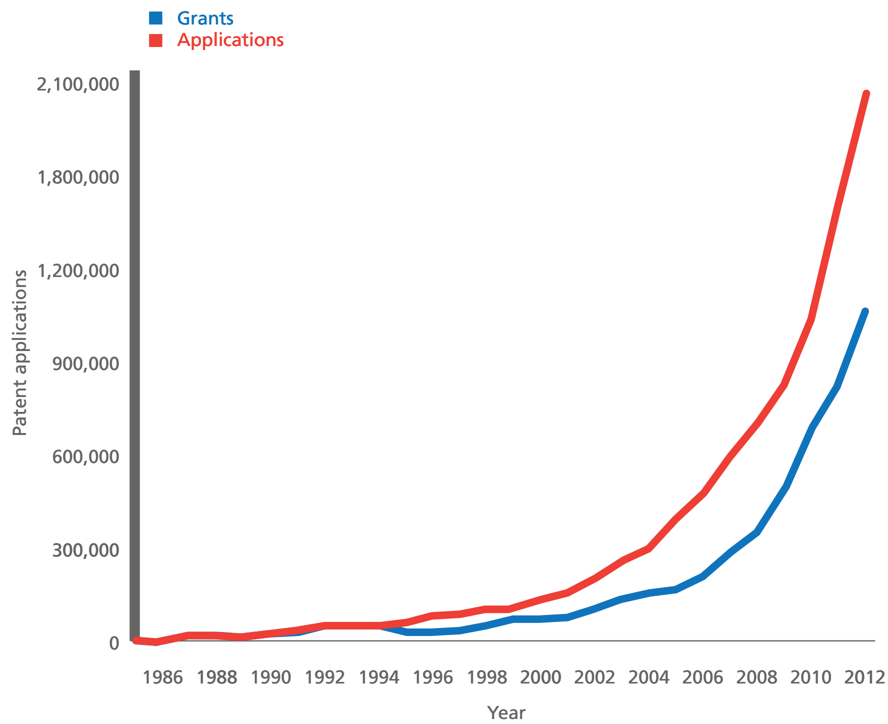
foreign technology and domestic innovation

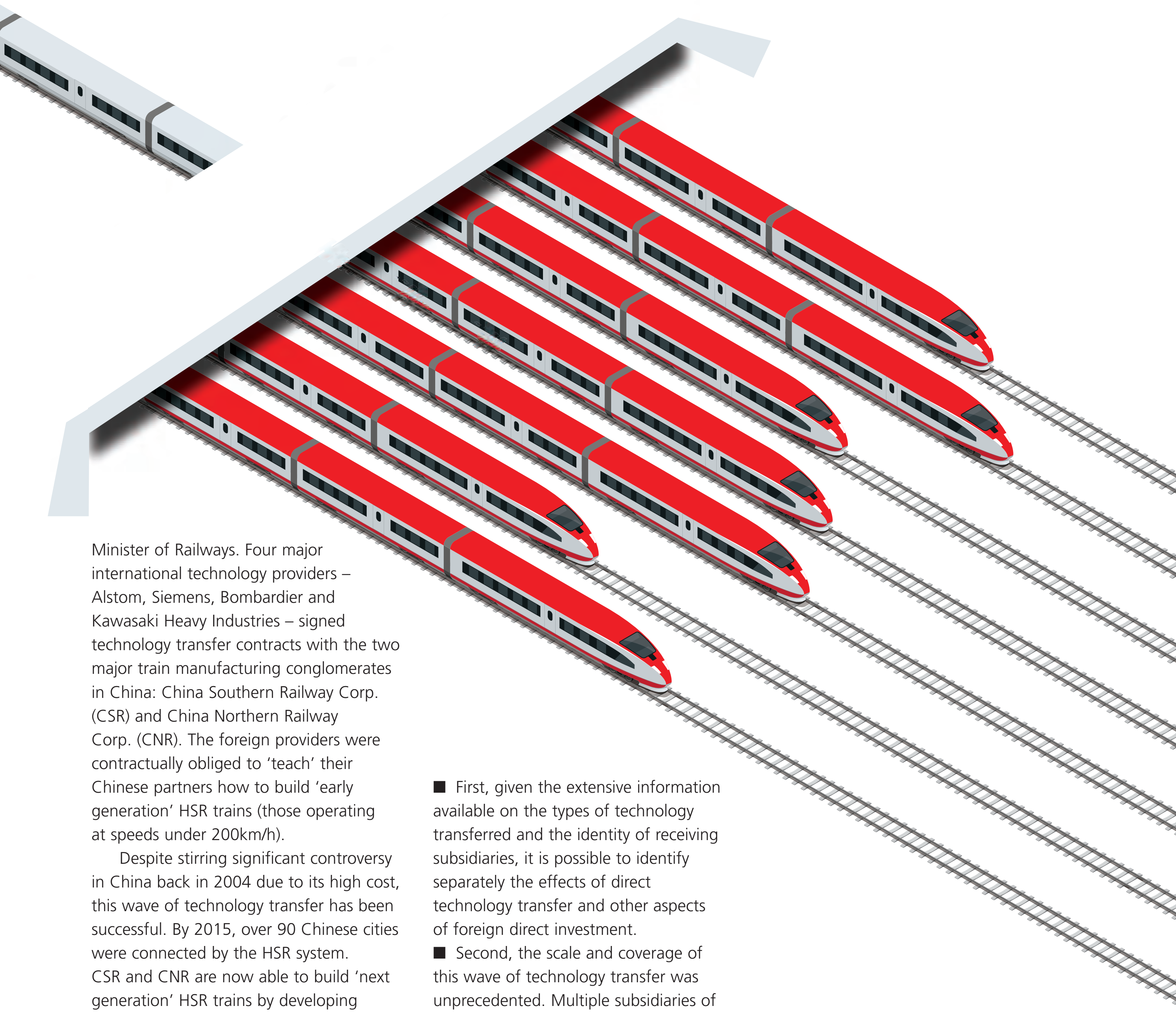
The rate of growth in technological innovations in China has increased significantly in the past two decades (see Figure 1). What's more, it is widely believed that the ability to learn from foreign technology and chase the global technological frontier relatively quickly has been a key contributor to China's growth miracle (Van Reenen and Yueh, 2012). The Chinese government has actively pursued what it calls a 'market for technology' policy: demanding that in return for having market access, foreign multinationals should develop technology cooperation with local firms.

Our research explores the extent to which international technology transfer spurs domestic innovation. We focus on the best example of the market for technology policy: the introduction of state-of-the-art technology into China's high-speed railways (HSR) during the massive expansion of its HSR system in recent years.

The decision to require HSR technology transfer was made rather abruptly in 2004 by Liu Zhijun, the then

Figure 1:
Annual number of patent applications filed and granted at the Chinese Patent Office, 1985-2012 (Zhang, 2014)





Minister of Railways. Four major international technology providers – Alstom, Siemens, Bombardier and Kawasaki Heavy Industries – signed technology transfer contracts with the two major train manufacturing conglomerates in China: China Southern Railway Corp. (CSR) and China Northern Railway Corp. (CNR). The foreign providers were contractually obliged to 'teach' their Chinese partners how to build 'early generation' HSR trains (those operating at speeds under 200km/h).

Despite stirring significant controversy in China back in 2004 due to its high cost, this wave of technology transfer has been successful. By 2015, over 90 Chinese cities were connected by the HSR system. CSR and CNR are now able to build 'next generation' HSR trains by developing indigenous capability and improving on imported foreign designs. The top speed of indigenous-designed Beijing-Shanghai HSR trains reaches 380km/h, faster than any other HSR trains in the world. In the meantime, the Chinese government has been actively promoting the export of HSR technology to other countries, including the UK.

Nowadays, Chinese train-makers and rail-builders are competing directly with the established European and Japanese manufacturers, and sometimes partnering with them in overseas markets. This spectacular success story for technology transfer practice provides an opportunity for researchers to analyse the lessons for innovation policy:

■ First, given the extensive information available on the types of technology transferred and the identity of receiving subsidiaries, it is possible to identify separately the effects of direct technology transfer and other aspects of foreign direct investment.

■ Second, the scale and coverage of this wave of technology transfer was unprecedented. Multiple subsidiaries of CSR and CNR located in 25 different cities have received HSR-related technology transfer of various degrees. Many of the introduced technologies – ranging from engines, dynamos and electricity transmissions to railway signal control systems – have applications separate from the HSR system with great potential for technology 'spillovers'.

■ Third, the abrupt and top-down nature of this technology transfer means that the subsequent surge in innovation activities is more likely to be a direct response to technology transfer than to other factors that jointly determine the introduction of foreign technology and domestic innovation.

Technology transfer from developed countries can spur innovation in developing countries

Our study compiles a firm-patent matched dataset from 1996 to 2012 and checks if there was a surge in innovation activities, measured by the total amount of patents, in the cities and technology classes affected by the 2004 policy decision. We also decompose the observed increase in patenting activities into 'direct' and 'spillover' effects by looking separately at the patents applied for by immediate receivers of foreign technology, by certified suppliers of the Ministry of Railways and by other firms that are neither receiving transferred technology nor directly supplying China's HSR projects.

We find a 42% increase in patent applications in the cities and technology classes with HSR technology transfer after 2004. The number drops to 20% after we exclude patents that were applied for directly by CSR or CNR affiliates and HSR suppliers, but it remains significant. These findings indicate that technology transfer from developed countries can significantly spur innovation in receiving developing countries both within and outside direct recipient partners.

The quantitatively important spillover effects are particularly striking, as they were not necessarily expected by China's policy-makers. Understanding the mechanisms behind these spillover effects is important not just in this context, but for innovation policies in general. Since the most important rationale for supporting innovation is its positive spillovers to firms that follow the new ideas but do not have to pay for the upfront research costs, policy-makers would like to spend more resources encouraging innovation in places where they are expected to have wider effects.

Our study looks deeper into the mechanisms at work by tracing innovation from the places where it has its first effects to nearby cities and related technology classes. We find that technology similarity plays an important role in technology diffusion, but there are no significant effects of geographical proximity.

Put differently, we observe faster patent growth in other technology classes that are similar to railway technology, but not in cities that are geographically closer to the cities where CSR or CNR affiliates are located. This indicates that the knowledge spillovers across similar technologies occur largely outside the railway sector, but they are local and only present within cities.

We also find that prior university research in relevant fields is also conducive to stronger technology spillovers: spillovers to non-related firms are only found in cities with previous university research in HSR-related fields (as measured by university patenting behaviour). This is despite the fact that the main effects are comparable across cities with and without railway-related research.

A story that is consistent with both pieces of evidence is that the spread of transferred HSR technology to non-CSR and non-CNR firms and cities occurs mainly through cooperation between CSR and CNR and other research institutes, notably universities. Given the facts that the knowledge spillover from industry to university in this case is highly intentional and directional and that only a limited number of cities have strong basic research backgrounds in relevant fields, technology similarity plays a more important role in explaining spillovers than geographical proximity.

Given the massive effects of HSR technology transfer on innovation in China's railway and related sectors, it is important to understand the broader implications: are Chinese firms still chasing the technology frontier or are they actually pushing the frontier? Does the active participation of Chinese players in the global market for HSR manufacturing discourage innovation by other international players?

As more data on international patent filing by both Chinese and foreign firms become available, future research will look at a more complete picture of the effects of international technology transfer on global innovation activities, taking account of reactions from both the sources and destinations of transferred technology.

This article summarises 'International Technology Transfer and Domestic Innovation: Evidence from the High-Speed Rail Sector in China' by Yatang Lin, Yu Qin and Zhuan Xie, CEP Discussion Paper No. 1393 (http://cep.lse.ac.uk/pubs/download/dp1393.pdf).

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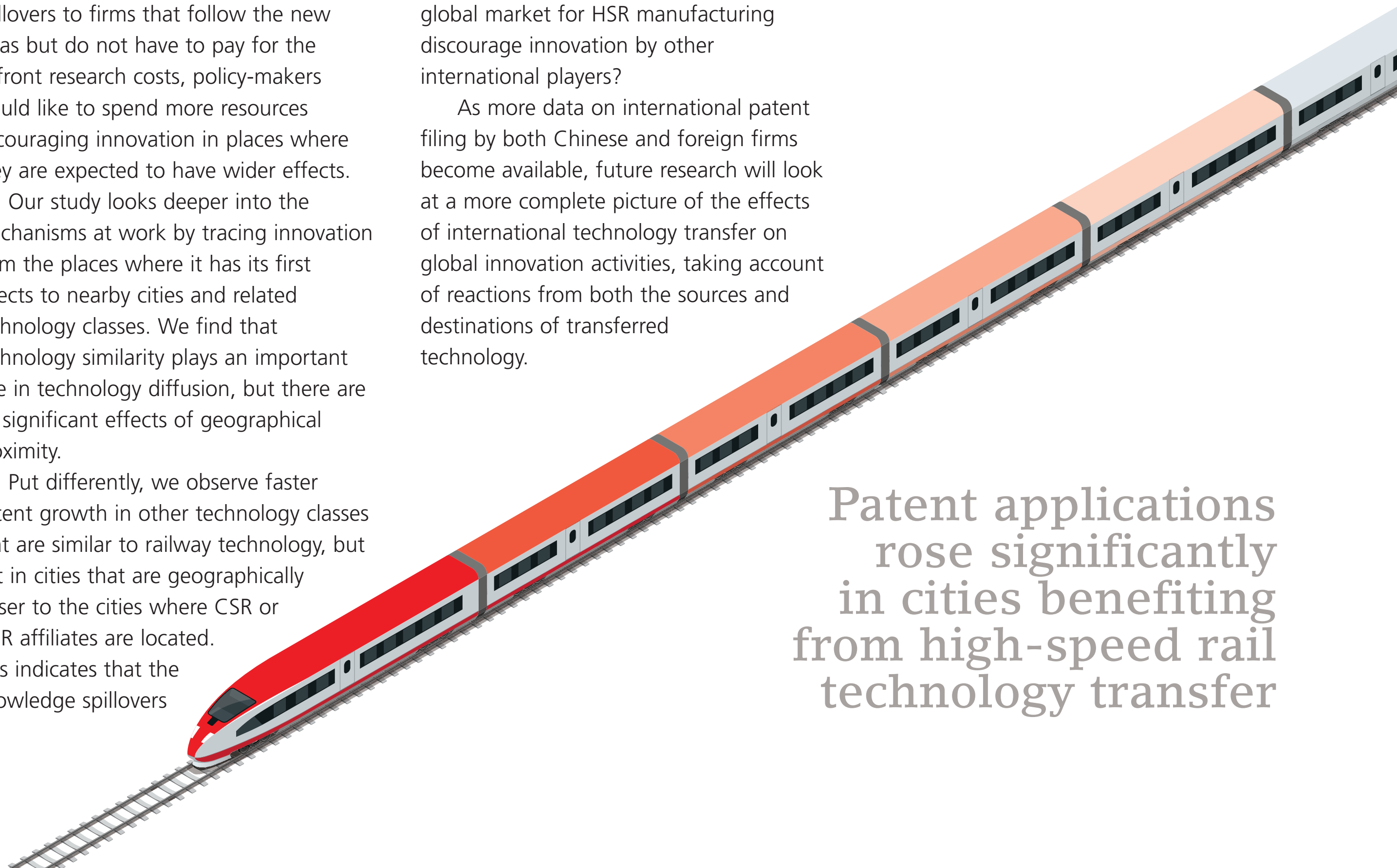
Further reading

John Van Reenen and Linda Yueh (2012) 'Why Has China Grown So Fast? The Role of International Technology Transfer', CEP Discussion Paper No. 1121 (http://cep.lse.ac.uk/pubs/download/dp1121.pdf).

Haiyang Zhang (2014) 'Patent Institution, Innovation and Economic Growth in China', Chapter 20 in *Deepening Reform for China's Long-term Growth and Development* edited by Ross Garnaut, Cai Fang and Ligang Song, ANU Press (http://press.anu.edu.au/wp-content/uploads/2014/07/ch20.pdf).



Patent applications rose significantly in cities benefiting from high-speed rail technology transfer