行政院國家科學委員會專題研究計畫　成果報告

清朝末年台灣基礎交通建設南北間的差異

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1. Introduction

This project was an attempt to describe and explain the north-south differences in Taiwan's late-Ch'ing Dynasty transportation network. Statistics compiled by the Japanese in 1899 showed that the transportation infrastructure of north Taiwan was much superior to that of south Taiwan. I have used the data collected by the Japanese and also compiled data from gazetteers and *pei* inscriptions to confirm that southern transportation was less developed and to try to explain why. I have identified a few contributing factors to transportation differences: mainly the greater density of the rural population in the north and the lower interest rates faced. Most of the difference, however, still remains unexplained. This research has failed to directly generate a publishable paper but, as explained in the conclusions, it provides a good foundation for further research.

2 Roads and Bridges in Late-Ch'ing-Dynasty Taiwan

2.1 The General State of Taiwanese Ground Transportation

Western visitors criticized the state of ground transportation throughout the Ch'ing Empire and Taiwan was no exception. Naturalist Joseph Beal Steere visited Taiwan in 1873-1874 and described the road from Tainan to Chiayi as a path that "went winding about among the rice fields." There were a few simple bridges close to towns, but most streams had to be forded or crossed by means of a small ferryboat (Steele 26-27). In general, he describes the situation in Taiwan thus: "[The] lack of any system by which works for the public good can be planned and carried out is the reason that there are no public roads worthy the name in the island. Foot paths run out a mile or two from the larger towns, rudely paved with flat stones. At the end of the pavement there is often a tablet set up with the names of those who have given money for the work, so that the passers by may recognize their public spirit" (Steele 124). The British customs report for Takow in 1875 states, "the main traffic from the south to the capital of the island passes over paths one foot and less broad, through paddy fields and for short distances over cart roads. The latter during the whole summer or rainy season are nothing less than river beds draining the surrounding fields of superfluous water, and requiring foot passengers at some places to wade up to the waist in water (Huang, Lin and Ang, vol. 1, 202). James Davidson described Taiwan's ground transportation on the eve of the Japanese occupation as follows: "In the south there were a few stretches of heavy road passing through the sugar fields and suitable for buffalo carts; but these roads were for the convenience of the sugar growers, and could scarcely be called public highways. In other parts of the island, with few exceptions, roads were practically non-existent. Rice fields are

divided into small plots separated by an artificial earth ridge which presents a surface sometimes not over a foot in width. These ridges were frequently the only highways; and consequently travel, other than on foot or by chair, was impossible" (Davidson 619).
The Japanese made their first survey of Taiwan's road system in 1899. They found 6734.45 km of road and and 1378 bridges. They did not count paths between paddies as roads but 70% of the so-called roads they identified were less than 1.8 meters in width and most bridges were no wider. In quite a few of the 堡 and 里 (townships) into which Taiwan was divided, they found no roads or bridges. Within 10 years, they almost doubled road mileage and more than quadrupled the number of bridges, vastly improving the quality of both.

2.2 Factors Limiting Ground Transportation in Taiwan

To some extent, the lack of roads and bridges in Taiwan might be ascribed to a lack of demand. During the early part of the Japanese era when transportation was quickly improving, Taiwan was moving from a society of self-sufficient farmers to a market-based economy. This may have caused the increasing investment in transportation but it may have also been caused by better transportation. The direction of causality in this relationship is an interesting question but not one addressed in this project. During the Ch'ing dynasty, land transportation was primarily based on coolie labor (as it was on the mainland). Again, one could argue that the use of coolies rather than animal power was due to the lack of good roads and bridges, but it is also possible that there were other constraints on the use of animals for transportation, such as restraints on fodder production, and this led to a low demand for good roads since coolies could use simple paths.
There were also serious supply-side problems facing Taiwanese ground transport projects. The Taiwanese plain running along the strait where most of the population was settled was cut by broad boulder-strewn flood plains that periodically carried floods of water down from the mountains. The high cost of bridging these flood plains made such projects completely uneconomical given the late-19th-century economy and the existing technology. An attempt to bridge one of these flood plains was made in 1870 at an enormous cost and resulted in the construction of a bridge that lasted less than a year before being washed away. The inability to bridge such flood plains meant that ground-based transportation of goods was only used for short distances, usually to the nearest harbor.
Another supply-side problem, from the point of view of the populace, was the government's attitude toward transportation. The Japanese claimed that the Ch'ing government actively discouraged the construction of roads and bridges since they feared transportation improvements would be used by bandits (臺北廳御編纂, 459). The Japanese probably exaggerated the Ch'ing's obstructionist tendencies but there is evidence that bridges sometimes became the focal point of banditry (臺灣銀行經濟研究室 (1962), 53). Most

Ch'ing officials were probably pro-status-quo as far as transportation was concerned. They only served in Taiwan a short while and had little to gain from long-run economic growth which would occur after they had left. There concern was to keep the island quite and new transportation improvements could stir up problems. Although a new bridge might help the economy generally, it would produce both winners and losers as new cross-river competitors could now enter a market. Farmers who used the new bridge to get their goods to a market would gain, but those farmers who did not use the bridge would now face new competition. Finally, there was the problem of capital cost. Interest rates were very high in Ch'ing-dynasty Taiwan and roads and bridges required a great deal of capital.

2.3 How Roads and Bridges Were Supplied

In spite of a generally unhelpful attitude toward transportation improvements generally, Ch'ing officials did sometimes involve themselves in building roads and bridges. There was one relatively well maintained north-south highway with endowed free ferry service at the main river crossings which was supervised by the government. This road was maintained mainly for military purposes and had to be relatively wide since it was used by government horses. Government officials also supported the building of some bridges especially in, and around, Tainan City. A cynical view of this activity suggests that the bridges were built primarily for show, not to meet any clear demand, and that more care was used constructing the monumental marker which recorded the official's merit than was actually expended on the bridge. In any case, the great majority of roads and bridges were local undertakings, neither funded nor ordered by officials (e.g. 何培夫 makes this clear).

The best descriptions of how roads, bridges and ferries were built and maintained come from the inscriptions on the monumental markers (碑) that sometimes accompanied transportation projects. These inscriptions must be treated with caution, however, because 碑 inscriptions survive for less than 2% of the transportation projects and this sample is not representative. The bigger the project the more likely an inscription survives. Small projects often had no marker, or only a wooden marker which quickly rotted. Many markers only listed the name of the project, the date it was carried out, the names of those who had given money for the project and the amount they gave. Those giving money were not necessarily individuals: businesses, guilds and temples also figured prominently in many lists. The money given was called a donation, but donations were not always completely voluntary. Local governance was informal and one's status in the community, partly determined by one's donations to such projects, determined the rights and obligations one had in the community. Sometimes markers also listed a person's title or place of residence. More descriptive markers might give additional information such as a record of expenditures, the names of the project's directors, a description of what was built, a short history of what was being rebuilt,

the reason for building or rebuilding the project, etc. Some markers (roughly 30%) offer only description with no donor list. In general, transportation markers were very similar to temple markers and the process of gathering funds to construct a bridge was probably very similar to gathering funds for a local temple. The two major post-war marker-inscription-collection projects found 25 inscriptions for bridges, 4 inscriptions for roads and 2 inscriptions for ferries in late-Ch'ing Taiwan (1862-1895, the T'ong-chih and Kuang-hsu reign periods). The number of donors in the 21 projects with donor lists ranged from 18 to 124 with an average of about 45. This was little over half the average number of donors per project in earlier times (臺灣銀行經濟研究室 (1962, 1966), 臺北市文獻委員會, and 何培夫).

3. North-South Differences in Ground Transportation

3.1 The Early Japanese Data

The focal point of this project is to describe and explain the north-south differences in transportation. Earlier work has shown that there were significant differences between Taiwanese north and south of the *Chuo-Shuei-Hsi.* The population in the south had a higher death rate and was shorter in stature. While population was growing in the north, it was shrinking, or at best, stagnating in the south. In local financial markets, southerners faced a higher interest rate, probably due to a higher risk premium. Partly, as a result of this, they were less likely to irrigate their land.

When the Japanese came to Taiwan in 1895, they found fewer roads and bridges per square kilometer in the south than in the north. As shown in the figures, when they first began compiling statistics in 1899, there were only 54% as many roads per square kilometer in the south as in the north and only 21% as many bridges. By the early 1910s, Japanese investment had partially corrected this imbalance so that the south then had roughly 70% as many public roads and 60% as many public bridges. Besides government investment, private sugar companies also invested heavily in southern transportation infrastructure so that the difference had narrowed even more if one includes light rail and light rail bridges in the statistics. The fact that Japanese investment narrowed the differences so quickly suggests that the lack of roads and bridges in the south was not simply due to geography.

Several difficulties with these figures, however, require serious examination. One problem is that there are no figures for the first four years of Japanese occupation. Could the north-south imbalance be due to an imbalance in Japanese roadbuilding from 1895 to 1899? While the evidence is not completely conclusive, Japanese records strongly suggest the 1899 imbalance was no greater than the 1895 imbalance. Most road building before 1899 was done by the military and military records show that they did not concentrate their road and

bridge building in the north.

A more troublesome problem is the vague definition of “road” and “bridge.” The roads measured by the Japanese in 1899 were little more than footpaths while many of the bridges were slabs of rock thrown across streams. Local Japanese inspectors were told not to consider the paths between rice paddies but otherwise the definition of what constituted a road or bridge was very elastic. Those measuring roads in the south of the island may have used a different definition of road or bridge than those in the north. I doubt this was a problem because western Taiwan was divided into three regions in 1899: north, south and a middle region that straddled the *Chuo-shuei-hsii*. Not only did the southern region report fewer roads and bridges than the northern region, but there was also a clear difference between the southern section or the middle region and the northern section of this region. Another problem is that there may have been good consistent reporting but many paths in the south may have been not quite large enough to be considered roads while northern paths were slightly wider and better developed and were considered roads. I have found no evidence, however, suggesting this was the case. In fact, since a much greater proportion of northern field was irrigated, there should have been many more between-paddy paths in the north, so that the northern transportation system was probably more superior to the southern system than the road length statistics would lead one to believe.

The greatest problem with the Japanese figures is that there are great regional differences within both the north and south and some of these differences look troublesome. In the south, both the Chiayi and Pingtung areas are reported as having almost no bridges. This may have been true of Chiayi since the late-Ch’ing local report on the region show very few bridges (*嘉義管內打貓各堡采訪冊*), but the local report on Ahou shows a great number of bridges (盧德嘉). Most of the bridges listed in the gazetteer were over irrigation channels and the Japanese statistics may have ignored these small bridges and only reported bridges over streams and rivers. In any case, the large growth in bridges in the far south after 1900 would seem suspect. In the following regressions, the dependent variables do not do a very good job of explaining the regional variation so that error terms suffer from serious spatial correlation problems which I have been unable to resolve.

3.2 Regression Results

The following regressions contain several problems (most importantly spatial correlation) and should be seen as simple descriptive regressions rather than structural regressions. The table presents two regressions describing the relationship between a set of variables and the length of road constructed in an area and two otherwise identical regressions showing how these variables relate to the number of bridges built in an area as of 1899 (民政部文書課 1901). In all cases, I use the earliest reasonable data the Japanese collected so as to try to reflect

conditions in the late-Ch'ing. Each observation is one of the 184 townships (堡 and 里) in which the western part of the island was divided.

The first regression for both roads and bridges basically shows the extent of north-south differences once population is taken into account. It classifies the population into two types: urban and rural. Urban areas are towns with a population of over 1000 in 1899. By this definition, slightly over 10% of the Chinese population in both the north and south were urban in 1899 (民政部文書課 1901). All the regressions also contain a dummy variable for Tainan City. Tainan City was a clear outlier. It had many more improvements in transportation infrastructure than any economic factors could justify. It is evidence that the cynical theory of transportation infrastructure is at least partially correct. Government officials probably built many roads and bridges with inscribed monuments in Tainan City not because they were needed there but because, as the capital of the island until the mid-1880s, that was the place where the official's greatness was best advertised. What these two regressions show is that a larger rural population was correlated with an increase a greater amount of roads and bridges, but a greater urban population was correlated only with a greater number of bridges. Perhaps, since urban populations lived close together, an increase in urban population did not necessitate a significant increase in roads. Part of the reason there was less transportation infrastructure in the south was that the south was less densely populated. After controlling for population, though, there was still significantly less transportation infrastructure south of the *Chuo-shuei-hsi* than in the north.

The second regression for both roads and bridges is a descriptive regression which shows how these dependent variables correlated with several factors which may be important causal factors in determining investment in transportation infrastructure.

On the demand side, one would expect self-sufficient farmers to need less transportation than farmers producing for a foreign market. One might therefore expect transportation improvements to be greater in areas producing Taiwan's export crops: tea in the north and sugar in the south (statistic taken from 民政部文書課 1901-1903 and 總督官房文書課). The regression shows that there were more roads in tea areas, but fewer bridges. It may be that coolies carrying tea leaves had little trouble fording mountain streams and that investment in bridges was unnecessary. Down south, sugar areas did not have any more roads and bridges than non-sugar areas. This is troublesome since sugar is very much a transport-intensive good. English customs officials claimed that a lack of good transportation in the south was a bottleneck in the sugar industry and this regression would seem to support their claim. One of the first things the Japanese sugar mills did when they entered southern Taiwan was to invest heavily in transportation. A small crop of sugar was produced up north and, in the north, sugar-producing did have significantly more roads and bridges than other areas. Finally, the existence of paddy land affected the demand for transportation infrastructure. Since paddies naturally created paths between plots of land,

they lowered the demand for roads that substituted for these paths and they also increased the demand for bridges by creating numerous canals to be crossed. The regressions show this affect may exist, but is too small to be identified for certain.

On the supply-side, a factor raising the cost of building roads and bridges was mountainous terrain. There was no easily obtained figure to judge the roughness of an area's terrain. I observed each bao and li on the old Japanese topographic maps and assigned each a value of (1) one, if I judged it mainly mountainous, (2) one-half, if I judged it to have large flat areas along with large mountain areas and (3) zero, if I judged it to be almost completely on the plains. I found, as expected, there were significantly fewer roads in areas with mountains. There were also fewer bridges but this difference was not statistically significant. It may be that mountain streams are sometimes easier to bridge than the wider streams down on the plains. Another important cost factor was the cost of capital. Roads and bridges were mainly funded locally and a circa-1906 Japanese study showed that interest rates varied throughout the island (臨時臺灣土地調查局 1906a & b). The regressions show that a large part of the variation in roads and bridges can be explained by the difference in area interest rates. Interest rates around Chiayi averaged roughly 24.5% per year while interest rates around Taipei and Ilan were about 14.5% per year. On this basis, one would predict 0.28 km less of roads per square kilometer around Chiayi compared with Taipei. The difference is reported as statistically significant, but again these variables suffer from spatial correlation problems so statistical significance is overstated. It is hard to interpret this result. The great variability in local interest rates throughout the island suggest that transaction costs in financial markets were high. We don't know to what extent the interest rates differed directly due to supply and demand and to what extent the rates differed due to a varying risk premium. It is possible that high interest rates merely show poor economic cooperation in a region and it was this lack of cooperation that held back public works.

4. Conclusions & Extensions

Conclusions are few. My research confirms that there were probably north-south differences in transportation but the quality of the evidence is much poorer and the situation more complex than I thought it would be when I was applying for this grant. I have hope that the evidence I have uncovered in gazeetters and *pei* inscriptions may lead to a publishable paper which deals with the change in the provision of transportation infrastructure over time or cross-strait differences rather than focusing on north-south differences. I now have compiled a data base of *pei* inscriptions that deal with the funding of local transport and temple projects and I am trying to use this to analyze regularities in the funding of public projects throughout the island.

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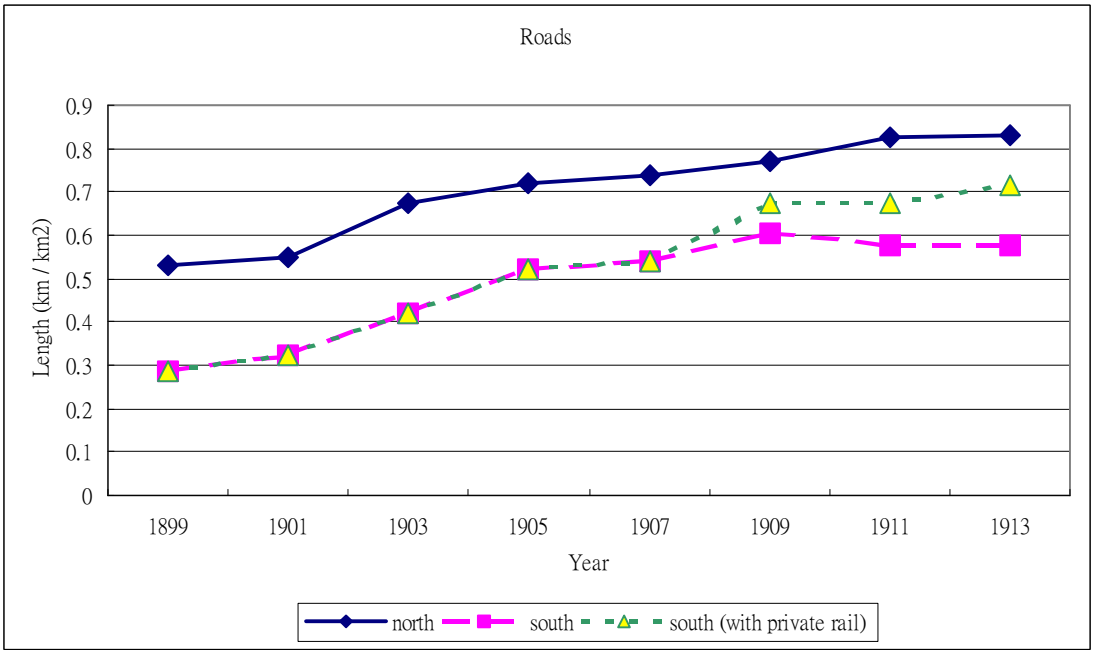
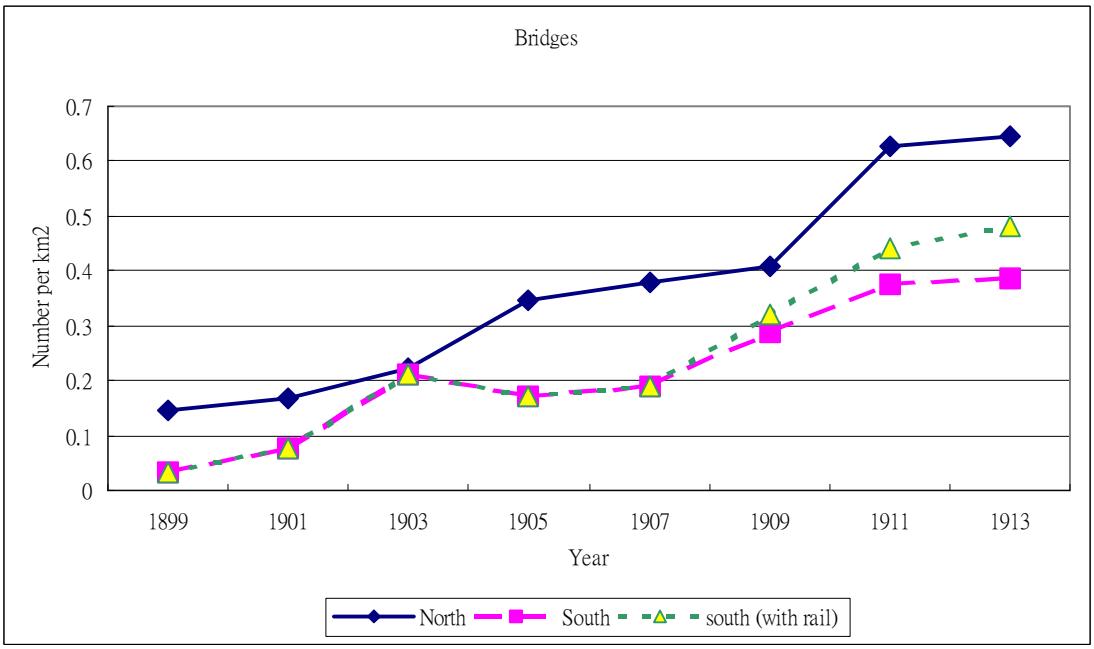
Table

Independent Variables	Dependent Variable			
	Roads (1899)		Bridges (1899)	
Intercept	0.352**	0.947**	0.087**	0.286**
	(0.056)	(0.169)	(0.020)	(0.064)
Tainan City	19.410**	19.259**	6.773**	6.984**
	(2.145)	(1.905)	(0.766)	(0.718)
South	-0.221**	-0.074	-0.108**	-0.089**
	(0.050)	(0.057)	(0.018)	(0.021)
Rural Population	1.123**	0.543	0.348**	0.069
	(0.280)	(0.372)	(0.100)	(0.140)
Urban Population	0.021	0.029	0.231**	0.208**
	(0.223)	(0.198)	(0.080)	(0.075)
Mountains		-0.173*		-0.042
		(0.070)		(0.026)
Paddy		-0.114		0.051
		(0.118)		(0.044)
Tea		29.516**		-7.666*
		(10.062)		(3.791)
Southern Sugar		-0.464		0.037
		(0.341)		(0.129)
Northern Sugar		5.649**		1.972**
		(1.230)		(0.464)
Interest Rate		-0.028**		-0.009**
		(0.007)		(0.003)
Observations	184	182	184	182
Adj. R-squared	.599	.701	.692	.744
Dep. Variable's Average Value	1.60	1.60	1.35	1.35

Roads are in units of km/km2. Bridges are #/km2. Figures given in the Japanese statistical tables are in 里 which are the equivalent of 3.92727 km. Population figures are 1000s/km2. Paddy is 1000s of 甲 per km2. Sugar and tea are in 1000s of 斤 per km2. I took an average of the amount harvested and manufactured (respectively) in the three years 1899-1901. Interest rates are in % per annum. The area of each township is that given by the 1903 land survey results.

Figures





Figures calculated from *臺灣總督府統計書*.