The “Belt and Road Initiative” and comparative regional productivity in China

John Gibson | Chao Li

Department of Economics, University of Waikato, Hamilton, New Zealand

Correspondence
John Gibson, Department of Economics, University of Waikato, New Zealand. Email: jkgibson@waikato.ac.nz

JEL Classification: D24; O47; R11

Abstract
We study potential internal effects of China's Belt and Road Initiative. These effects may occur sooner than the international effects, since they face no delay from partner negotiations and from financing and security concerns. For a key part of the overland Silk Road Economic Belt, we identify 46 prefectural-level units in a corridor from the China–Kazakh border to Xi’an that are likely to see increased investment and economic activity from Belt and Road. These units are smaller, more diverse, poorer, and less productive than are prefectural-level units in the rest of China. The Belt and Road Initiative will disperse some economic activity to places that the market would not direct it, such as to this corridor. Given that these areas are less productive and are likely to have lower absorptive capacity, investments here will have an efficiency cost since they should yield more GDP if deployed elsewhere in China.

KEYWORDS
Belt & Road, China, DEA, regional policy, sub-national productivity

1 | INTRODUCTION

The Belt & Road Initiative has the potential to remake the economic geography of China, moving a lot of investment and economic activity to the western regions. Originally proposed by...
President Xi Jinping in 2013 under the “One Belt, One Road” banner, it has two major components. The “Silk Road Economic Belt” is designed to develop overland economic corridors through Central Asia to Europe, by building railways, roads, and oil and natural gas pipelines along the route. The “21st Century Maritime Silk Road” aims to expand the maritime shipping routes from China’s coast to Europe and elsewhere, through the South China Sea, the Indian Ocean, and the Pacific Ocean, by building ports and other coastal infrastructure along the routes. This improved transport infrastructure is meant to be accompanied by special economic zones for logistics and trade hubs and may also see manufacturing plants move closer to these key infrastructure corridors.

While academic studies on the Belt & Road Initiative are emerging, they typically focus on the implications for the international economic system and effects in the partner countries. For example, Huang (2016) considers if the Belt & Road Initiative is a self-defence for China against its possible exclusion from the Trans Pacific Partnership; Cheng (2016) considers which of the 60 or so countries covered in the Belt and Road Initiative will be the priority targets for economic cooperation with China, and Du and Zhang (2017) study acquisitions in Belt & Road countries by Chinese companies, finding that these rose faster than their merger and acquisition activity in other countries. Dellios (2017) studies the cultural underpinnings of the “win–win” discourse that China has used to explain her ambitions for the Belt and Road Initiative.

Yet it is likely to be internally that Belt and Road has the biggest effects. Many Belt and Road partner countries have poor sovereign credit ratings so there is considerable skepticism in China about investment returns for projects in these countries (Cai, 2017). The focus on key infrastructure is also a vulnerability, given separatist movements and political instability in the regions linking China to Europe and the Middle East. In contrast, China can proceed with Belt and Road projects within its own jurisdiction at a faster pace. This is especially because an economic motivation for the initiative is to deal with industrial sector overproduction, so there is already capacity in place to quickly build infrastructure. Thus, almost all of China’s provinces have proposed infrastructure plans and other investments related to the Belt and Road Initiative, partly to obtain cheap funding and political support from central government (Cai, 2017).

Although investment related to the Belt and Road is being proposed throughout most of China, it is particularly western regions of China that are expected to benefit:

*The OBOR [now Belt & Road] strategy is expected to help develop China’s vast western hinterland. The strategy will turn the western interior into the frontier in opening up to the world, development opportunities in the central and western regions will increase, and new growth points will emerge. Du and Zhang (2017, pp.3)*

This change in the location of economic activity is required, if Belt and Road is to be a break from business as usual. In other words, there must be some investment that will be directed to regions that otherwise would not receive it and some economic activity that will disperse to places where the market would not otherwise direct it, for Belt and Road to be a major change. Of course, trying to disperse economic activity is a long-term feature of economic planning in China; for example, the 1990 “City Planning Law” (Zhonghua Renmin Gongheguo Chengshi Guihua Fa) aimed at “strictly controlling the size of large cities and developing medium-sized and small cities” (Xu, 2009). While that planning law has been updated, with emphasis now on “eco-urbanization” (Wang, Deng, & Wong, 2016), it remains true that concentration of economic activity in China, historically, has been low, and even in the most recent
period, it is state-owned firms that are more spatially dispersed than the private firms (Brakman, Garretsen, & Zhao, 2017).

These efforts to disperse economic activity ignore the agglomeration benefits that result from firms and workers comoving to locations where they are most productive. These benefits have accrued in China despite unfavorable features like *hukou* that provide frictions to movements of the factors of production (Li & Gibson, 2015). Unsurprisingly, some commentators have noted the risk of intra-China reallocation of resources under Belt and Road being like the previous “Develop the West” initiative, which produced few tangible results (Cheng, 2016). In fact, because of heavy state subsidies, the western regions have unbalanced economies, with a high concentration of state-owned enterprises, with four of them (Xinjiang, Tibet, Qinghai, and Gansu) having the lowest scores on the China Economic Research Institute’s Free Market Index due to their low levels of private enterprise (Cai, 2017). More state-directed investment into these regions under the Belt and Road Initiative may further skew their economic structure.

The goal of this paper is to point out that there are costs of directing resources to locations where they would not naturally be pulled by the centripetal forces of agglomeration effects. It is too early to study impacts from Belt and Road, since to date it has mainly been speeches and plans. However, it is never too early to discuss the likely effect of carrying out a particular plan, using evidence from the past to back up the claims. Indeed, this is one way that research can help forward-looking policy makers to assess the likely costs of their plans.

We focus on the Northwestern China to Kazakhstan component of Belt and Road. This over-land route proceeds from Xi’an (the terminus of the original Silk Road) through to Khorgos on the China–Kazakh border, which has become China’s primary western gateway. There are 46 prefectural-level units in a corridor from there to Xi’an, and these spatial units should see more investment and economic activity from Belt and Road infrastructure building, as well as from any resulting trade flows and internal migration of people and firms. A diversion of economic activity towards these western areas is likely because a key outcome desired for the Belt and Road Initiative is that some of China’s exports will go west to markets in Europe and the Middle East, by land through Central Asia. Current exports are highly concentrated; eight of China’s coastal provinces account for 82% of exports, even though these provinces have just one third of China’s residents. Indeed, Guangdong alone provides one third of China’s goods exports. In contrast, the nine western and northwestern provinces, covering two thirds of China’s land area and home to 19% of China’s residents, contribute just 4% of China’s exports.1

The evidence from elsewhere is that changes in transport infrastructure can have major effects on the location of economic activity. For example, the development of canals and rail lead to the rise of Chicago, as the hub that linked concentrated and rising demand in the eastern United States (e.g., Boston, New York, and Philadelphia) with the new agricultural frontier in the Midwest. Chicago became the fastest growing city in the world, going from being only the 92nd largest city in the United States in 1840 (with just 1.4% of the population of New York City) to being the second largest city within 50 years (with 73.2% of the population of New York by 1890).

Panama Canal expansion in 2016 gives a modern example. Larger “post-Panamax” ships will tilt the entry point of many Asian imports from the West Coast of the United States to the East Coast. Currently, many containerized shipments enter West Coast ports, transload, and go via truck or train to their final destination. Bratton, Burke, Ulrich, Laxmana, and Raetz (2015)

---

1We use the term “provinces” to include Autonomous Regions, such as Xinjiang and Tibet. The eastern-most provinces in this group of nine are (from South to North) Yunnan, Sichuan, Shaanxi, and Inner Mongolia.
forecast that East Coast ports will gain a further 10% of market share for imports from Asia from the expanded Panama Canal, because larger ships will provide a lower overall transport cost. With this switch in the entry point for imports, some economic activity will move from the West Coast to the East Coast.

Likewise, if Belt and Road provides more overland trade for China, economic activity may relocate to western China from the coastal provinces that benefit from sea trade. This is especially because China’s economic geography has proved quite malleable; for example, prior to the reform beginning in 1978, some coastal provinces that are now amongst the richest, such as Fujian and Zhejiang, were in the second poorest quartile in terms of GDP per capita. Conversely, some that were in the richest quartile in the prereform era, such as Heilongjiang, are now well below the median level of income. This reshuffling reflects the change in location premia as economic activity oriented towards the world market.

While relocation of economic activity in China due to Belt and Road is likely, it may not be efficient. Our prospective analysis shows that the 46 likely-to-be-affected prefectural-level units in the Xi’an to Khorgos corridor are smaller, more administratively and ethnically diverse, and have higher outmigration rates than is typical for the 311 prefectural-level units in the rest of China. They also are poorer than average, with GDP per capita just two thirds of what is observed elsewhere. Of course, just because an area is poor does not mean that investment should go elsewhere; it could be a “poor but efficient” area which is constrained in the availability of inputs, and so investment in this poor area could bring high rates of return.

At least in the recent past, the “poor but efficient” characterization does not seem to apply to the Xi’an to Khorgos corridor. According to Data Envelopment Analysis (DEA)-based productivity estimates, these areas are less efficient at converting labor and capital into GDP than elsewhere in China. Compared with the frontier efficiency of 1.0 (and the mean efficiency of about 0.5), the efficiency scores in these areas are 0.13 to 0.17 lower. This lower efficiency seems to be intrinsic to this corridor area, rather than due to their observable characteristics (such as being smaller or poorer) because there is no similar efficiency gap for a matched set of regions elsewhere in China that have similar observable characteristics. Given that these areas in the Xi’an to Khorgos corridor are less productive, resources allocated there are likely to have a high opportunity cost, in the sense that they would yield more GDP elsewhere. Whether the international strategic benefits for China of the Belt and Road Initiative outweigh these intranational efficiency costs is a key question for evaluating the overall impact of this major regional development policy.

2 | THE BELT AND ROAD INITIATIVE

In a speech at Nazarbayev University, Kazakhstan in September 2013, President Xi Jinping proposed the concept of jointly building the “Silk Road Economic Belt”. This would connect China to Europe, through Central Asia. A month later, when addressing the Indonesian Parliament, he called for the creation of the Asian Infrastructure Investment Bank and proposed the “21st Century Maritime Silk Road” which would connect the Southeast Asian region to China’s southern provinces through ports and railways.

These later became officially known as the “One Belt, One Road” initiative, and later still, simply the “Belt and Road Initiative”. The changing nomenclature recognizes the fact that, like the old silk road, there is more than one route (Dellios, 2017). Indeed, the Silk Road Economic Belt has three broad routes, one terminating at the Baltic, one going to the Persian Gulf and the
Mediterranean, and one going to the Indian Ocean, while the Maritime Silk road has one arm that goes to Africa and Europe and another going down to the South Pacific. In addition to routes and countries covered by the Belt and Road, two existing “economic corridors” for China–Pakistan and Bangladesh–China–India–Myanmar are also to be closely coordinated with the new initiative.

Following on from these speeches, at the 12th National People’s Congress in 2014, Premier Li Keqiang called for the “intensification of the planning and building a Silk Road Economic Belt and a 21st Century Maritime Silk Road” in the Report on the Work of the Government. In March 2015, under State Council authorization, the National Development and Reform Commission and the Ministry of Foreign Affairs and Ministry of Commerce of the People’s Republic of China jointly issued the “Visions and Actions on building the Silk Road Economic Belt and the 21st Century Maritime Silk Road”. More recently, in October 2017, the 19th National Congress of the Communist Party of China (which meets just twice a decade), amended the Party constitution to add “pursue the Belt and Road Initiative” to its charter (along with the possibly incompatible call to “let the market play a decisive role” in the economy).

In addition to these high-level visions, state-owned financial institutions like the China Development Bank have pledged around US$ 1 trillion for projects related to the Belt and Road Initiative (Cai, 2017). There is also a US$40 billion Silk Road Fund to encourage private sector investment (Dellios, 2017). Finally, a considerable amount of sectoral activity is also taking place, which does not necessarily rely on centralized funds, such as the Universities Alliance of the New Silk Road, headquartered at Xi’an Jiaotong University.

Despite these impressive figures, few projects have made much progress. One problem is that nearly two thirds of countries covered by the Belt and Road Initiative have sovereign credit ratings that are below investable grade, so there is considerable risk for the Chinese banks that invest in projects in these countries (Cai, 2017). This investment risk issue is not helped by the fact that, according to Huang (2016), most Chinese outward Foreign Direct Investment projects are not profitable. For this reason, the Chinese domestic components of Belt and Road projects likely will be built before the foreign components, since Beijing can enforce its plans much more effectively within its own jurisdiction (Cai, 2017). Our focus on intranational comparisons, contrasting productivity of the parts of western China most likely to be affected by Belt and Road activity with the rest of China, is informed by this key point, that one should look for more immediate effects domestically.

3 | DATA AND DESCRIPTIVE COMPARISONS

Our sample is all prefectural-level units in China. The administrative structure in the 2010 census has 363 such units: 287 prefectural cities, 30 autonomous prefectures, 17 autonomous regions, three leagues, 14 provincially administered county-level cities, and 12 provincially administered counties. Compared with 10 years earlier, at the previous census, one prefectural city, four provincially administered county-level cities, and one county had been upgraded (and so data on these new spatial units is not separately reported in 2000). In order to have comparability over time, in the 2010 data, these newly upgraded units are merged back into the

---

2Including the four province level municipalities, Beijing, Tianjin, Shanghai, and Chongqing.

3In the merging process, value data, for example, population, GDP, capital, employment, are simple summations, while data on rates, ratios, and proportions are weighted averages based on the resident population of constituent units.
prefectural-level units they belonged to in 2000. In the reverse process, one provincially adminis-
trated county and one autonomous prefecture in 2000 had been downgraded by 2010, and so their
data for 2000 are merged in with the prefectural-level unit that engulfed them by 2010. After this merging process, we have a spatially consistent sample of 357 prefectural level units for both 2000 and 2010.

We restrict our attention to 2000 and 2010, which are the most recent years with population census data. While Chinese statistical yearbooks have a wealth of annual data, the population data (and therefore per capita variables) in these yearbooks only have counts of people who have hukou registration from those localities, rather than counts of people who actually reside in each place. This introduces large biases, which vary over time and space, into measures based on per capita data (Li & Gibson, 2013) and also affects series based on employment numbers, which are also miscouunted in the annual yearbooks (Gibson & Li, 2017). Only census years have subnational data on resident population and total employment that are reliable. We are interested in measures in terms of shares of population, such as ethnic group shares and urbanization rates, and in regional income in per capita terms, and total employment for the productivity analysis, so the most reliable results come from restricting attention to years with population census data.

In order to identify prefectural-level units that are most likely to be affected by Belt and Road activity, we study the corridor between Xi’an and Khorgos, on the China–Kazakh border. Khorgos is 670 km west of Urumqi and 300 km east of Almaty and is near the Eurasian Pole of Inaccessibility (the point on land furthest from any ocean). Until recently, only a few thousand people lived there. However, Khorgos has become China’s primary New Silk Road gateway and was recently upgraded to city status, with a planned population of 200,000. A key loca-
tional advantage for Khorgos is that this is where containers are trans-shipped from one train to another, which is needed because the track gauge in Kazakhstan (and throughout the former Soviet Union) is about 4 in. wider than the international gauge used for railways in China and Europe. It is expected that the Khorgos facilities will eventually handle 0.5 million containers per year, although current trade volumes are only about 70,000 containers (Shepard, 2017).

We construct a 200 km-wide buffer between Xi’an and Khorgos and any prefectural unit that intersects this is part of our “treatment” group of the areas that are likely to be affected by extra economic activity that overland trade will generate. This group of 46 prefectural-level units includes 29 prefectural cities (20 in 2000), 16 autonomous regions, prefectures and leagues (25 in 2000), and one provincially administered county-level city. If we have made this buffer too large, we will be biased towards finding smaller differences between the prefectural units in the treatment group and the prefectural units in the rest of China. This conservative stance for the analysis is appropriate, given the uncertainty about how Belt and Road developments will actually unfold. Figure 1 provides a map of the two groups of spatial units.

We use three main data sources: the City Statistical Yearbooks (CSY) that cover 2000 and 2010 (NBS, 2001a, 2011a), the Provincial Statistical Yearbooks that cover those years (NBS, 2001b, 2011b), and the 2000 and 2010 Population Census (NBS, 2003, 2012). We need the provin-
cial yearbooks because CSY only compiles data for prefectural cities, with information on the other types of prefectural-level units found in the provincial yearbooks. For the efficiency

There were also 23 leagues, regions, and autonomous prefectures in 2000 upgraded to prefectural city status by the time of the 2010 census. These do not change the number of, or matching of, observations from 2000 to 2010.

These are in terms of 20 foot-equivalent units (TEUs). By way of contrast, the largest container port in the world, Shanghai, handles about 32 million TEUs per year.
analysis, we need data on GDP, labor (employment), and capital; these variables are listed in the CSY and provincial yearbooks, but these employment data omit most private sector workers since their firms do not report directly to the statistical authorities, unlike enterprises from formerly planned economy sectors (Li & Gibson, 2015). Instead, we use the “long form” census data, which is for a random sample of 10% of the population, and has comprehensive all-sector employment and occupation data (which is not in the short form census). The monetary values of GDP and of capital are inflated to 2010 prices, using the provincial annual consumer price index and provincial annual fixed capital price index from various issues of the China Statistical Yearbook.

The descriptive statistics for labor, capital, and output are reported in Table 1. The average employment in the likely-to-be-affected prefectural-level units is just over one million, while it is double that in prefectural-level units elsewhere. While labor input only rose 6%–7% from 2000 to 2010, the real value of fixed capital rose to be 4.8 times as high in 2010 as in 2000 in the corridor from Xi’an to Khorgos, while it rose to be 4.4 times as high elsewhere. This increase in capital saw the corridor area switch from below average levels of capital per worker to above average, following the trend noted by Cai (2017) of a large involvement of state-owned enterprises (that tend to concentrate on capital-intensive heavy industry) in western China. The value of real output per worker in 2010 rose to be 4.5 times as high as in 2000 in the likely-to-be-affected units, slightly more than the rise to be 4.2 times as high in the rest of China. Real output per worker in the corridor that is likely-to-be-affected is just 65% to 70% of what prevails elsewhere.

The likely-to-be-affected areas have a smaller resident population, in line with their smaller workforce, averaging two million residents, compared with four million elsewhere. Their resident population has also grown more slowly, increasing by just over 7% in the intercensus

---

Our capital variable is firms’ existing fixed capital stock, which is directly reported in CSY and is available as a difference (between total capital and flowing capital) in the provincial yearbooks.
period, while in the rest of China, the population increase was by almost 10%. This slower population growth is an unfavorable feature because, from 2020, China faces headwinds from a “demographic debt” that will lower economic growth rates, due to unfavorable population structure, as the flipside of the “demographic dividend” that contributed about one quarter of the economic growth over the last three decades (Cai & Lu, 2016). The Xi’an to Khorgos corridor already had a larger, favorable, age structure change than did the rest of China, with the share of the population of working age rising 6.2% from 2000 to 2010, compared with 4.3 percentage points in the rest of China, so any “demographic dividend” effects in this region will have well and truly run their course by 2020 and will be expected to be reversing.

It is somewhat surprising that the population increase in the Xi’an to Khorgos corridor has been so low. The population in this area is characterized by having a higher rate of ethnic minorities (approximately 14% versus 8% in the rest of China) and is less urbanized (with an urbanization rate about 7% below the rest of China in both 2000 and 2010), and so, all else the same, it might be expected to have higher population growth rates since family planning restrictions were less binding on minority and rural households (Liang & Gibson, 2017). As discussed below, a likely cause of the slower population growth is migration, with people (on net) voting with their feet to leave the area. These migration decisions suggest that residents saw better economic prospects elsewhere in China.

A theme in discussion of some western areas, such as Xinjiang, is in-migration of the Han majority group from other areas in China. Yet despite this, the likely-to-be-affected prefectural-level units had higher rates of out-migration between 2000 and 2010 than elsewhere, based on the comparison of the resident population (a de facto concept) and the hukou-registered population from these areas (a de jure concept). On average, in the rest of China, the population with hukou registration was 0.28% higher than the resident population, at the time of the 2010 census, which is the expected pattern because the army and overseas Chinese maintain hukou but do not count in the resident population. However, in the Xi’an to Khorgos corridor, the hukou-registered population was 1.2% higher than the resident population, which is consistent with a net out-migration from the area (especially because the proportionate gap between de jure and de facto populations was the same as elsewhere in China at the time of the 2000 census).

The diversity of administrative structures in China and the ability of central government to upgrade and downgrade particular areas has already been alluded to. It is worth noting that the Xi’an to Khorgos corridor is marked by a high level of administrative diversity; only 44% of the spatial units at the time of the 2000 census were prefectures, with the rest as autonomous regions, leagues, provincially-administered units, and so forth, while in the rest of China over three quarters of the units had prefectural status at the time. A rapid prefecturalization process

### TABLE 1 Descriptive statistics for labor, capital, and output of prefectural-level units, China 2000 and 2010

|                          | Likely-to-be-affected prefectural units | Prefectural units in the rest of China |
|--------------------------|----------------------------------------|----------------------------------------|
|                          | 2000        | 2010        | 2000        | 2010        | 2000        | 2010        |
| Employment (ten thousands) | 103.3 (78.9) | 109.4 (86.9) | 199.7 (161.3) | 213.9 (178.3) |
| Fixed capital (million yuan, 2010 prices) | 0.747 (0.797) | 3.565 (3.352) | 1.570 (2.803) | 6.887 (9.833) |
| GDP (million yuan, 2010 prices)       | 1.027 (1.141) | 4.875 (5.298) | 3.065 (4.274) | 13.619 (19.545) |

Note: Standard deviations in (). There are \( n = 357 \) prefectural-level units in total, with 46 in the likely-to-be-affected areas and 311 elsewhere in China.
meant that by the 2010 census, 63% of the administrative units in the Xi’an to Khorgos corridor had prefecture status, but this was still 20% lower than in the rest of China. Having prefecture status gives more power to local governments (e.g., controlling counties under them and being able to transfer rural areas into urban areas) so leaders at this administrative level are likely to have more capacity and autonomy. Thus, the large share of nonprefecture units in the Xi’an to Khorgos corridor may indicate limits on the absorptive capacity for handling large public investments.

The final descriptive comparison we make, before going on to the productivity analysis, is for GDP per capita. The areas in the corridor between Xi’an and Khorgos likely to be affected by Belt and Road are considerably poorer than the rest of China. In 2010, the GDP per resident in the likely-to-be-affected areas averaged about 24 thousand yuan (US$3,500) while elsewhere in China the average was over 34 thousand yuan (Figure 2). In other words, average per capita income in the Xi’an to Khorgos corridor was just 70% of what it was in the rest of China. This was a slight rise from the year 2000, when the average was 65% of that elsewhere. Having an average per capita GDP of just two thirds of that elsewhere is consistent with the out-migration noted above, since workers will vote with their feet (to the extent that they can overcome mobility barriers) and move to the areas where they believe pay is higher (reflecting higher productivity).

4 | DATA ENVELOPMENT ANALYSIS OF PRODUCTIVITY DIFFERENCES

Lower levels of GDP per capita in the areas likely to be affected by Belt and Road activity in western China do not necessarily imply inefficiencies in that region; it could simply be that these areas are constrained in their inputs of labor and capital. However, the existing, provincial level, evidence does not favor this poor but efficient hypothesis, given that inland regions of China exhibit lower total factor productivity TFP and slower growth in total factor productivity than in coastal provinces (Laurenceson & O’Donnell, 2014). This evidence uses DEA; a nonparametric linear programming method introduced by Farrell (1957) for assessing efficiency and

![Figure 2](https://ssrn.com/abstract=3188461)
productivity of decision-making units (DMUs), who may either be firms or administrative units. In this section, we report on a prefectural-level DEA, using the labor, capital, and GDP data that are summarized in Table 1. Our interest is in seeing whether the Xi’an to Khorgos corridor less efficiently creates GDP from labor and capital than occurs elsewhere in China, and we report results for 2 years (2000 and 2010) to check if we are finding stable patterns.

The advantages of DEA are that it does not require any assumptions about the functional form of the relationships between inputs and outputs or about the distribution of the random errors in regression equations and their independence from explanatory variables. Thus, the DEA method needs fewer assumptions than either the stochastic frontier approach or the growth accounting approach to measuring productivity (Laurenceson & O’Donnell, 2014). Amongst the minimal assumptions that DEA does rely upon are “strong disposability” of inputs and outputs, where an increase in inputs cannot reduce output (e.g., due to congestion effects), and that production possibility sets are convex; this means that if two or more DMUs are found to produce certain amounts of output using certain sets of inputs, it is technically possible to produce any convex (weighted-average) combination of the input–output bundles. The particular DEA method used here also assumes constant returns to scale (Charnes, Cooper, & Rhodes, 1978); a DMU that produces a certain quantity of outputs using certain quantities of inputs could produce a scalar multiple of its outputs using the same scalar multiple of each input.7 DEA is also based on variables being measured without error, and this is plausible in the current setting because we use full census enumerations to measure labor input rather than relying on annual employment data that miss many workers in China, especially in the private sector (Li & Gibson, 2015). While the accuracy of data on capital stocks may be debated, the difficulties in measuring capital are common to all approaches to assessing economic efficiency.

We use an input-oriented DEA, which examines the fraction by which inputs (labor and capital) can be reduced with output (GDP) fixed. In other words, we estimate if the GDP produced by each prefectural-level unit could be produced from proportionately less of each input, from the standpoint of the frontier that is formed by using linear programming to envelop the observed input–output vectors of all of the prefectural-level units. Thus, it is a relative efficiency measure, in the sense that it is benchmarked against the prefectural-level units that are the most efficient (they tend to be coastal prefectures), with scores less than one indicating inefficiency.

A simple example for a two-input, one-output technology with five decision-making units is given in Figure 3. In this example, two of the units (#1 and #4) are on the frontier formed by enveloping the points for the input and output ratios that are closest to the origin. The other three units use more input per unit of output than is required on the frontier formed by the convex-combination of the two most efficient units. Each of the inefficient units could contract along a ray from the origin, which keeps their ratios of inputs the same, to a projected point on the frontier (shown by the pink dots). For example, #5 could reduce the ratios of $x_1/q$ and $x_2/q$ by 0.5, which is the technical efficiency score for this unit.8

The efficiency scores are (upper) bounded by one, so comparing scores between groups of DMUs requires accounting for this truncation. The efficiency estimates for different DMUs also are correlated by construction (from the linear programming problem). In the results below, we use the DEA algorithm provided by Ji and Lee (2010). In the second stage we use a Tobit model and a bootstrapping procedure from Simar and Wilson (2007) that accounts for these features when testing for statistical significance of any differences between the prefectural-level units.

7Allowing for variable returns to scale does not change the results reported below.
8For #2, the efficiency score is 0.71, and for #3, it is 0.83.
that are likely to be affected by Belt and Road activity in western China and those in the rest of China.

In Figure 4, we show the mean relative efficiency scores, in both 2000 and 2010, for the prefecral-level units in the Xi’an to Khorgos corridor and for the units in the rest of China. Roughly speaking, state-directed resources deployed into the Xi’an to Khorgos corridor might be expected to produce more than twice as much GDP if they, instead, went to the most productive locations in China, based on the patterns existing in 2000 and 2010. A further concern with the results in Figure 4 is that China is becoming relatively less efficient at turning labor and capital into GDP; in the Xi’an to Khorgos corridor the mean efficiency scores fell from 0.39 to 0.36, while elsewhere they fell from 0.53 to 0.42.

FIGURE 4 Mean relative efficiency scores from Data Envelopment Analysis: Xi’an to Khorgos corridor and the Rest of China, 2000 and 2010

There are five observations with missing data, so the sample size reduces to 352 (46 in the Xi’an to Khorgos corridor and the remainder in the rest of China).
In Table 2, we report tests of the hypothesis that the efficiency scores in the Xi’an to Khorgos corridor are the same as those elsewhere in China, where our methods account for the relative efficiency scores being bounded at one. Whether using a Tobit model or the Simar–Wilson approach, there is a statistically significant 13 point gap in efficiency scores in 2010, between the units in the Xi’an to Khorgos corridor and those in the rest of China. This gap is not a one-off feature because in 2000, the gap was from 17 to 18 points. If we consider a “difference-in-difference” approach where we test for a change over time in the gap, there is no significant difference ($t = 1.20, p < .23$) in the two periods. Thus, it appears to be at least a medium-term feature that the efficiency of producing GDP in the Xi’an to Khorgos corridor is lower than elsewhere in China.

This lower efficiency appears to be an intrinsic feature of the Xi’an to Khorgos region and is not just due to the characteristics of the DMUs, such as their smaller size and lower income level. We calculated propensity scores, based on GDP per capita, the urbanization rate, the growth rates for population and for GDP and indicators for the type of administrative unit. For the 46 units from the rest of China that are most like those in the Xi’an to Khorgos corridor (i.e., they had the highest propensity scores), we tested to see if their efficiency was equal to elsewhere, and the null hypothesis could not be rejected ($t = 1.20$, for a five point difference in efficiency scores).

### Table 2

Differences in efficiency scores (prefectural-level units likely to be affected compared with the rest of China)

|                | Tobit | Simar–Wilson | Tobit | Simar–Wilson |
|----------------|-------|--------------|-------|--------------|
| Census 2000    | −0.183 (0.03) | −0.170 (0.04) |       |              |
| Census 2010    | −0.126 (0.03) | −0.127 (0.04) |       |              |

Note: $N = 352$ (46 in the likely-to-be-affected group and 306 elsewhere). Bootstrapped standard errors in (). Coefficients show differences in Data Envelopment Analysis relative efficiency scores between prefectural-level units likely to be affected by Belt and Road and elsewhere, taking account of the bounding of the efficiency scores at a maximum of one.

In Table 2, we report tests of the hypothesis that the efficiency scores in the Xi’an to Khorgos corridor are the same as those elsewhere in China, where our methods account for the relative efficiency scores being bounded at one. Whether using a Tobit model or the Simar–Wilson approach, there is a statistically significant 13 point gap in efficiency scores in 2010, between the units in the Xi’an to Khorgos corridor and those in the rest of China. This gap is not a one-off feature because in 2000, the gap was from 17 to 18 points. If we consider a “difference-in-difference” approach where we test for a change over time in the gap, there is no significant difference ($t = 1.20, p < .23$) in the two periods. Thus, it appears to be at least a medium-term feature that the efficiency of producing GDP in the Xi’an to Khorgos corridor is lower than elsewhere in China.

This lower efficiency appears to be an intrinsic feature of the Xi’an to Khorgos region and is not just due to the characteristics of the DMUs, such as their smaller size and lower income level. We calculated propensity scores, based on GDP per capita, the urbanization rate, the growth rates for population and for GDP and indicators for the type of administrative unit. For the 46 units from the rest of China that are most like those in the Xi’an to Khorgos corridor (i.e., they had the highest propensity scores), we tested to see if their efficiency was equal to elsewhere, and the null hypothesis could not be rejected ($t = 1.20$, for a five point difference in efficiency scores).

### 5 CONCLUSIONS

China is attempting to open a new, land-based, frontier as part of the Belt and Road Initiative. This may reshape China’s economic geography, by increasing economic activity in the western regions. The coordination with partner countries to create long-distance infrastructure corridors and related logistics hubs is a new feature, but the general thrust of trying to increase economic activity in the west has been a feature of China’s regional policy for two decades. These policies can also be seen as part of the effort to disperse economic activity, for both political and military reasons, and to limit the size of the largest agglomerations, and these were long-standing features of the centrally planned era.

In this paper, we examined one component of the Belt and Road Initiative, by focusing on the Xi’an to Khorgos corridor that is a key segment of the Silk Road Economic Belt. The prefectural-level spatial units in this corridor have smaller populations, are less urban, are more ethnically diverse, and are administratively more varied than is true of other parts of China. These areas also have a slower growing resident population, and despite the widely noted inflows of Han Chinese from other areas, this corridor area experienced net out-migration between 2000 and 2010. One possible reason for this voting with the feet is that average income levels in this area are much lower than elsewhere, and there is only a slow catch-up. Moreover, these areas...
appear to be less efficient at transforming labor and capital into GDP than is true of other parts of China, with a significant gap in their efficiency scores in the DEA results. Thus, any state-directed reallocation of resources to favour this region will have a high opportunity cost, since these inputs would have yielded more GDP if they were deployed to other areas of China.

We have only been able to carry out a prospective analysis, due to the early stage of Belt and Road activity in China. Yet the likely costs from directing resources away from agglomerations to create a new frontier should be considered in future evaluation of the Belt and Road. This is especially because the internal components are likely to be constructed well before the external ones are in place.

ACKNOWLEDGEMENTS

We are grateful to Geua Boe-Gibson and Xiangzheng Deng for assistance with the analysis and to two anonymous reviewers and to participants at the Shanghai Forum and the North American RSAI meetings for helpful comments.

ORCID

John Gibson http://orcid.org/0000-0003-3886-6873

REFERENCES

Brakman, S., Garretsen, H., & Zhao, Z. (2017). Spatial concentration of manufacturing firms in China. Papers in Regional Science, 96(S1), 179–205.

Bratton, J., Burke, D., Ulrich, P., Laxmana, S., & Raetz, S. (2015). Wide open: How the Panama Canal expansion is redrawing the logistics map. Boston Consulting Group. Accessed May 20, 2016. https://panamacanal.salini-impregilo.com/static/upload/bos/bostongrouponpanamajune2015.pdf.

Cai, F., & Lu, Y. (2016). Take-off, persistence and sustainability: The demographic factor in Chinese growth. Asia & the Pacific Policy Studies, 3(2), 203–225.

Cai, P. (2017). Understanding China’s belt and road initiative. Lowy Institute for International Policy, Sydney. https://www.lowyinstitute.org/publications/understanding-belt-and-road-initiative

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 2(6), 429–444.

Cheng, L. (2016). Three questions on China’s “Belt & Road Initiative”. China Economic Review, 40(1), 309–313.

Dellios, R. (2017). Silk roads of the twenty-first century: The cultural dimension. Asia & the Pacific Policy Studies, 4(2), 225–236.

Du, J., & Zhang, Y. (2017). Does One Belt One Road initiative promote Chinese overseas direct investment? China Economic Review (Forthcoming) Doi: https://doi.org/10.1016/j.chieco.2017.05.010, 47, 189–205.

Farrell, M. J. (1957). The measurement of productive efficiency. Journal of the Royal Statistical Society. Series a (General), 120(3), 253–290.

Gibson, J., & Li, C. (2017). The erroneous use of China’s population and per capita data: A structured review and critical test. Journal of Economic Surveys, 31(4), 905–922.

Huang, Y. (2016). Understanding China’s Belt & Road Initiative: Motivation, framework and assessment. China Economic Review, 40(1), 314–321.

Ji, Y. B., & Lee, C. (2010). Data envelopment analysis. The Stata Journal, 10(2), 267–280.

Laurenceson, J., & O’Donnell, C. (2014). New estimates and a decomposition of provincial productivity change in China. China Economic Review, 30(1), 86–97.
Li, C., & Gibson, J. (2013). Rising regional inequality in China: Fact or artifact? *World Development, 47*(1), 16–29.

Li, C., & Gibson, J. (2015). City scale and productivity in China. *Economics Letters, 131*(1), 86–90.

Liang, Y., & Gibson, J. (2017). Location or *Hukou*: What most limits fertility of urban women in China? *Asia & the Pacific Policy Studies, 4*(3), 527–540.

National Bureau of Statistics (NBS) (2001a). *China City statistical yearbook 2001* (Zhongguo Chengshi Tongji Nianjian 2001). Beijing: China Statistics Press.

National Bureau of Statistics (NBS) (2001b). *Provincial statistical yearbook 2001* (individual issue for each of the 31 provinces). Beijing: China Statistics Press.

National Bureau of Statistics (NBS) (2003). *Tabulation on the 2000 population census of the People’s Republic of China by county* (Zhongguo 2000 Nian Renkou Pucha Fenxian Ziliao). Beijing: China Statistics Press.

National Bureau of Statistics (NBS) (2011a). *China City statistical yearbook 2011* (Zhongguo Chengshi Tongji Nianjian 2011). Beijing: China Statistics Press.

National Bureau of Statistics (NBS) (2011b). *Provincial statistical yearbook 2011* (individual issue for each of the 31 provinces). Beijing: China Statistics Press.

National Bureau of Statistics (NBS) (2012). *Tabulation on the 2010 population census of the People’s Republic of China by county* (Zhongguo 2010 Nian Renkou Pucha Fenxian Ziliao). Beijing: China Statistics Press.

Shepard, W. (2017). Khorgos: The new silk road’s central station comes to life. *Forbes* February 20, 2017. https://www.forbes.com/sites/wadeshepard/2017/02/20/khorgos-the-new-silk-roads-central-station-comes-to-life/#68d52a83c22e

Simar, L., & Wilson, P. W. (2007). Estimation and inference in two-stage, semi-parametric models of productive efficiency. *Journal of Econometrics, 136*(1), 31–64.

Wang, Z., Deng, X., & Wong, C. (2016). Integrated land governance for eco-urbanization. *Sustainability, 8*(9), 903–919.

Xu, Z. (2009). Productivity and agglomeration economies in Chinese cities. *Comparative Economic Studies, 51*(3), 284–301.

**How to cite this article:** Gibson J, Li C. The “Belt and Road Initiative” and comparative regional productivity in China. *Asia Pac Policy Stud.* 2018;5:168–181. [https://doi.org/10.1002/app5.237](https://doi.org/10.1002/app5.237)