Public transportation: The Hidden Benefits of High-Speed Rail

Improvements in public transport are often regarded as essential to combat climate change. A study on the Chinese high-speed rail system suggests that these benefits could operate through other channels than one might expect.

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Carbon dioxide emissions from transportation have long been recognized as one of the main culprits for climate change, as the sector has generated around a quarter of global CO2 emissions during the last twenty years. Some technological improvements notwithstanding, progress has been limited. A key problem is that intercity passenger transportation still predominantly relies on motor vehicles that use fossil fuels. Substitution of road transportation by railways has often been hailed as an alternative, but clean evidence for its potential is rare. While there is a rapidly growing literature on the effects of public transportation on local pollutants, corresponding studies for global pollutants are missing. Writing in *Nature Climate Change*, Yatang Lin and colleagues are among the first attempts to fill the gap.[i]

The paper is related to several studies suggesting that improvements in public transportation can help to reduce local pollution, though the effects are not clear-cut in all cases. The evidence includes recent work showing how the Chinese high-speed rail system has reduced carbon monoxide pollution near highways (but not PM 2.5 and ozone pollution).[ii] Going beyond that particular context, a new metro system in Taipei was found to reduce carbon monoxide emissions by 5-15%.[iii] Railway strikes in Germany have been shown to increase particle pollution by 14%.[iv] In the same country, large scale improvements in local passenger railways led to reductions in carbon monoxide and nitrogen oxide emissions, but did not affect sulfur dioxide and ozone concentrations.[v] A study for the U.S. on the effects of public transport on automobile travel leads to more skeptical conclusions, emphasizing that desirable effects may fade away in the longer term.[vi] Given the heterogeneity of the results for local pollution, it appears important to investigate the effects of railway projects on greenhouse gas (GHG) emissions carefully rather than taking them for granted.

Relying on extensive traffic-monitoring data and standard statistical methods (difference-in-difference), the paper by Lin et al. shows that the massive expansion of the Chinese high-speed rail network since 2006 has led to a reduction in annual GHG emissions equivalent to just below 11 million tons of carbon dioxide, which corresponds to 1.3% of the total GHG emissions in China's transport sector. Though the

high-speed rail system has reduced the passenger vehicle traffic on highways by around 20%, this direct substitution has not had any notable effect on overall emissions. However, the expansion of the high-speed rail system has some hidden benefits: It reduced the flow of freight transport vehicles on highways by about 15% -- though the system is exclusively for passenger transportation. The authors provide a plausible explanation for this reduction: By moving passenger transportation away from conventional railway lines, the new high-speed lines free capacity on the former lines for freight transportation. This capacity increase results in a substitution of road freight by rail freight transportation, which, in contrast with the passenger substitution, does contribute to lower CO2 emissions.

The absence of a direct substitution effect from lower passenger road traffic reflects specific features of the electricity mix used for high-speed trains in China, which has a large fossil-fuel component. The high-speed rail system would have induced a much stronger CO2 reduction if the electricity mix had been closer to those of European countries who rely less on fossil fuels and more on nuclear energy and/or renewables. For instance, the authors calculate that the beneficial effect of the high-speed rail system would have been around twice as high in a hypothetical scenario with the Chinese electricity mix replaced by the French structure. In addition, passenger road transportation in China is characterized by much greater vehicle occupancy than in many Western countries, which further limits the direct substitution benefits. Another supplementary analysis shows that the emission reduction would be considerably larger with a vehicle occupancy similar to Western countries. In contrast with the absence of the effect of shifting passengers from road to rail, the indirect effect from greater rail freight capacity may well be of broader relevance, as for instance in European countries traditional railway infrastructure is often simultaneously used for freight and passenger transportation as well.

The authors are open about the limitations of the paper. First, they do not claim to provide a full analysis of the climate effects of the high-speed rail system. For instance, on the one hand, the main analysis does not deal with potentially beneficial substitution effects between rail and air passenger transportation. On the other hand, some potential adverse effects, for instance, those resulting from substitution of conventional passenger rail transportation by high-speed rail are not treated either. A supplementary analysis of the authors based on less detailed data suggests, however, that such opposing additional effects do not change the broad conclusion of the analysis. Second, the results are specific to China in a particular state of its development – but given the importance of the country as a CO2 emitter, this does not seriously reduce the relevance of the work. Third, without further analysis it is hard to judge how cost-effective the high-speed rail system is as a means of reducing GHG emissions (which, of course was not its main purpose).

Nevertheless, the paper conveys very useful insights. Given the unprecedented scale of the Chinese high-speed rail system (by 2020, the network size has increased above 30,000 km and is still growing rapidly), quantifying its environmental effects is interesting in its own right. Beyond the Chinese

context, it appears to be the first contribution identifying GHG-reduction effects of high-speed rail systems – previous work on Italy has not found any effect.[vii] Arguably the most useful aspect of the paper is that it reveals how sensitive the benefits of transportation infrastructure may be to details of the setting – traveling habits, capacity constraints and the energy mix used for rail transportation. On a related note, it also suggests that policy should think carefully about which types of investments in railway infrastructure are most effective in reducing GHG emissions. Are countries heading for the right mix between infrastructure for high-speed passenger traffic, regional passenger traffic and freight transportation? To get a fuller understanding of the GHG reduction potential of public transport in general and rail infrastructure projects in particular, follow-up studies in different settings would therefore be highly desirable.

The authors declare no competing interests.

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