

The Impacts of Industrialization on Freight Movement in China

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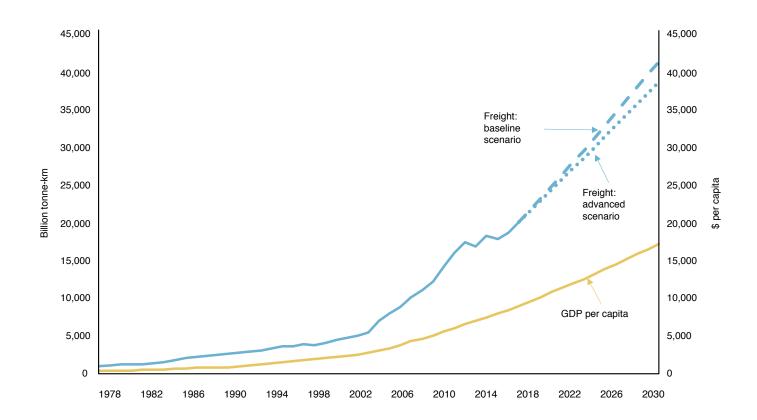
Key Points

apid economic growth in China has enabled the fast development of freight transport across the country and, partly related, growth in fuel consumption. The Chinese government is making structural changes to national economic development while facing a growing number of challenges including energy security, a shrinking labor force, a worsening domestic environmental situation, and an escalation and a broadening of global trade tensions, particularly with the United States.

What might the impact of future economic growth be on freight movement in China? To answer this question, this paper establishes the link between key indicators of industrialization and freight transport through the use of a dynamic vector autoregressive model. Based on the analysis of two different scenarios, the study finds:

Staying at the later stages of industrialization, China would double its freight turnover by 2030 against the level in 2017. Compared with 10% annual growth during 2003-2016, much slower growth is expected for 2017-2030, at around 5% per year.

Figure 14. Scenario analysis for freight activity in China 1978-2030.



Source: KAPSARC.

Key Points

China could reduce the volume of its freight transport by transforming its process of industrialization through coordinated urban planning, using new materials, developing its high-tech industries and expanding the share of the service sector in its economy. This paper finds that these measures could result in a reduction of 2.6 trillion tonne-kilometer of freight transport, 6% lower than the business-as-usual model of urban and industrial development.

Changes to the country's economic structure may also lead to structural changes in modes of transportation, such as an increased share for railroads, the growing use of automotive transportation, and the increased use of containers in China's integrated freight transport system.

Summary

conomic growth is a key determinant for freight movement — the two typically grow in tandem when a country is on a rapid development track. However, analyzing time series for the United States, the United Kingdom and Japan has shown that freight activity may level-off or decrease when a country has reached a high level of economic development. This mainly results from the adoption of a low carbon transport policy, structural changes in the economy and/or from improved logistics systems.

The stages of a country's industrialization capture the structural changes of an economy and can help to explain China's level of freight activity. For example, as China enters the later stages of industrialization it is displaying economic growth and freight movements that diverge from the earlier stages of its industrialization.

Slower economic growth dampens overall production and consumption, leading to slower growth in freight transport.

The development of higher-value industries and the service sector is a national priority, while the presence of traditional energy-intensive industries remains strong. This necessitates further improvements to the integrated network for the long-distance transportation of bulk commodities. It also creates a growing need for flexible and time-responsive transport for higher-value products and consumer goods.

The disparity in the industrialization of different regions means that the sites of industrial production and urban construction will shift.

This evolution will alter transportation needs, particularly for commodities and energy-intensive industries.

China may remain in the later stages of industrialization until 2030. This will dictate the continued growth of freight transportation over the next decade. Freight turnover, measured as a metric tonne of goods transported over a distance of one kilometer (km), could double by 2030 compared with the 2017 level, even with policy initiative interventions for economic and energy transitions.

The adoption of a different process of industrialization could lead to a different level of transport intensity and affect the distance between production sites and consumer centers. In the advanced scenario, 2.6 trillion tonne-km of freight transport could be reduced by 2030 through coordinated urban planning, the use of new materials, the development of high-tech industries, and a growing share for the service sector in the economy. This advanced scenario figure is about 6% lower than the baseline scenario, which sees the growth of mega cities continue and a heavier reliance on industrial development in the Chinese economy.

The evolution of industrialization may also impact the modal structure of the freight transport system. A change in the structure of the Chinese economy could trigger further investment in railway networks and improvements to internal waterways. This could lead to an increased share of rail in freight traffic. The increased requirement for door-to-door delivery may also increase the use of short-distance automotive transport. Improved connectivity between railways, waterways and highways will increase the use of container transportation for higher value-added industrial products and consumer goods.

Introduction

orldwide transportation energy use has doubled in the past 30 years. Passenger transport accounted for 61% of global transportation energy use in 2016. Light duty passenger vehicles consume more energy than all other modes of freight transport, including heavy trucks, marine and rail combined (EIA 2016). However, increasingly integrated global supply chains, re-industrialization in developed countries, as well as the growing needs of infrastructure construction and improved living standards in developing and emerging countries, are increasing freight activity rapidly.

This trend has been reflected in the rise of oil consumption by road freight transport:

In the developed world, road freight oil consumption continues to increase, even as oil demand for passenger vehicle fleets has begun to plateau and decline.

In developing and emerging economies, the pace of oil demand growth from the road freight sector has begun to outstrip that of the passenger vehicle sector in many countries (IEA 2017).

While policymakers and researchers have largely focused on passenger transportation and urban

infrastructure, freight transportation research has received much less attention. Existing studies (IEA 2017; Fu et al. 2011; Hao et al. 2015) capture key aspects of freight transport, including freight turnover, modal structure and energy intensity, used to predict the future energy consumption and greenhouse gas emissions (GHG) from freight transport. However, an important element lacking in these studies is that their assumptions do not explicitly explain the growth pattern of freight turnover. This highlights the need to conduct further research into freight turnover so as to better project future freight transport energy use.

There is a direct link between a country's economy and its freight activity. International initiatives, domestic economic reforms, industrial restructuring and rising standards of living will all significantly affect freight movement, especially in developing and emerging economies where much of the global economic growth occurs. This is the case for China, whose future economic and industrial development trajectory is at a crossroads and facing uncertainty from global trade and investment. It is important to understand the direction of this structural change and its impact on freight activity in China, which has seen the world's largest incremental rise in transportation energy use.

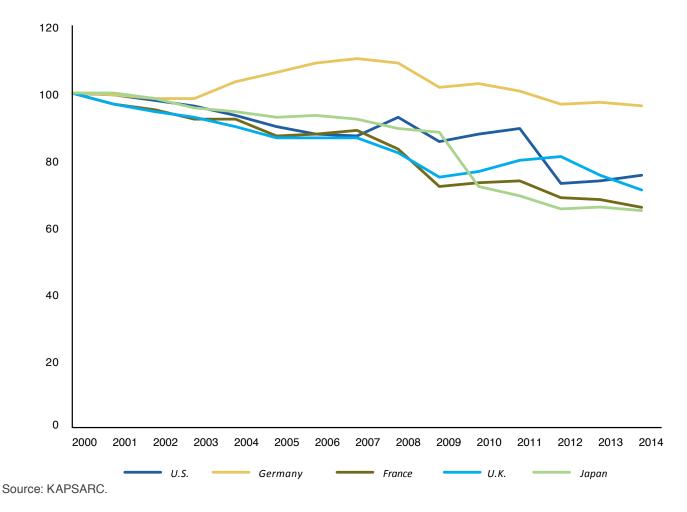
Freight Transport and Economic Growth

reight transport has typically grown in tandem with national economic growth. Other factors can also impact the demand for freight, including an abundance of natural resources, geographic distances, population density and transport infrastructure capacity. However, freight growth mainly results from changes in a country's economic structure that create supply and demand for goods in specific geographic regions, forming the basis of transport flows between those regions. Production specialization and concentration and greater separation between the stages of value creation, as well as the increasing internationalization of companies' economic activities, have boosted transportation volumes globally and average transportation distances

have increased. A country's economic growth and industrial structure are the most important drivers of national freight activity (Bennathan et al. 1992; Wang 2004; Wang et al. 2012; Li et al. 2013; Tavasszy and De Jong 2014; Luo et al. 2016).

Measured as the ratio of total freight turnover — expressed as the transport of one tonne of goods by a given transport mode over a distance of one kilometer, or tonne-km. — to total gross domestic product (GDP), the freight transport intensity indicator shows the actual freight activity required to produce a unit of goods and services in the country's GDP. The decline of freight transport intensity in some developed countries, as shown Figure 1, suggests either GDP growing at a faster

Figure 1. Freight transport intensity in the U.S., Germany, France, U.K. and Japan (index 2000=100).



rate than freight transport growth or an increase in freight transport productivity. For China, the significant drop in the freight transport intensity of GDP in real terms between 1978 and 2003 can largely be attributed to a series of economic reforms and market liberalization moves, most notably in 1978 and 1992 (Figure 2). The country's GDP grew almost ninefold in real terms during this period, while freight growth lagged, rising fourfold. This trend was reversed between 2003-2012 and followed China becoming a member of the World Trade Organization (WTO) in December 2001. The globalization of production activities and the nature of industrial distribution created higher growth in freight transportation than in GDP growth, as China transformed itself from a mainly agricultural country at the margins of the world economy to the hub of many global manufacturing production chains.

Statistical trends support the hypothesis that freight transportation is on a growth path linked to rising GDP (in real terms). However, the results of time series statistical analyses cannot be regarded as fixed, because relationships between macroeconomic aggregates can change over time. For example, the European Union has identified the decoupling of economic growth from freight transport growth as a key issue on the path to sustainable transport, following the release of its first White Paper on Transport in 2001. Such policy intervention has changed the interaction between freight transport and GDP. Pastowski (1997) did

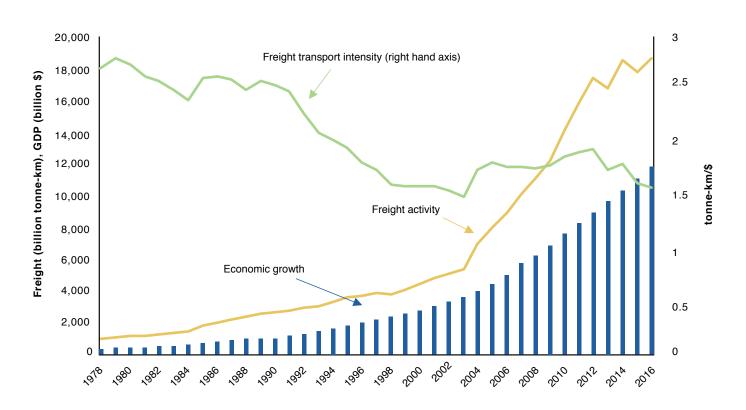


Figure 2. Freight activity, intensity and GDP China (1978-2016).

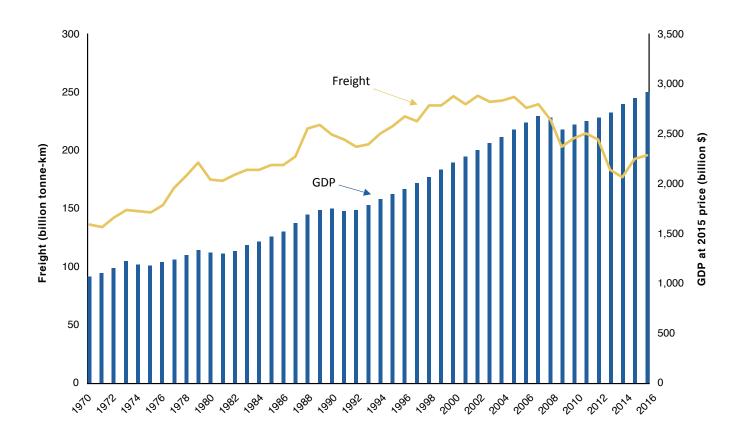
Source: KAPSARC.

not observe a decoupling of economic activity and freight transport in Germany in data from 1960 to 1995. The data analysis in our research shows 14% economic growth in Germany from 2009 to 2016 but lower growth in freight movement, at just 5%, during the same period. In the United Kingdom (U.K.), freight activity stabilized at around 240 billion tonne-km from 1998-2007, then quickly fell to below 200 billion tonne-km while the economy grew steadily, except for the fluctuation caused by the 2008 global economic recession (Figure 3).

A decoupling of economic development from freight activity was also observed in other developed

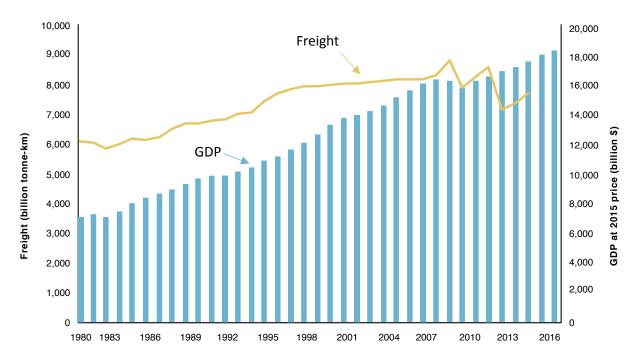
countries. For example, in the United States (U.S.) freight activity stagnated at around 8,000 billion tonne-km between 1996 and 2007 and declined after 2011, although economic growth continued after that date (Figure 4). In Japan, freight activity stagnated at around 570 billion tonne-km between 1990 and 2007 and then fell sharply (Figure 5). The structural change in the U.S. economy, toward larger contributions to overall GDP from the high-tech and service sectors, was the major reason for the decoupling of freight and GDP, while for Japan the same decoupling resulted mainly from the improved efficiency of the country's logistics system (Taniguchi 2015).

Figure 3. Freight and the economy in U.K. (1970-2016).



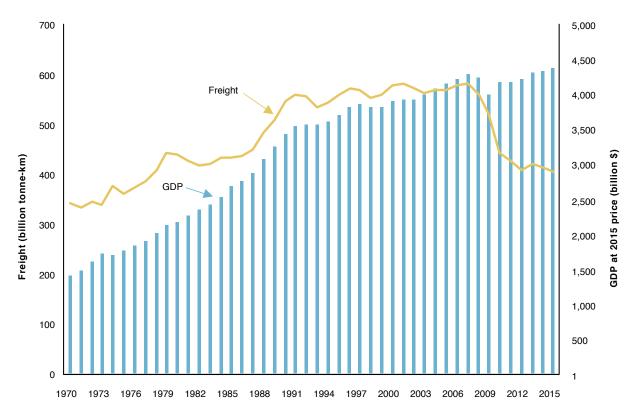
Source: KAPSARC, based on Enerdata and U.K. Department for Transport (2018).

Figure 4. Freight activity and the economy in U.S. (1980-2016).



Source: KAPSARC, based on Enerdata and BTS (2017).

Figure 5. Freight activity and the economy in Japan (1970-2015).



Source: KAPSARC, based on Enerdata and Japan Statistical Yearbook (2017).

These country case studies show that the stage of economic development and the structure of an economy are crucial for determining a country's freight transportation needs. In the years when freight movement in the U.S., U.K. and Japan started to decline, per capita GDP ranged from \$33,452 in Japan to \$53,645 in the U.S. (expressed

in 2015 dollar terms), and the service sector's share of GDP ranged between 68% in Japan and 76% in both the U.S. and U.K. (Table 1). This shows that a country's economic growth might not require equivalent growth in freight activity, but that freight activity levels off or decreases at a high level of per capita GDP (IEA 2017).

Table 1. Economic characteristics when freight starts to decline (U.K., U.S. and Japan).

	Year freight starts to decline	GDP per capita (in 2015 \$)	Services as a percentage of GDP
U.K.	2000	37,601	76
U.S.	2008	53,645	76
Japan	2007	33,452	68

Source: KAPSARC, based on Enerdata, U.K. Department for Transport (2018), BTS (2017), and Japan Statistical Yearbook (2017).

China's Industrialization Gets Underway

he usual way of measuring the change in a country's economic structure is to look at indicators such as the sectoral distribution of the labor force, consumption patterns and income distribution variables. Kuznets (1963) studied the changes in the composition of consumption, production, trade and other aggregates for individual advanced countries as incomes rose over time. Chenery and Syrquin (1975) added more categories of economic and social variables to analyze the structural changes applicable to all countries. These additional categories included investment, government revenue, education, urbanization

and demographic changes. Branson et al. (1998) analyzed the patterns of development from 1970-1994 through dataset analysis of 93 countries and provided 45 macroeconomic indicators to define the key changes in economic structures.

These studies provide a sound basis for measuring China's economic and industrial development.

A Chinese Academy of Social Science study (Huang and Li 2017) assessed the industrialization stages using five indicators, as shown in Table 2: GDP per capita; sectoral shares of production value; manufacturing industry value-added in

Table 2. Indicators measuring the stages of China's industrialization.

Indicators	Pre- industrialization	Early stages of industrialization	Mid- industrialization	Later stages of industrialization	Post- industrialization
GDP per capita @ 1964 \$	100-200	200-400	400-800	800-1500	Above 1500
GDP per capita @ 1995 \$	610-1220	1220-2430	2430-4870	4870-9120	Above 9120
GDP per capita @ 1996 \$	620-1240	1240-2480	2480-4960	4960-9300	Above 9300
GDP per capita @ 2000 \$	660-1320	1320-2640	2640-5280	5280-9910	Above 9910
GDP per capita @ 2002 \$	680-1360	1360-2730	2730-5460	5460-10200	Above 10200
GDP per capita @ 2004 \$	720-1440	1440-2880	2880-5760	5760-10810	Above 10810
GDP per capita @ 2005 \$	745-1490	1490-2980	2980-5960	5960-11170	Above 11170
GDP per capita @ 2010 \$	827-1654	1654-3308	3308-6615	6615-12398	Above 12398
Sectoral shares of production value*1 (%)	P > S	P > 20% P < S	P < 20% S > T	P < 10% S > T	P < 10% S < T
Value-added of manufacturing industry in total commodity production*2 (%)	Below 20	20-40	40-50	50-60	Above 60
Urban as share of total population (%)	Below 30	30-50	50-60	60-75	Above 75
Share of labor force in primary sector (%)	Above 60	45-60	30-45	10-30	Below 10

Notes:

Source: Huang and Li (2017).

^{*1:} P-refers to the primary sector, S-refers to the secondary sector, and T-refers to the tertiary sector.

^{*2:} Commodity production in the primary and secondary sectors.

total commodity production; percentage of urban population out of the total population; and share of the labor force in the primary sector. The study concluded that China is moving into the later stages of industrialization. Other studies (Feng et al. 2012; CCIEE 2014) that selected different economic indicators produced similar results.

What does this mean for China's economic and industrial development?

Slower economic growth in China will become the 'new normal' for the long term

China's rapid GDP growth, at around 10% per year over the last decade, has become history. Now, with per capita GDP at \$6,893 (in 2010 dollars), 57% of the population living in urban areas, 58% of commodity production value-added coming from manufacturing, tertiary industry's share of GDP at 51.6%, and 27.7% of the labor force working in the primary sector, the drivers of China's economic growth are changing rapidly. While trade conflicts with other countries increasingly challenge the export oriented model, the Chinese government's policy of driving economic growth through investment in infrastructure and construction has become less effective. Demographic dividends, cheap land, low-cost energy and loose environmental regulation — factors that supported China's previous rapid economic growth — are waning.

Industrial production is moving up the value chain while advantages in energy-intensive industries remain

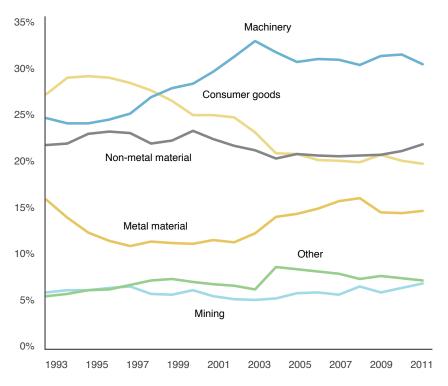
High tech and emerging industries will grow and

move up the value chain of industrial production, this will take place in parallel with the continued strong presence of energy-intensive industries. Our analysis of subindustries showed significant growth in the machinery and equipment industry (official specifications are listed in the Appendix, Figure A1). The industrial machinery sector's share of China's overall gross output rose from 24% in 1993 to 30% in 2011 (Figure 6). The fastest future growth in the machinery and equipment sectors will come from communications and computer equipment manufacturing and from transportation equipment manufacturing - representing the development of high-end manufacturing in China (Figure 7). The metal materials sector also showed substantial growth, led by the development of the machinery and equipment industry and state investment in urban infrastructure.

The disparity of industrialization in different regions will see industries move location

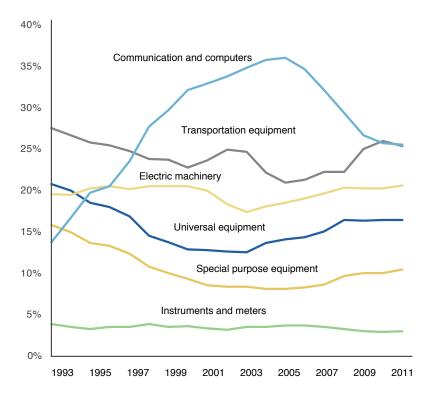
The most active economic zones in the central and eastern regions of China (i.e., the Pearl River Delta, Yangtze River Delta, Beijing-Tianjin-Hebei Integration and Bohai Bay Economic Rim), usually have strong comparative advantages in high tech and knowledge-based industrial development. As Table 3 shows, Jiangsu, Shandong and Guangdong are very active in high-end machinery manufacturing, together accounting for almost 50% of that sector's sales in China. Guangdong predominates in the communications, computer and other electronic equipment manufacturing sectors. Jiangsu leads in transportation manufacturing, including aviation, rail, ship and automotive machinery. Shandong has significant petroleum processing and chemical production capacity.

Figure 6. Structural changes of industry sectors (1993-2011).



Source: KAPSARC, based on CEIC.

Figure 7. Structural changes in machinery and equipment subsector (1993-2011).



Source: KAPSARC, based on CEIC.

However, many other provinces are still struggling to transition from resource-based and energy-intensive industrial development. Hebei province, for example, is a leader in ferrous metal mining, quarrying, smelting and pressing. Inner Mongolia,

Shanxi and Shaanxi are still the major players in coal, petroleum, natural gas and other mining activity, together accounting for 40% of those sectors' sales values in China.

Table 3. Geographic distribution of China's key industries, 2016.

	Selected key industries	Top three provinces (percentage of final sales value)					
1	Communications, computer and other electronic equipment manufacturing	Guangdong (33%)	Jiangsu (19%)	Chongqing (4%)			
2	Transportation equipment manufacturing (aviation, rail and ship)	Jiangsu (18%)	Shandong (10%)	Chongqing (7.5%)			
3	Transportation equipment manufacturing (automotive)	Jiangsu (9.7%)	Shandong (8.7%)	Guangdong (8.4%)			
4	Electric machinery and equipment manufacturing	Jiangsu (23%)	Guangdong (17%)	Zhejiang (8.7%)			
5	Ferrous metal smelting and pressing	Hebei (17%)	Jiangsu (14%)	Shandong (8%)			
6	Non-ferrous metal smelting and pressing	Shandong (14%)	Henan (10%)	Jiangxi (9.5%)			
7	Petroleum processing, coking and nuclear fuel processing	Shandong (23%)	Liaoning (8.7%)	Guangdong (6.4%)			
8	Raw chemical materials and chemical product manufacturing	Shandong (20%)	Jiangsu (20%)	Guangdong (7%)			
9	Chemical fiber manufacturing	Jiangsu (35%)	Zhejiang (30%)	Fujiang (13%)			
10	Coal mining and quarrying	Shanxi (21%)	Inner Mongolia (16%)	Shaanxi (11%)			
11	Petroleum and natural gas extraction	Shaanxi (16%)	Heilongjiang (11%)	Inner Mongolia (11%)			
12	Ferrous metal mining and quarrying	Hebei (27%)	Inner Mongolia (9.8%)	Sichuan (8.8%)			
13	Non-ferrous metal mining and quarrying	Henan (25%)	Shandong (18%)	Inner Mongolia (9%)			

Source: KAPSARC, based on China Industrial Statistics Yearbook (NBS 2017a).

Impact of Government Policy on Industry and Freight Transportation

government's economic development strategy is affected not only by the structure of the country's economy but also by its social objectives and willingness to use various policy instruments. In China, government policies and initiatives have long played a central role in shaping the country's economic and social activities. The following discussion provides an analysis of four of Beijing's major policies that are likely to shape the development of the nation's industries and freight transportation sector. The policies are Made in China 2025, supply side structural reform, energy revolution, and the Belt and Road Initiative (BRI) (Figure 8).

Made in China 2025

China released its Made in China 2025 plan on May 19, 2015, setting the roadmap and timelines for boosting China's manufacturing competitiveness and driving new economic development. The plan reflects Beijing's intention to transition China away from a volume production workshop toward building Chinese brands and innovation capacity. The plan prioritized 10 industries: information

technology; high-end numerical control machinery and automation; aerospace and aviation equipment; maritime engineering equipment and high tech vessel manufacturing; rail equipment; energy saving vehicles; electrical equipment; new materials; biomedicine and high performance medical devices; and agricultural equipment (State Council 2015).

This plan shaped the strategic position of China's manufacturing industry, with a focus on coupling the manufacturing and the service sectors. That is: the service sector's growing share of China's GDP should not result in a decline in the manufacturing industries, as an advanced manufacturing capability would serve as the basis for the future growth of the service sector. Under the plan, business areas such as product design, research and development, marketing, after-sales service and financial and legal services are viewed as inseparable from manufacturing industry.

The plan also proposed integrating manufacturing with the information technology sector. As China's industrial economy has developed, leading industries have evolved from being resource- and

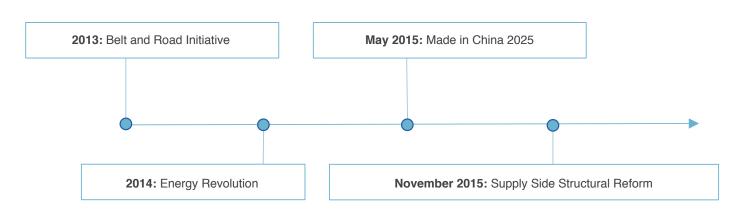


Figure 8. Timeline of four major policy initiatives in China (2013-2015).

Source: KAPSARC, based on Chinese government documents.

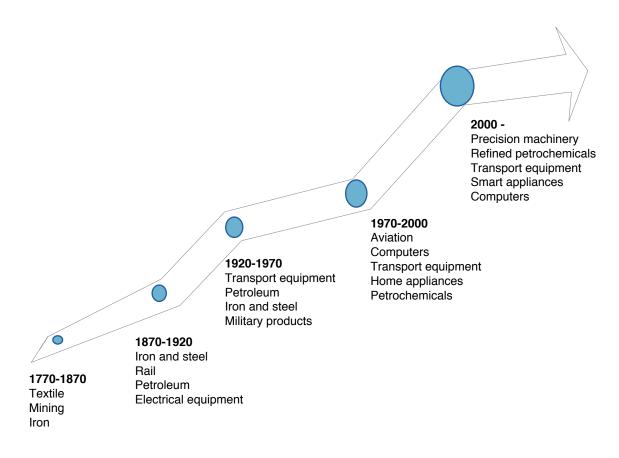
labor-intensive into high tech and knowledge-based industries (Figure 9). At the time of writing, intelligent and digitalized technology is transforming industrial production processes in China. As a result, traditional boiler, furnace, and forging equipment could soon be replaced by industrial robots, while technologies and innovations such as 3D printing, high-end numerical control machinery, new materials and new developments in the energy sector will likely become the drivers of future industrial growth in China (Xiong and Fu 2017).

China is no longer a low-cost labor market – other countries including Vietnam, Cambodia and Laos have become more competitive in that regard.

China's advanced and core technology development

is also lagging developed countries such as Japan, the U.K and U.S. The objective of Made in China 2025 is not simply to increase manufacturing industries' share of GDP, but to add capability that can drive long-term economic growth. The accumulated capabilities and knowledge embedded in the productive structure of an economy account for about 78% of the variation in income across 128 reviewed countries, while a country's position in the product space determines its opportunities to expand its productive knowledge and increase its level of economic complexity (Hausmann et al. 2013). This helps explain the global wave of reindustrialization, such as the advanced manufacturing program in the U.S. and the Industrie 4.0 strategic initiative in Germany.

Figure 9. Evolution of the leading industries in the global industrial economy.



Source: Xiong and Fu (2017).

Supply-side structural reform

The supply-side structural reform process that began in China in 2015 currently dominates the country's economic policymaking landscape. It shapes everything from the government's efforts to reduce excess industrial capacity to initiatives designed to reduce property inventory, curb high levels of corporate debt and lower corporate costs.

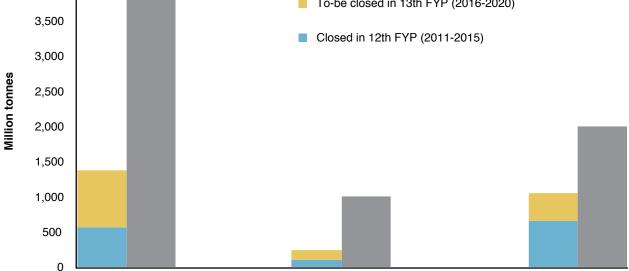
Cutting excess industrial production capacity is not a new strategic element. It has been one of the Chinese government's policy aims for decades. However, it was only enforced as a mandatory target starting with China's 12th Five-Year Plan (FYP) (2011-2015) and continues under the current 13th FYP (2016-2020). Under the policy, new investments and new project approvals for legacy industries regarded as having excess capacity have been subject to strict limits.

A capacity swap program has been implemented for the steel, cement, electrolyzed aluminum and flat glass industries. Under the program, capacity for any new, renovation or expansion project can be approved if it is swapped for cuts in existing capacity elsewhere. Mergers between stateowned enterprises (SOEs) may also be arranged by the government to improve the performance of these businesses.

The volume of cement production capacity that has been closed, or has been earmarked for closure, during the 12th and 13th FYPs totals about half of the country's planned active production capacity in 2020. While the total volume of coal production capacity that was cut in the 12th FYP and will be closed in the 13th FYP, equals about a third of the slated national coal production capacity in 2020 (Figure 10). These capacity cuts have created space for advanced technology upgrading via sector swaps.



Figure 10. China, closed and to-be closed excessive industrial capacity, 2011-2020.



Note: Cement data includes clinker and grinding capacity for the 12th FYP, but includes only clinker capacity for the 13th FYP. Source: KAPSARC, based on MIIT (2016a, 2016b), NDRC and NEA (2016a).

Steel

Coal

Cement

The long-term effect of this policy on China's economy is still unclear. Major capacity reductions so far have mainly targeted idle production capacity and failing SOEs. Many local regional and city governments and companies have been hesitant to go further because of their uncertainty as to the impact of the policy on the market. For example, government interventions in the coal sector through coal production capacity cuts and miners' working day limits, which were introduced in 2016, resulted a range of unintended consequences, including supply shortages, price spikes and other market distortions (Shi et al. 2018). The industrial capacity reduction policy is government-led through a topdown process. If the political will supporting the initiative were to ebb then — without underlying changes to banking, pricing, subsidy policies and market entry criteria — excess capacity might persist (EIU 2017).

Energy revolution

In June 2014, China's President Xi Jinping called for an 'energy revolution.' Fundamental changes to energy production, energy consumption, energy technology and energy administration then became national strategy, aimed at securing China's energy supply and future sustainable development. The central government set out its plan to boost China's reliance on renewable energy and natural gas and rolled out an efficiency improvement strategy. Under the plan, non-fossil fuels will account for 50% of China's power generation capacity and natural gas will account for 20% of overall energy consumption by 2030 (NDRC and NEA 2016a). Advances in technology and production efficiency have reduced the country's energy costs, making China the world's biggest supplier of solar panels and making its electric vehicle industry the biggest and fastestgrowing in the world.

The supply-side structural reform should substantially reduce China's coal production capacity, while the energy revolution initiative is set to reduce the use of coal from demand side. The international commitment by the Chinese government to see carbon dioxide (CO₂) emissions peak around 2030, together with the domestic requirement to tackle environmental pollution, leave no room for increased coal use. Several studies have discussed peak coal use in China and have reached different conclusions as to the likely year that demand will peak or has peaked. The IEA (2016) holds that China's coal consumption peaked in 2013, ERI (2015) forecasted it would peak before 2020, and Lin et al. (2018) estimated that coal use would continue to grow at least until 2020. However, there is widespread agreement that coal consumption in China will plateau after 2020, even if some studies still predict demand fluctuations.

More important for this discussion is the impact of China's reduction and redistribution of coal use on the transportation of coal. Coal transportation currently accounts for 58% of China's rail freight in tonnes and 38% of railroad freight tonne-km (NBS 2017b). According to the national plan, coal mining project construction in the country's Eastern region will be stopped, and over 87% of new coal mining projects will be located in the Western and North regions. As Figure 11 shows, East Inner Mongolia mainly provides coal for local use and power transmission to China's North and Northeast power grids. Xinjiang has an independent coal market, mainly for that autonomous region's coalto-chemical (CTC) projects and for coal-fired power transmission for the country's central provinces. The Shendong and Shanbei coal deposits, in conjunction with those of Inner Mongolia, Shaanxi and Shanxi provinces, not only provide feedstock for the growing number of CTC projects but also

Net export

Net import

Russia

Mongolia

Xinjiang

Inner Mongolia

Shanxi

Shaanxi

Taiwan

Figure 11. Movement of coal between regions in China.

Source: NDRC and NEA (2016b).

secure the use of coal in the country's middle and southern regions through various coal transportation channels (NDRC and NEA 2016b). The development of an advanced power grid system and the power transmission lines that are currently under construction for these regions would partially reduce the need for coal transportation.

Belt and Road Initiative

The Belt and Road Initiative (BRI), first proposed

by President Xi in the fall of 2013, aims to create new growth over a huge, growing, and not strictly defined area of the globe, comprising primarily the Silk Road Economic Belt, which aims to link China to Central and South Asia and onward to Europe by land; and the New Maritime Silk Road, a sea route linking China to Southeast Asia, the Middle East, North Africa, and Europe. The BRI aims to strengthen mainly freight, but also passenger, transport connections via new highways, railroads and ports; to facilitate trade and investment in

new infrastructure; and to build bilateral ties for educational and cultural exchanges.

In the five and a half years since the BRI was first announced, China has established new maritime shipping routes with more than 600 ports in over 200 countries. BRI-related port investments in Southeast Asian countries to date include projects in Indonesia, Malaysia, the Philippines and Singapore. A BRI-funded economic corridor linking the Pakistani port of Gwadar, on the Arabian Sea, with the autonomous region of Xinjiang, in China's northwest, has the potential to create a new trade route linking North Africa, South and Central Asia. On land, more than 12,000 freight trains ran from 56 Chinese cities to 49 cities in Europe in 2018 (Belt and Road Portal 2019), while agreements with Laos and Indonesia on high-speed rail construction projects are part of China's intention to establish global high-speed rail transportation links. If built, four new regional railroads currently under discussion could reshape trade flows and create a modal structure for freight transportation.

The improved transport connectivity offered by the BRI also aims to facilitate trade and reduce cross-border trade costs through standardized consignment notes, customs coordination, harmonization of standards, mutual recognition of certifications and other initiatives aimed at smoothing international trade and transportation. A recent World Bank study found that the BRI could reduce shipping times for all country pairs in the world by between 1.2% and 2.5%. The largest estimated gains were for the trade routes connecting East and South Asia and along the

BRI corridors. If all BRI transport infrastructure projects are implemented, they would reduce aggregate global trade costs by between 1.1% and 2.2% (De Soyres et al. 2018).

The potential trade benefits from the BRI vary for different regions. One study has identified 11 countries in Southeast Asia as having the highest commercial interdependency with China (Zou et al. 2015). Between them, these 11 countries accounted for 43.9% of total trade volume under the BRI in 2014 and contributed significantly to economic growth in China's coastal provinces and in southwestern Yunnan province, which borders Myanmar and Laos. A further 19 countries in western and central East Asia accounted for 28% of BRI-related total trade volume in 2014, while China's autonomous region of Xinjiang and Heilongjiang province benefit from their proximity to Russia, Mongolia and some Central Asian nations.

However, more studies are needed in order to understand the current and future impact of the BRI on China's domestic and international trade flows and to measure to what extent the initiative has and will reshape freight transport through improved connectivity and reduced bureaucracy. The range of projects and the geographical scope of the BRI continue to develop, as is the nature of any open platform initiative. It is also difficult to predict the completion or likely success of many BRI-linked projects, given that the political, economic and social risks vary greatly in the scores of countries included in the initiative. The uncertainties associated with such long-term infrastructure investments will have to be addressed on a case by case basis.

Empirical Methodology and Results

Methodology

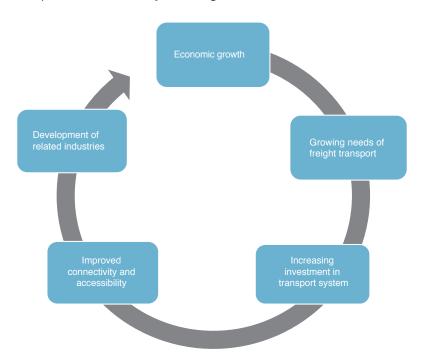
DP is commonly used as an indicator of economic activity in a region or in a country when studying freight transportation development in trend and time series models (de Jong et al 2004; Wang 2004; Kveiborg and Fosgerau 2007; Zhang et al. 2009; Vanoutrive 2010; Wang et al. 2012; Meersman and Van de Voorde 2013; Tian et al. 2014; Muller et al. 2015; Gao et al. 2016). At a national aggregate level, no other indicator is better than GDP for interpreting economic development and its relationship with freight movement. Muller (2015) concluded that 91% of goods transported in Germany could be explained by economic activity. Wang (2004) calculated that 94.76% of freight growth in China could be attributed to the country's GDP growth between 1985 and 2001. But there are also constraints to the use of this method.

First, GDP figures do not show the change in the composition of GDP and industrial structure. These changes might be caused by globalization, policies

aimed at decoupling freight and economic activity, and changing business behaviors. It might be more appropriate to translate the gross value-added of key industries into the amount of important transported goods. Meersman and van de Voorde (2013) suggest that disaggregated methods are needed, based on the microeconomic analysis of the behavior of shippers and freight transportation companies. Input-output tables can provide information on how an industry is related to products on the supply and consumption sides. However, the translation of money flows into freight transportation is still a challenge (Muller 2015). Lack of data also make it difficult to validate the results of such studies.

Second, GDP is not exogenous in terms of freight transportation. The circular relationship between an economy and freight may create a simultaneity bias for linear models which cannot be overlooked. On the one hand, the level of economic development represents the overall product output, which determines the level of freight activity (Figure 12). The change in economic structure and the change

Figure 12: Circular relationship between economy and freight.



Source: KAPSARC.

in the spatial distribution of industries affects the demand for freight services. On the other hand, expanded freight infrastructure and an improved logistics industry may create opportunities for the development of other industries. The more investment there is in freight movement infrastructure, the better accessibility and connectivity results. This encourages the creation of leading industries in the core region and supporting industries in neighboring regions, eventually boosting overall economic growth.

Taking these factors into account, a vector autoregressive (VAR) model was identified in this study to overcome the endogeneity issue and estimate the dynamic relationship between China's industrial economy and freight activity. The VAR is an n-equation, n-variable linear model in which each variable is in turn explained by its lagged values, plus current and past values for the remaining n-1 variables. This simple framework provides a systematic way to capture rich dynamics in multiple time series and offers the promise of providing a coherent and credible approach to data description, forecasting, structural inference and policy analysis (Sims 1980; Stock and Watson 2001).

The VAR equations can be expressed as:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 x_{t-1} + \mu_{ty}$$

$$x_t = \beta_3 + \beta_4 x_{t-1} + \beta_5 y_{t-1} + \mu_{tx}$$

Where, $y_{_t}$ represents the dependent variable and $x_{_t}$ represents the independent variable. β_0 , β_1 , β_2 , β_3 , β_4 , and β_5 are the coefficients to be estimated. μ_{tx} and μ_{ty} are the error terms associated with the respected variables.

Theoretically, the following process is needed to build the model that is appropriate for this study:

The stationarity of the time series data is tested before establishing the model. The standard unit root tests (augmented Dickey-Fuller [ADF], Dickey-Fuller Generalized Least-Squares [DFGLS] or Kwiatkowski-Phillips-Schmidt-Shin [KPSS] tests) are used to test whether these variables have a unit root.

The Johansen cointegration test is then applied to check whether cointegration exists between the variables. In this process, the maximum eigenvalue test and the trace test are used to determine the number of cointegration vectors.

The Breusch-Godfrey Serial Correlation
Lagrange Multiplier (LM) test is a useful test for
autocorrelation in regression model errors. It
makes use of the residuals from the model which
are considered in a regression analysis and from
which a test statistic is derived.

Heteroscedasticity occurs when the variance of the error terms differs across the observations.

The autoregression (AR) root stability test estimates the VAR model's stability if all roots have a modulus less than one and lie inside the unit circle. If the VAR is not stable, at least one of the roots will have a modulus that lies outside the circle.

Empirical results

We introduced a variable, *I*, to reflect the development of China's industrial economy. It is the ratio of value-added for industry against industry employment. These two indicators can best represent the level of industrialization, as Table 1 indicates. The value-added data for industry sectors is stated in 2015 U.S. dollars from Enerdata, and the employment data for the industrial sector is from China's National Bureau of Statistics (NBS 2017b), both covering the period 1978-2016. All data were converted into log-log equations for time series processing. The coefficient can be interpreted as

an elasticity. To address the structural breakpoints of the variable seen in 2003, which reflects the market and economy changes after China joined the WTO in December 2001, we introduced a dummy variable, 'D.' A dummy variable is one that takes the value 0 or 1 to indicate the absence or presence of structural breakpoints that may be expected to shift the outcome. In this study, we have used D as a dummy variable, which takes 0 as a binary number from the period 1978-2002 and 1 from 2003-2016.

The ADF unit root test was performed at level, including a test equation at intercept and trend-intercept, which indicated that the null hypothesis of a unit root at level cannot be rejected at the 5% significance level. However, the ADF test at first order difference indicates that the null hypothesis of a unit root at first order difference can be rejected at the 5% significance level. Thus, all the variables were found to be first order difference stationary with intercept and trend-intercept, so we could proceed with the cointegration test (see Appendix, Figure A2).

In the process of VAR model construction it is important to select a proper lag period because long lag structures can reduce the autocorrelation of the error term but may also reduce the explanatory power. As shown in Appendix, Figure A3, a lag order of 1 was selected in this study, as dictated by the results of the logarithmic likelihood ratio (Log L), Akaike information criterion (AIC), Schwarz criterion (SC), sequential modified likelihood-ratio (LR), final prediction error (FPE) and the Hannan-Quinn information criterion (HQC).

Johansen's approach derives two likelihood estimators for the cointegration rank: a trace test

and a maximum eigenvalue test. Following the lag length criteria, lag 1 is recommended from the test, and there is no cointegration between the variables at the 0.05 level for both trace test and maximum eigenvalue (see Figure A4). However, in this study, we also carried out the autoregressive distributed lag (ARDL) test for cointegration, since the ARDL cointegration test outperforms all the other cointegration tests for the small sample size (Pesaran et al. 2001; Mikayilov et al. 2017). We found that there is a long-term cointegration at a significance level of 1% in the ARDL test (see Figure A5). Given that the VAR model gives consistent forecasts, we continued our analysis using VAR (Sims 1980; Stock and Watson 2001).

We obtained estimates of VAR (Appendix, Figure A6). The equations can be described as follows:

$$F = 0.9253F_{t-1} + 0.038I_{t-1} + 0.33 + 0.0954D$$

$$I = 0.106F_{t-1} + 0.887I_{t-1} + 0.164 + 0.014D$$

Where F represents the freight activity, I represents the level of industrialization, and D is the dummy variable.

To ensure the preferred model is correctly specified, it is necessary to conduct a stability test for the VAR model. Figure A7 Appendix shows that all the characteristic roots are less than 1 and lie inside the unit circle. It indicates that the VAR model and the parameters of the equations satisfy the stability condition. The result of the residual tests of serial correlation (Figure A8) and heteroscedasticity (Figure A9) further prove the validity of the VAR model we obtained. This model will be used in the following section for future freight forecasting based on the scenario analysis.

Future Development of Freight Transport in China

Scenario settings

s discussed earlier in this paper, slower growth will be a 'new normal' status for the Chinese economy in future. In its progress toward the later stages of industrialization, China needs new momentum to continue its economic growth. If the uncertainties and potential risks that we have discussed prove manageable, China can likely maintain its economic growth at around 6.5% per annum out to 2020 and at between 4% and 5% from 2020 to 2030 (CAE 2016; Liu 2017; IMF 2018).

The regional disparity of industrialization in China will extend the overall industrialization process. It will also allow for the migration of traditional industries from developed regions to locations requiring urban

construction and industrial development. The share of the industrial sector in the national economy is gradually declining, while the service sector 's share is growing more rapidly.

The population of China is expected to remain stable until the 2030s, after which date it may begin a slow decline (UNDESA 2017). The labor force in the 15 to 59 age group has decreased at a rate of about two million people per year since 2013 (Liu 2017). Structural changes in the economy by 2030 will drive up employment in the service sector while reducing employment in the industrial sector.

In this context, we have constructed two scenarios which reflect potential ways forward for industrialization in China over the next decade (Figure 13).

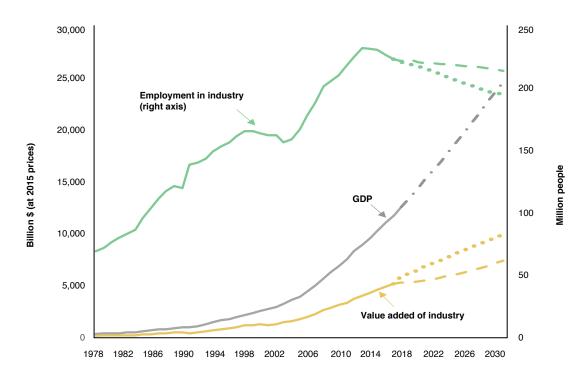


Figure 13. Scenario setting for China's industrial economy, 1978-2030.

Note: Dotted lines = advanced scenario, dash lines = baseline scenario, GDP growth is the same under both scenarios. Source: KAPSARC, based on Enerdata, NBS (2017b), Liu (2017) and Oxford Economics (2018).

In the baseline scenario, urbanization progresses as it has done in the past. China's Central and Western provinces continue with urban construction and rural development. Most energy-intensive industries will likely reach peak production around 2020 but remain at this peak level until 2030. This is especially likely for coal, cement, iron and steel. Structural changes in the economy occur gradually. This is reflected in the relatively heavy weighting of the industrial sector in the national economy, with slightly reduced employment in this sector. In this scenario, the share of the industrial sector in China's GDP will remain constant at 44% out to 2020, declining slightly, to 40%, by 2030. Employment in China will continue to grow, from 781 million people at work in 2020 to 789 million in 2030, while employment in the industrial sector will likely decline slowly, from 220 million people in 2020 to 216 million by 2030 (Oxford Economics 2018).

In the advanced scenario, coordinated city cluster development and smart city planning will reduce the need for infrastructure construction. In addition, the use of high performance products and new construction materials will contribute to further reductions in energy-intensive industrial production. The use of artificial intelligence and the upgrading of China's manufacturing industry will significantly increase overall productivity. The population's growing desire for a better life will boost the development of the education, tourism. entertainment and healthcare industries. Internetbased consumption, such as online education, ride sharing and food delivery, is also driving the development of a new service sector. A large proportion of the labor force has been diverted into the information technology, logistics and business support service sectors. In this scenario, the share of industry in China's GDP will fall from 35.8% in 2020 to 30% in 2030. Total employment in China

will decline from 770 million people in 2020 to 750 million in 2030. This will lead to a faster reduction in industrial sector employment than in the baseline scenario, from 216 million people in 2020 to 195 million by 2030 (Liu 2017).

Results analysis

China's freight transportation sector will continue to grow for the next decade, even under a slower economic growth scenario. As discussed in the previous section, when freight activity in the U.S., U.K. and Japan started to decline, the GDP per capita of these countries was between \$33,000 and \$53,000 (in 2015 dollars) and the share of the service sector in the three countries' total GDP ranged between 68% and 76%. By 2030, China's GDP per capita may reach around \$17,000 (in 2015 dollars). This is far below the level at which the U.K., U.S. and Japan started to see reductions their freight activity. In other words, the freight movement sector in China will not peak before the country completes its later stages of industrialization.

In the baseline scenario, the industrial sector will continue to play a major role in creating economic value and employment. In order to satisfy the demand for energy products, industrial materials and final products, freight turnover in China will likely double by 2030 compared with the 2017 level (Figure 14). China's rail network will be further extended to overcome the transportation bottlenecks for coal and bulk commodities that now exist in some regions. Highway network intensity will be increased to meet the growing needs of highly concentrated mega cities, which will be developed under China's traditional urban planning model. The modal structure of freight transportation will show a slow evolution, with continued investment in railroad and highway infrastructure.

In the advanced scenario, smart city planning and coordinated regional development will shorten the physical distance between production and consumption, and industrial upgrading will further reduce freight transport intensity. Total freight turnover will be 6% lower than in the baseline scenario (Figure 14). The effective implementation of the energy revolution strategy and supplyside reform will constrain the volume of freight transportation for coal, steel and other bulk commodities. At the same time, Made in China 2025 and the BRI will stimulate the rapid development of the high value-added manufacturing and service sectors. This will generate more stringent requirements for the safety, speed, flexibility and convenience of freight transportation, thus boosting

the automotive and aviation freight sectors.

In the later stages of industrialization, freight transportation will slow and experience structural changes. Both the baseline scenario and the advanced scenario indicate reduced freight growth, at around 5% per year during 2017-2030, compared with 10% annual growth during 2003-2016 (Figure 14). The rail network, inland waterways and seaborne coastal lines will retain their advantages in both scenarios for long distance freight transportation. The improved connectivity between railroads, waterways and highways, and the increased use of shipping containers for high value-added industrial products and consumer goods, lead to improved efficiency in the freight transport system in the advanced scenario.

45,000 45,000 40,000 40.000 35.000 35.000 Freight: baseline scenario 30,000 30 000 3illion tonne-km capita 25,000 25,000 Freight: advanced \$ per o scenario 20,000 20,000 15,000 15,000 10,000 10 000 GDP per capita 5,000 5,000 0

Figure 14. Scenario analysis for freight activity in China, 1978-2030.

Source: KAPSARC research.

1978

1982

1986

1990

1994

1998

2002

2006

2010

2014

2018

2022

2026

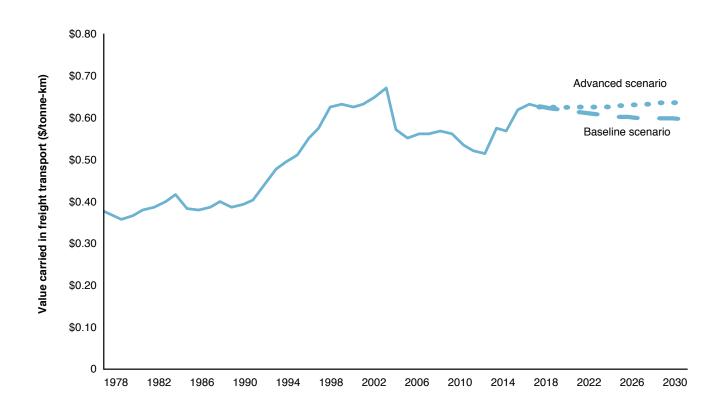
2030

Future Development of Freight Transport in China

The value carried in 1 tonne-km of goods shipment by 2030 is higher in the advanced scenario than in the baseline scenario (Figure 15). This can be attributed largely to the difference in the marginal benefit of the freight transportation system. The transportation infrastructure and services that accommodate conventional industrial development carry less value compared with a system adapted to an upgraded industrial economy. Time responsive freight requirements also drive up innovation and transportation productivity.

By using a VAR model, this study provides a better approach to capturing the changing process of industrialization and its impact on freight transportation in China. Our results are consistent with other studies, even those that used different methodologies (Appendix, Figure A11). This proves the applicability of the VAR model to capturing the impact of industrialization on freight activities. It could be used as a valuable reference for future studies on freight transportation by different modes and for transporting different commodities.

Figure 15: Scenarios analysis for value (\$/tonne-km) carried in freight transport in China, 1978-2030.



Source: KAPSARC research.

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Notes

Notes

Appendix

Figure A1. Official specification for six subindustrial sectors.

	Subindustry	Specification
1	Mining	Coal mining and dressing, petroleum and gas extraction, ferrous metal mining and dressing, non-ferrous metal mining and dressing, other mining.
2	Consumer goods	Agricultural and sideline food processing; food manufacturing; beverage manufacturing; tobacco processing; textile industry; garment, footwear and headgear manufacturing; leather, fur, down and related products; timber processing, bamboo, cane, palm fiber and straw products; furniture manufacturing; paper making and paper products; printing and record medium reproduction; cultural, education and sports articles.
3	Non-metal materials	Petroleum processing, coking and nuclear fuels processing; raw chemical materials and chemical product; medical and pharmaceutical products; chemical fiber industry; rubber products; plastic products; non-metal mineral products.
4	Metal materials	Smelting and pressing of ferrous metal; smelting and pressing of non-ferrous metal; metal products.
5	Machinery and equipment	Universal equipment; special purpose equipment; transportation equipment; electric machinery and equipment; communication, computer and other electronic equipment; instrument, meters, cultural and office machinery.
6	Others	Production and supply of electricity and heat; production and supply of gas; production and supply of water; handicraft and other manufacturing; waste resources and materials recovery and processing.

Source: KAPSARC analysis.

Figure A2. Results of unit root test for freight turnover and level of industrialization.

			Intercept		Trend-intercept		
			t-statistic	Probability	t-statistic	Probability	
Freight turnover (at first difference)			-4.54	0.0008		0.0008	
	1% level	-3.62			-4.23		
	5% level	-2.94			-3.54		
	10% level	-2.61			-3.20		
Level of industrialization (at first difference)			-6.04	0.0000	-6.01	0.0000	
	1% level		-3.57		-4.15		
	5% level		-2.92		-3.50		
	10% level		-2.60		-3.18		

Figure A3. Lag order selection by criterion.

Lag	Log L	LR	FPE	AIC	sc	HQ
0	3.169627	NA	0.003596	0.047450	0.225204	0.108811
1	102.1913	175.4098*	1.58e-05*	-5.382360*	-5.026852*	-5.259638*
2	103.1083	1.519566	1.89e-05	-5.206187	-4.672925	-5.022105
3	104.1491	1.605865	2.26e-05	-5.037092	-4.326076	-4.791650
4	105.3325	1.690621	2.70e-05	-4.876146	-3.987375	-4.569342

^{*} Indicates lag order selected by criterion.

Source: KAPSARC analysis.

Figure A4. Johansen cointegration test.

Hypothesized number of	Eigenvalue	Trace	0.05	0.05			
cointegrating equations (CEs)		Statistic	Critical value	Probability			
None At most 1	0.232414 0.030333	10.92635 1.139698	15.49471 3.841466	0.2161 0.2857			
Hypothesized number of CEs	Eigenvalue	Max-eigen statistic	0.05 Critical value	Probability			
None At most 1	0.232414 0.030333	9.786657 1.139698	14.26460 3.841466	0.2263 0.2857			

Source: KAPSARC analysis.

Figure A5. ARDL bounds test.

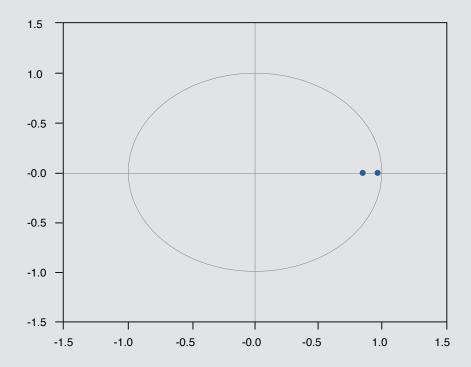
Test statistic	Value	k
F-statistic	16.45284	1
Critical value bounds		
Significance	L0 bound	L1 bound
10%	3.02	3.51
5%	3.62	4.16
2.5%	4.18	4.79
1%	4.94	5.58

Appendix

Figure A6. VAR estimates.

	F	I
F(-1)	0.925316	0.106007
	(0.04604)	(0.06386)
	[20.0974]	[1.65995]
I(-1)	0.037951	0.887967
	(0.06258)	(0.08680)
	[0.60644]	[10.2300]
С	0.330038	0.164051
	(0.23943)	(0.33210)
	[1.37844]	[0.49399]
D	0.095433	-0.014190
	(0.03434)	(0.04763)
	[2.77904]	[-0.29791]
R-squared	0.996941	0.990355
Adj. R-squared	0.996671	0.989504
Sum sq. resids	0.090541	0.174189
S.E. equation	0.051604	0.071577
F-statistic	3693.086	1163.662
Log likelihood	60.83157	48.39912
Akaike AIC	-2.991135	-2.336796
Schwarz SC	-2.818758	-2.164418
Mean dependent	8.405330	8.856159
S.D. dependent	0.894341	0.698633

Figure A7. VAR roots of the characteristic polynomial.



Source: KAPSARC analysis.

Note: VAR roots stability test. All the characteristic roots (blue dots) have a modulus less than one and lie inside the unit circle.

Figure A8. Breusch-Godfrey serial correlation LM test.

F-statistic	0.121017	Prob. F(1,33)	0.7301
Observe R-squared	0.138844	Prob. chi-Square	0.7094

Source: KAPSARC analysis.

Figure A9. Heteroscedasticity test- ARCH.

dF-statistic	0.188281	Prob. F(1,35)	0.6670
Observe R-squared	0.197975	Prob. chi-square	0.6564

Appendix

Figure A10. Data and results for different scenarios.

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GDP growth (%)	6.5%	6.3%	5.8%	5.5%	5.4%	5.2%	5.1%	4.8%	4.6%	4.5%	4.3%	4.1%
Share of industry (%) - baseline scenario	45.4%	44.8%	44.3%	43.8%	43.4%	42.9%	42.5%	42.0%	41.6%	41.1%	40.6%	40.2%
Share of industry (%) - advanced scenario	37.8%	35.8%	34.9%	34.0%	33.2%	32.4%	31.7%	31.0%	30.7%	30.4%	30.1%	30.0%
Employment in industry (million people) - baseline scenario	221	220	220	219	219	218	218	217	217	216	215	214
Employment in industry (million people) - advanced scenario	218	216	214	211	208	206	204	202	200	198	196	195
Freight turnover (billion tonne-km) - baseline scenario	23095	24662	26259	27879	29517	31171	32836	34510	36189	37870	39549	41225
Freight turnover (billion tonne-km) - advanced scenario	22894	24307	25707	27118	28536	29962	31388	32816	34241	35677	37122	38569

Source: KAPSARC, Liu (2017) and Oxford Economics (2018).

Figure A11. Comparison of this study's results and methodology with other studies.

	Methodology	Freight activity by 2020 (billion tonne-km)	Freight activity by 2030 (billion tonne-km)
KAPSARC	Vector autoregressive model	Baseline scenario: 24,662 Advanced scenario: 24,307	Baseline scenario: 41,225 Advanced scenario: 38,569
Zhu et al. (2017)	Linear regression and elasticity assumption	Baseline scenario: 29,642 Reinventing scenario: 28,000	Baseline scenario: 47,284 Reinventing scenario: 41,100
CAE (2016)	Elasticity assumption	17,685	24,244
Hao et at. (2015)	Elasticity assumption	25,000	42,000
Fu et al. (2011)	Freight growth rate assumption	Baseline scenario: 15,264 High scenario: 16,170	Baseline scenario: 19,101 High scenario: 21,610

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About the Project

The project aims to provide insights for policymakers in both China and Saudi Arabia. China is actively seeking pathways to reach peak energy consumption and reduce carbon emissions in the transportation sector in order to meet its commitments under the Paris agreement on climate change. This project aims to help policymakers in China better understand how the evolution of the economy toward a state of less freight-intensiveness may impact the process of reaching its policy goals. The project also aims to better inform policymakers in Saudi Arabia on key trends in oil demand in China, which is a major buyer of the Kingdom's crude.



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