Chinese Immigration and the Canadian Pacific Railway: 1880-1885

Jincheng Zhi

Department of Economics
Queen's University
Kingston, Ontario K7L 3N6

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Abstract

The role of Chinese immigrants in building the Canadian Pacific Railway has often seemed controversial, but has been addressed with little economic analysis. Here, we analyze the details of their working contracts, which were essentially indentures, and we explain the nature of the role that Chinese workers played in the construction of CPR. A model of indenture allows us to make inferences about the productivity of Chinese workers. To help understand the motivation that led Chinese workers to migrate, a life-cycle model is presented to illustrate these immigrants' decisions.

Introduction

Canada has the largest population, after the United States, of Chinese people outside Asia. Between 1881 and 1981, the population of Chinese in Canada increased from 4,383 to 288,750 and the number is still increasing (Tan and Roy 1985, 17). The significant role that the Chinese have played in shaping the national demographics of Canada has led researchers to analyze the origins of Chinese immigration. Although there were a few Chinese, who came to Canada in the early 1800's, mass immigration from China did not begin until the 1880s.[1] The principal event marking the start of Chinese migration was the construction of the Canadian Pacific Railway (CPR), the transcontinental railroad that united the newly confederated Canada.

A great deal of research has been done on Chinese overseas migration in the context of social and ethnic studies, but the economics behind it, including the economic characteristics of the Chinese workers, has hardly been explored. The central questions addressed in this paper are: 1) what were the characteristics and nature of the roles that Chinese played in constructing the CPR, and 2) what attracted the Chinese to these jobs? I apply a model of indenture to address the first question, and a life-cycle model to explore the second. These models are used to explain the productivity of Chinese labour and to clarify the outcomes of their migration decisions. Part I provides background information on Chinese migration and the early role of Chinese workers. In Part II, I analyze the employment contracts of Chinese workers and make inferences about their productivity and other characteristics. Part III is concerned with their decision to migrate.

[1] Chinese came to Canada in large numbers first during the Fraser River gold rush, but in comparison to the construction of the CPR, that number was still small.

Part I Background

I.1 The Demand for Chinese Workers

Drawing on the experiences of railway construction in the United States, the Canadian Pacific Railway was built by the private CPR syndicate.[2] Unlike in other provinces, government directly put out the construction of some of the railway segments in British Columbia to private contractors, whose lowest price bid would win the contract.[3] This was part of the subsidy that the government provided to the CPR. Andrew Onderdonk, an experienced American rail construction contractor and engineer, won all the contracts to build the sections from Port Moody to Savona Ferry. In addition to placing the lowest bid, Onderdonk attributed his winning of these contracts to the government's preference for engaging a single builder (Su 1987, 53).

In particular, the contracts he won, totalling 212 miles, included the line through the Fraser Canyon and routes in the Rockies (see Table I.1). These were among the most difficult sections to build of the entire transcontinental railway.[4] Upon completing these contracts for the government, Onderdonk, in 1884, also took on a contract from the CPR syndicate to build an additional 125-mile section from Savona Ferry to Eagle Pass, meaning that Onderdonk supervised 337 miles of railroad construction altogether (Wright 1988, 6).[5]

[2] The Central Pacific Railway in the U.S. was built by private contractors, and Chinese migrant workers represented 90% of the total work force. The employment of Chinese was believed to have been the key to the completion of the railroad (Kraus 1969, 44-57).

[3] In other provinces, the railway was constructed by the government-subsidized CPR syndicate. Only construction in B.C. was directly contracted out by the government.

[4] The sections that Chinese workers worked were among the most difficult and costly ones. In particular, the section between Lytton and Fraser River cost Onderdonk $185,000 per kilometer (Stewart and McLean 1978, 84-86).

[5] The government contracts for the 212 miles of construction were the ones where the Chinese workers were employed.

Table I.1
Contracts Awarded to Onderdonk

Contract	Segments	Mileage	Bid ($)	Date
No. 60	Emory to North Bend	29 Miles	2,727,300	Dec 23, 1879
No. 61	North Bend to Lytton	29 Miles	2,573,640	Feb 10, 1880
No. 62	Lytton to Junction Flat	28.5 Miles	2,056,950	Dec 23, 1879
No. 63	Junction Flat to Savona Ferry	40.5 Miles	1,746,150	Dec 15, 1879
No. 92	Port Moody to Emory	85 Miles	*	Apr 13, 1882

* The exact details of this contract could not be found. The price is unknown, and so is the date that Onderdonk won this contract. However, as reported in *Inland Sentinel* April 13, 1882, Onderdonk's work began on this date.
Source: Kamloops Art Gallery, *the Onderdonk Way*, accessed on Aug, 2011

In order to reduce labour costs, Onderdonk adopted the American practice of hiring Chinese workers and stipulated this as a condition of his contract with the government. John A. Macdonald accordingly granted him special permission to hire labour from China (Tan and Roy 1985, 7). Facing anti-oriental protests by local communities, Prime Minister Macdonald clarified the purpose of having these Chinese workers in Canada: "It is simply a question of alternatives: either you must have this labour or you can't have the railway" (Berton 1971, 249-250).[6]

Although there was a preference for white workers over Chinese, Chinese were willing to work at lower wages and at the more unpleasant jobs (Canada, *Royal Commission* 1885, 46). As the *British Columbian* reported (at the wage offered to Chinese), "[in] no country did the supply ever fall so much short of the demand as it does here at the present time" (*British Columbian* 1882, April 19th). Between 1881

[6] To help counter the political opposition to Chinese labour, Onderdonk offered $75,000 (to compensate for their transportation costs) to bring 1,000 white labourers from other provinces to work for 2 years. However, the Provincial Government declined the offer (*British Columbian*, 1883, May 15th). The one feasible alternative they had left to them was to keep hiring Chinese.

and 1884, over 15,701 Chinese workers came to B.C. to work on the railroad (Canada, *Royal Commission* 1885, v).[7]

I.2 Chinese Immigration: the Push and Pull Factors

Most of these Chinese workers came from Siyi and Sanyi in Zhu San Jiao, the coastal region of Guangdong Province (Canton).[8] This south-eastern part of Guangdong was the origin of about 70 percent of all overseas Chinese in the nineteenth century (Tan and Roy 1985, 3). They came for reasons other than that Guangdong was geographically "China's window to the West" (Berton 1971, 197). In the middle of the nineteenth century, farmers there, who accounted for more than 60 percent of the population, owned just 6 percent of the agricultural land (Con and Wickberg 1982, 9). With a limited amount of farming land and a large population of farmers, earnings of farmers were low. One estimate puts the daily income as low as $0.07; although given the difficulty in comparing prices, this figure can hardly be verified (Berton 1971, 198).[9]

During the 1840s and 1860s, China experienced significant outflows of silver and other resources, first for opium, and then as reparations for the Opium Wars. The First and Second Opium Wars further broke down the tumbling Chinese agricultural economy, and with the civil revolution started by farmers (the Taiping Rebellion of 1850~1864), the entire Guangdong province was sent into social and economic

[7] Out of these, estimated deaths during construction of the railway were about 1,500 (Morton 1974, 135). This number is arguable, and compares to the 600 deaths reported by Onderdonk (Con and Wickberg 1982, 24). As the company did not record the names even of living Chinese workers and the bodies of the dead were often not found or sent back China, all these numbers represent guesswork (CCNC, Retrieved 2011).

[8] We preserve the official translation of Chinese here: Guangdong is the province of Canton; Zhu San Jiao is the Pearl River Delta of Guangdong. According to Lai's study (1975, 6), 99% of all the Chinese in B.C. originated from Guangdong in the 1880s.

[9] Converting the $0.07 to 1990's U.S. dollar values, this was about $1. It is not surprising that the average daily incomes for farmers in Guangdong were just about at subsistence levels after the conversion. In comparison, in Hong Kong a house servant received $0.10 to $0.33 per day, while a skilled mechanic could get $0.20 to $0.40 per day (Canada, *Royal Commission* 1885, 270).

turmoil (Tan and Roy 1985, 3). Throughout this ongoing national crisis, it became part of the culture for Guangdong citizens to send young men outside the province, so that they could send money to those back home (Su 1987, 31).

These "push factors" encouraged people to emigrate, but the "pull factors" that brought people to Canada were most likely the key motivators. The Convention of Peking, signed after the opium wars in 1860, permitted foreign companies to recruit labour in China.[10] Many Guangdong citizens returning from abroad, especially from the United States, brought substantial savings. Those who worked in U.S. gold mines and on the Central Pacific Railway in the 1850-1870's did particularly well (Street 2004, 349). America thus came to be regarded as the "Gold Mountain," the symbol for prosperity. With the Fraser River gold rush of 1858-1860, the Chinese began to perceive Canada as the new "Gold Mountain." To meet the demand for rail workers, Canadian firms established recruiting offices in Guangdong (Morton 1974, 84). The citizens of Guangdong had a long history of working in Cuba, Brazil and other South American countries, but work in the new "Gold Mountain" was much more attractive.[11] Slogans and ballads about the heavenly life in Canada were spread by those returning to China and by recruiting agents (Zhang and Mei 2001, 28).

Workers came to Canada by signing contracts under the "Credit Ticket" system.[12] Once they arrived, they worked under the supervision of the company, and regained their freedom only by fulfilling the duties outlined in the contract (see Part II). Many workers signed the contract with the idea of returning with substantial

[10] With the Emancipation Proclamation, the Convention of Peking had relieved North America's demand for cheap labour (Campbell 1923, 86).
[11] Canada, of all other countries in the western hemisphere, is one of the closest to Guangdong geographically.
[12] As most of them could not afford the transport costs, the "Credit Ticket" system involved essentially a type of indentured labour that allowed the worker to migrate without making any cash payments.

savings, and thus saw themselves as temporary workers.[13] For some, the path to wealth was more difficult and railway work was much harsher than the recruiting agents had claimed (Zhang and Mei 2001, 32).

Part II Chinese Workers as Indentured Servants

II.1 A Model of Indentured Servitude

To explore the characteristics and nature of the roles Chinese played during the construction of CPR, a model of indentured servitude is applied. This model, as outlined by Galenson (1981) and Grubb (1985) describes a credit system by which labour was leased, interpreting the position of immigrants to the America in the seventeenth and eighteenth centuries as a state of indentured servitude. The contracts dealt with the borrowing constraints faced by low-income European workers, who were unable to save for the cost of their passage, a problem also faced by Chinese workers. They were unable to get the funds to migrate, and the indenture allowed them to borrow against their future earnings. They obtained passage by selling claims along with other conditions on their future labour income. The borrowing constraint of migrant workers, a barrier to emigration, was thus mitigated through the indenture system.

A Chinese worker first signed a contract, with his guarantor providing collateral for the passage cost advanced by the recruiter. During the contract term, he received the promised earnings. He also agreed to repay the original passage plus 2.5 percent of his earnings to the agent (to compensate for recruiting costs, see Appendix

[13] In the "Credit Ticket" system, the worker needed a guarantor's assets as collateral in the event he could not make the repayment. It was not uncommon for these migrant workers to use their wives or other family members as collateral (Su 1987, 50).

A.2 for a detailed breakdown).[14] The agent then transported the workers to Canada and sold the contract to the railway contractor, who was the final employer (Zhang and Mei 2001, 28). With the indentured wage lower than the perceived marginal productivity of workers, the railway contractor paid the amount of their cost savings to the agent (Su 1987, 51).

Formally the indentured servitude contract can be written as:

$$P = \sum_{t=1}^{T} \frac{(MP_t - W_t)}{(1+i)^t} \quad (1)$$

Where *P* is the value of the contract, *MP* is the marginal productivity of the worker, *W* is the wage in the contract, *i* is the discount rate, and *T* is the contract length. If the market was efficient, the recruiting agency would receive the value of the contract, *P*, from the rail contractor, Onderdonk. This amount would be the same as the recruiting agent's net cost of bringing over the migrant worker.

II.2 Voyage Cost and the Length of the Trip

The cost for indentured workers to travel from Guangdong to Vancouver was about $15 to $20 per head (Canada, *Royal Commission* 1885, 46). Under the indenture system, this amount was advanced by the agent, to be paid back by the worker at the end of the contract period. This fare was heavily discounted and did not cover the true cost of the passage. As an illustration, the distance from Hong Kong (the point of embarkation) to Vancouver is almost twice that from Liverpool to New York, but the ticket price was about the same (Lewis 2001, 176).[15] The price was less than the cost of travel to San Francisco from Vancouver, and was available only through the recruiting agent. Those who needed to return home for personal reasons, such as

[14] He was only required to pay back the face value of the trip at the end of the contract.
[15] We are comparing the discounted fare from Hong Kong to Vancouver with the regular price from Liverpool to New York City.

sickness, had to pay the regular fare, roughly $50 (Canada, *Royal Commission* 1885, 46; 218). In our analysis, we assume this to be the true cost of bringing a Chinese worker to Canada (including the recruiting costs).[16]

The one-way trip took an estimated three to six months (CCNC, Retrieved 2011). Travelling from Liverpool to New York City took an average of 44 days, so at about double the distance (6374 miles versus 3307 miles), we expect it would take an average of 88 days to go from Guangdong to Vancouver.[17] We shall assume that the one-way trip took $4\frac{1}{2}$ months.

II.3 Contract Length

Although I did not find an actual contract signed by these Chinese rail workers, a reasonable assumption is that these workers were indentured for two or three years. This assumption is based on the experience of Chinese workers in the California gold rush and their work on railway construction in the United States, for which the lengths of contracts have been recorded, most of them ranging from two to three years (*New York Times*, April 28th 1879). As further evidence of this contract period, most workers from China arrived after 1882 and construction was completed in 1885.[18] The large influx of Chinese workers from Guangdong only began in 1882 (Canada, *Royal Commission* 1885, 158). In that single year, roughly 8,000 Chinese workers arrived, accounting for more than 50 percent of the migrant Chinese for the period 1880-1885 (Con and Wickberg 1982, 36). Together with the evidence that the expected

[16] The net difference between the true cost of the trip and what the workers paid back would be compensated by Onderdonk, thus the final employer of these migrant workers indirectly subsidized their low cost trip.

[17] The steamboat that these Chinese workers used were often referred to as the "floating hell" (Morse 1910, 165). It has been estimated that about 10% of the passengers died during such trips, although this mortality is highly doubtful (Gibbon 1973, 241).

[18] During the first two years of construction, 1880 and 1881, more than 50% of the Chinese rail workers came directly from California rather than China.

completion date of Onderdonk's rail project from Yale to Lytton was mid-1884, and the one from Lytton to Savona Ferry was mid-1885, we can deduce that most of the contract lengths were two or three years (Begg 1972, 429).

II.4 Wages Paid to Chinese Workers

The motive for hiring Chinese was to pay lower wages than to Canadians, and indeed the Chinese were paid significantly less. For non-Chinese unskilled workers, the minimum wage was typically \$2 to \$2.50 a day according to the *Royal Commission*.[19] In contrast, Chinese workers were paid \$0.75 to \$1.25 a day, and they had to purchase their own equipment at the construction site.[20] According to the official reports, the average gross wage of Chinese workers was \$25 per month, before expenses (Canada, *Royal Commission* 1885, 297-300, 366).

The Chinese wage was the same regardless of the work performed; \$25 per month was the rate for all types of job. After an adjustment of \$1.13 for the monthly cost of the working equipment, the true wage of a Chinese rail worker was \$23.87 per month.[21] On the other hand, non-Chinese labourers received \$55-\$175 per month, depending on their skill levels. A sample CPR advertisement is given in Appendix A.1. The weighted average monthly wage was \$81, and the wage for unskilled worker was \$55 (*Inland Sentinel* 1880, July 29th).

The Chinese rail worker worked nine months a year on rail construction (for three winter months there was no rail work), and they could take alternative part-time work for the remaining months. For the purpose of this paper, we consider only the

[19] A job advertisement posted by Onderdonk offered somewhat lower daily wages to non-Chinese, \$1.50 to \$1.75 per day (see Appendix A.1).
[20] The price of working equipment, such as picks, shovels and helmet, at the construction site was higher than at regular stores. If workers chose to buy elsewhere, they were charged a penalty (Zhang and Mei 2001, 71).
[21] The costs were \$10 for the 9 months of railway construction each year (Canada, *Royal Commission* 1885, 366).

wage received for rail construction and have normalized the wage received to a monthly basis, as reported in the *Royal Commission* (1885).

II.5 Value of the Indenture Contract

The net cost to the recruiting agent was the true cost of the passage, less what he received from the worker. For coming to work in Canada, the indenture system required the workers to repay the agent the price of the discounted fare that they had been advanced, plus an additional 2.5 percent of their earnings. This additional amount was mainly to compensate the agent for their recruitment costs.[22] Thus, the net cost to the agent, or the contract value can be formalized as:

$$P = P_f - P_d - 0.025 * E \quad (2)$$

Where P_f is the true transportation cost (including recruitment costs), P_d is the discounted price the agent charges, and E is the present value of the worker's total earnings. Depending on the assumed value of P_d, length of contract, the net cost, P, was between \$22 and \$32 (see Table II.1)

Table II.1
The Net Cost to Agents, P (dollars)

	T=2		*T*=3	
	i=0.04	*i*=0.08	*i*=0.04	*i*=0.08
P_d =15	30.81	32.09	26.24	28.37
P_d =20	26.19	27.80	21.79	24.40

Notes: Using equation (2), the net cost is calculated as in Appendix A.2. The numbers are \$50 less the "Total Paid" represented in Table A.1.

[22] See Appendix A.2 for a detailed decomposition.

II.6 Implied Marginal Productivity of Chinese Workers

To find the marginal product of the Chinese workers, we first discount all the cost savings the employer received over the contract term, which is the difference between the marginal product and the wage paid to these indentured workers. Assuming *MP*, *W*, and *i* are constant, it follows from equation (1) that:[23]

$$P = \frac{MP-W}{i}\left[1 - \frac{1}{(1+i)^T}\right] \quad (3)$$

$$MP = W + \frac{iP}{\left[1-\frac{1}{(1+i)^T}\right]} \quad (4)$$

With the assumed interest rate *i*=4% and 8%, *T*=2 years and 3 years, *W*=$23.87 per month, *Pf*=$50, and nine months of working each year, we solve for the implied *MP* (See Table II.2).

Table II.2
The Implied value of *MP* per Month

	T=2		*T=3*	
	i=0.04	*i*=0.08	*i*=0.04	*i*=0.08
Pd=15	28.62	28.98	26.57	26.83
Pd=20	28.08	28.44	26.31	26.56

Notes: See Appendix A.3 for the calculation that adjusts for the 9-month working year.

The implied marginal product is inversely related to the discounted fare price, since this is the amount paid by the worker. For a lower discounted fare, taking the true transport cost as given, the recruiters need more compensation from the railway contractor; thus the contractor would have to value the indenture contracts more. It follows that the marginal product of the worker is higher. For example, if P_d=15,

[23] To adjust for the fact that contracts for Chinese workers were nine months each year, the calculation is modified in Appendix A.3.

T= 2, and i =0.4, the implied *MP* of the worker is $28.62. It is $28.08 if P_d=20 is assumed. A longer indenture period also implies a lower marginal product.

II.7 Comparing Marginal Products of Chinese and Non-Chinese Workers

It was claimed that one non-Chinese worker produced as much as two Chinese workers, perhaps three times as much in winter (*Inland Sentinel* 1883, Sep 27th).[24] We apply the indenture model to deduce their relative productivities. For non-Chinese workers, the minimum wage and weighted average wage are assumed to equal their marginal productivities. Averaging the implied marginal product over the two interest rates for Chinese workers, the ratio of implied marginal product for Chinese [found in Section II.6] to non-Chinese workers is given in Table II.3.

Table II.3
MP of Chinese versus non-Chinese workers

	$\frac{MP}{MP_w}$	$\frac{MP}{MP_w^a}$
t=2	$\frac{28.5}{55} \approx \frac{1}{2}$	$\frac{28.5}{81} \approx \frac{1}{3}$
t=3	$\frac{26.6}{55} \approx \frac{1}{2}$	$\frac{26.6}{81} \approx \frac{1}{3}$

Notes: The calculation uses the numbers in Section II.4 and Table II.2. MP_w is the marginal productivity and MP_w^a is the weighted marginal productivity for white worker.

Chinese workers were roughly half as productive as unskilled white workers, and one-third as productive as the average of all non-Chinese workers. Clearly, the above comparison supports the apparent belief among Canadians of a large productivity discrepancy. The observed marginal productivity gap may be partially

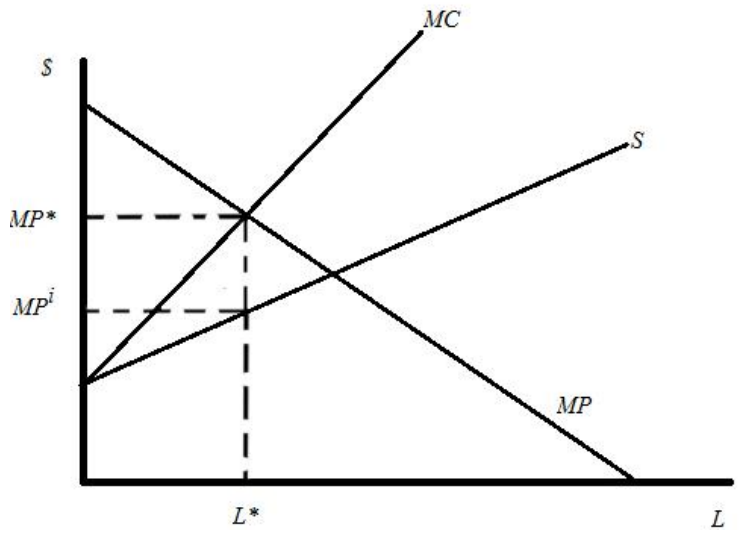
[24] With political pressure from the white community, the local contractors had to promote the image that the white workers were more productive than Chinese (*British Columbian* 1882, April 15th). Even the local laws contributed to reinforcing this perspective of the lesser productivity of Chinese workers (Roy 1989, 19).

explained by the fact that Chinese worked on the railway for a relatively short period. In contrast, the native workers stayed in the Canadian labour market, and thus obtained more experience.

II.8 The Productivity Gap and Monopsony Power

Although Chinese workers are assumed to receive their true marginal products, the railway contractor may have had monopsony power in the hiring of the Chinese. If that was the case, Chinese workers would have been receiving less than their marginal product.[25] In Figure II.2, Chinese workers receive MP^i, whereas their true marginal product is MP^*.

Figure II.1. The Labour Market for Chinese Migrant Worker



Equating MP^* to *MC*, we can solve for the relation between MP^i and MP^* from the labour supply curve:

$$MP^i = \rho L^\alpha = \text{the inverse labour supply curve} \quad (5)$$

$$MC = \frac{dMP^i{}_{*L}}{dL} = (1+\alpha)MP^i = MP^* \quad (6)$$

A larger value of α implies more monopsony power, and thus a greater productivity gap. The key implication is that in such a monopsonic labour market equilibrium the

[25] See Table II.2 for the value of the implied marginal product.

true *MP* of Chinese workers may have been much higher than what they were receiving. Suppose, for example, the labour supply elasticity ($\frac{1}{\alpha}$) was 1, then the true marginal product would be double their wage. Even if the elasticity were 3, their marginal product was one-third higher, in which case the marginal product of Chinese was close to ninety percent of that of unskilled non-Chinese workers. The value of the elasticity parameter was affected by the fact that Canada was a small market for all Chinese overseas workers, and thus the employer would likely had little monopolistic power. On the other hand, Onderdonk only hired citizens from Guangdong, and may have been drawing from a niche market. Note that Onderdonk advertised a daily wage (to non-Chinese workers) of 1.50 (See Appendix A.1). Assuming this wage would also result in a smaller implied productivity gap.

Part III The Migration Decision of the Chinese Workers: A Life-Cycle Approach

III.1 A Life-Cycle Model of the Migration Decision

Individuals may choose to migrate for reasons other than the expectation of higher income, but for the case of Chinese migration to Canada in the nineteenth century the economic benefit was likely the central motive. We formalize the migration decision with a life-cycle model of the type applied by Lewis and Armstrong (2010). Unlike the Lewis-Armstrong paper, here we assume no constraint on borrowing for the passage, because of the indenture arrangement.

With the borrowing constraint removed by the indenture system, those who migrate do so at the start of their (working) lives. Individuals base their migration decision on their lifetime utility. Their decision is determined by whether the lifetime utility associated with the different consumption streams is greater if they migrate. A

potential indentured worker faced three choices: 1) stay in China; 2) migrate and return to China after finishing the contract; 3) migrate and stay in Canada.

Case 1) Stay in China

The lifetime income of the person who stays in China is:

$$Y^s = \int_0^L w^s(t)e^{-it}dt \tag{7}$$

Where $w^s(t)$ is earnings in China at time *t*; *L* is the lifetime, and *i* is the discount rate. The lifetime budget constraint is:

$$\int_0^L c^s(t)e^{-it}dt = Y^s \tag{8}$$

Lifetime utility is given by:

$$U^{s*} = \int_0^L u[c^{s*}(t)]e^{-\rho t}dt \tag{9}$$

$u[*]$ is the utility function, ρ is pure rate of time preference, and c^{s*} is optimized consumption. Note that when $\rho = i$, consumption is constant over the lifetime.

Case 2) Migrate and Return

The cost of the one way trip, including the recruitment cost is P_f (Table A.1), and the cost for round trip is given by:

$$P_R = P_f + \frac{P_r}{(1+i)^T} \tag{10}$$

where T is the contract length and P_r is the cost of the return trip.[26] If the worker earns *MP(t)* in Canada, then lifetime earnings net of the transport cost are:

$$Y^r = \int_0^{t0} MP(t)e^{-it}dt + \int_{t0}^L w^s(t)e^{-it}dt - P_R \tag{11}$$

To allow for the disamenity cost of being in Canada, the utility function becomes $u(c) - \beta$ for those years when the migrant is in Canada. The disamenity cost term, β, summarizes the negative effect on utility of such factors as a language barrier, climate,

[26] P_r differs from P_f as that it does not include the agent's recruitment costs

and separation from family. Again, assuming $\rho = i$, and given the utility function has an additive disamenity cost, consumption (c^{r*}) is constant and the same in Canada and China. The lifetime budget constraint and lifetime utility (U^r) are given by:

$$Y^{r*} = \int_0^L c^{r*}(t)e^{-it}dt \tag{12}$$

$$U^{r*} = \int_0^{t0} u[c^{r*}(t) - \beta]e^{-\rho t}dt \; + \int_{t0}^{L} u[c^{r*}(t)]e^{-\rho t}dt \tag{13}$$

The worker's savings over the contract period is:

$$S = \int_0^{t0}[MP(t) - c^r(t)]e^{-it}dt - P_R \tag{14}$$

Case 3) Migrate and Stay in Canada

In this case the total migration cost is P_f, the cost of the one-way trip. With the assumption that the worker continues to earn $MP(t)$ in Canada after the contract ends, the lifetime earnings for this type of worker is given by equation (15). It equals lifetime consumption.

$$Y^m = \int_0^L MP(t)e^{-it}dt - P_{ow} = \int_0^L c^m(t)e^{-it}dt \tag{15}$$

Lifetime utility with a disamenity cost for living in Canada is given by:

$$U^{m*} = \int_0^L u[c^{m*}(t) - \beta]e^{-\rho t}dt \tag{16}$$

III.2 The Migration Decision: Comparing Consumption Streams

To further formalize the model, a Stone-Geary utility function is assumed with a constant intertemporal elasticity of substitution. If we assume a subsistence level of consumption of *s**, then the utility function can be written as:

$$u(c) = \begin{cases} \frac{(c-s^*)^{1-\delta}}{1-\delta}, \; if \; \delta \neq 1, and \; \delta > 0 \\ \ln(c - s^*), \; if \; \delta = 1, \end{cases} \tag{17}$$

where δ represents the inverse of the intertemporal elasticity of substitution. With a higher elasticity of substitution, the worker will be more willing to sacrifice short-

term consumption for gains in the long term. In other words, the agent is less time-sensitive and more willing to defer his consumption.

The subsistence consumption level for Chinese workers in Canada was likely lower than that of non-Chinese, in that they were willing to accept lower minimum consumption. However, a subsistence level of consumption for Chinese in Canada could not be found and the only credible source is the report of the *Royal Commission*, which reported that an indentured Chinese rail worker needed a minimum of $15.16 a month (Canada, *Royal Commission* 1885, 365). This amount includes the special taxes levied on Chinese workers only. The subsistence level of consumption in Guangdong was hard to find (Allen et al. 2004, p. 4). If we assume that the subsistence wage was the earnings of an average farmer, then it would be $2.10 a month.[27] To adjust for the different price levels in Canada and China, I employed a comparison of subsistence levels of consumption. For example, if the Chinese level of subsistence consumption is $2.1 per month, and the Canadian level of subsistence is assumed to be $10 per month, then every dollar of consumption in Canada is equivalent to $0.20 of consumption in China. In the analysis, we use three conversion rates.

To simplify the analysis, assume that the pure rate of time preference equals the discount rate, $\rho = i = 0.04$. In this case, workers will choose constant consumption throughout their lifetime. The lifetime budget constraint is given by:

$$Y = \int_0^L \bar{c}\, e^{-it} dt\,, \bar{c} = \frac{iY}{1-e^{-iL}}\,, \tag{18}$$

[27] Using the average wage of $0.07 per day (Berton 1971, 198).

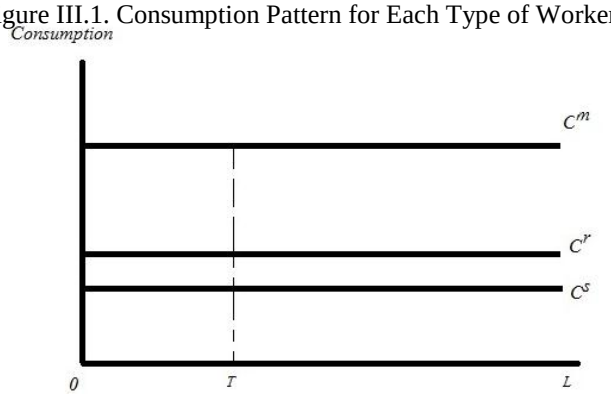
where Y is the present value of life time earnings, and $\bar{c}$ is constant consumption. Adjusting for the difference in price levels, the annual consumption for each case is reported in Table III.1.

Table III.1
Constant Annual Consumption for Each Type of Worker

$\frac{P_{ca}}{P_{cn}}$	$\bar{c}^S$	$\bar{c}^r$	$\bar{c}^m$
1.0	25.55	52.85	303.72
5.0	127.75	139.46	303.72
7.5	191.63	195.65	303.72

Notes: See Appendix A.5for calculations. $\frac{P_{ca}}{P_{cn}}$ is the ratio of the Canadian price level to the Chinese price level. The ratio of 5 is based on assumed subsistence in Canada of $10 per month. The value of 7.5 takes subsistence to be $15 per month (see text).

Figure III.1. Consumption Pattern for Each Type of Worker



The estimates in Table III.1 illustrate that, despite the existence of a disamenity cost, β, arising from anti-oriental discrimination, a different society, and hostile living and working conditions, migrants perceived the consumption gains as sufficient compensation. Though the true ratio of prices in Canada and China is unclear, a price ratio of 5 gives perhaps the most reasonable results as shown in Table III.1 and Figure III.1. As the consumption pattern suggests, the disamenity cost needed to be sufficiently large in order to make the migrant indifferent between staying and moving to Canada. This calculation also illustrates the reason why Canada was so attractive to Chinese workers. No matter how difficult the railway construction was, the work in Canada allowed significantly greater lifetime

consumption for those who returned to China, as well as for those who stayed in Canada. For a price ratio of 5, consumption of the migrant who returned to China was 10 percent greater; while the consumption of the migrant who stayed was nearly 140 percent greater.

Part IV Conclusion

Our analysis formalizes the nature of the indentured arrangement used to employ Chinese workers in the construction of CPR. Using information from both China and Canada, a model of the indenture has been used to analyze the productivity of Chinese labour. That productivity has been compared to the productivity of non-Chinese workers; and helps to shed light on what contemporaries viewed as large productivity gap. Using a life-cycle model, the paper also sheds light on the motivation of the indentured workers. Chinese workers who returned to China, enjoyed consumption that was perhaps 10 percent greater than that of workers who stayed; while the consumption of workers who remained in Canada was likely more than double.

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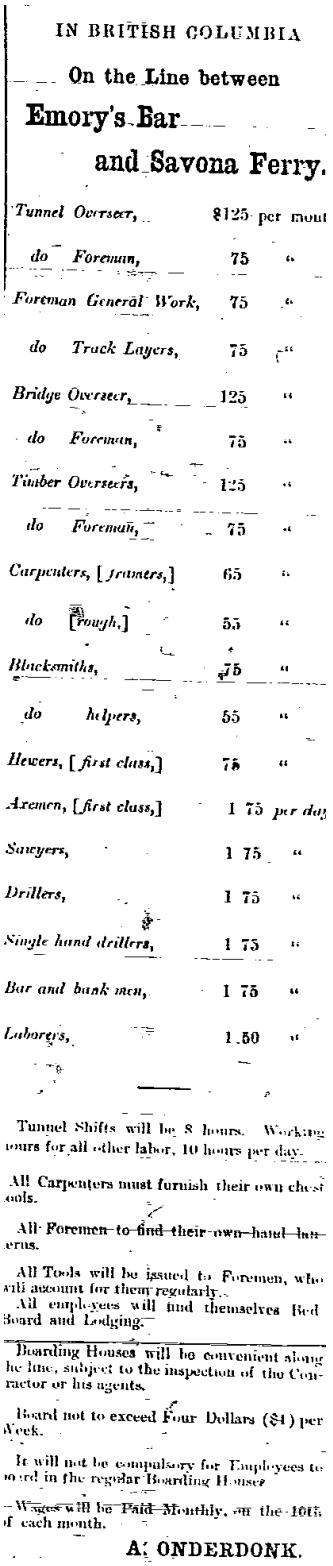
Appendix

A.1 Job Advertisement Posted by Onderdonk



IN BRITISH COLUMBIA

On the Line between

Emory's Bar

and Savona Ferry.

Tunnel Overseer,	$125	per mont
do Foreman,	75	"
Foreman General Work,	75	"
do Track Layers,	75	"
Bridge Overseer,	125	"
do Foreman,	75	"
Timber Overseers,	125	"
do Foreman,	75	"
Carpenters, [framers,]	65	"
do [rough,]	55	"
Blacksmiths,	75	"
do helpers,	55	"
Hewers, [first class,]	75	"
Axemen, [first class,]	1 75	*per day*
Sawyers,	1 75	"
Drillers,	1 75	"
Single hand drillers,	1 75	"
Bar and bank men,	1 75	"
Laborers,	1 50	"

Tunnel Shifts will be 8 hours. Working hours for all other labor, 10 hours per day.

All Carpenters must furnish their own chest tools.

All Foremen to find their own hand lanterns.

All Tools will be issued to Foremen, who will account for them regularly.

All employees will find themselves Bed Board and Lodging.

Boarding Houses will be convenient along the line, subject to the inspection of the Contractor or his agents.

Board not to exceed Four Dollars ($4) per Week.

It will not be compulsory for Employees to board in the regular Boarding Houses

Wages will be Paid Monthly, on the 10th of each month.

A. ONDERDONK.

*****Source: *Inland Sentinel*, July 29, 1880

A.2 Cost of Recruiting, Commission, and Interest on the Ticket

The workers agreed to pay 2.5% of all earnings in the indentured period. We now analyze what this amount was for. As shown in Table A.1, the longer the contract period, the more the agent would receive above the interest on the ticket; and the higher the interest rate, the less they would receive to compensate for other costs.

Table A.1
The Total Amount, Interest on the Advanced Ticket, and Commissions, Marketing/Recruiting Costs of the Agent Paid by the Migrant Workers

	Total Paid	Interest Paid	Commission, Marketing and Recruiting Costs
P_d=15,i=4%,T=2	19.19	1.22	2.97
P_d=15,i=4%,T=3	23.76	1.87	6.89
P_d=20,i=4%,T=2	23.81	1.63	2.18
P_d=20,i=4%,T=3	28.21	2.49	5.72
P_d=15,i=8%,T=2	17.91	2.49	0.42
P_d=15,i=8%,T=3	21.63	3.89	2.74
P_d=20,i=8%,T=2	22.20	3.33	(1.13)
P_d=20,i=8%,T=3	25.60	5.19	0.41

Note: Total paid $= 0.025 * \left(\frac{1}{i'}\left(1-\frac{1}{(1+i')^n}\right)\frac{1}{i}\left(1-\frac{1}{(1+i)^T}\right)\right) * W + \frac{P_d}{(1+i)^T}$

Interest Paid=$P_d * [(1+i)^T - 1]$, where i' is the monthly interest rate, W is the monthly wage (23.87), and n=9

A.3 Modified Indenture Model

The formula assumes the worker is employed by the railway for nine months each year.

$$P = (MP - W)\left(\frac{1}{i'}\left(1-\frac{1}{(1+i')^n}\right)\frac{1}{i}\left(1-\frac{1}{(1+i)^{T-1}}\right)\right) \qquad \text{(A.1)}$$

$$MP = W + P\left(\frac{ii'}{\left(1-\frac{1}{(1+i')^n}\right)\left(1-\frac{1}{(1+i)^{T-1}}\right)}\right) \quad \text{(A.2)}$$

Where *MP* is the marginal productivity, *W* is the wage, *P* is the net cost to the agent, *i* is the annual interest rate, *i'* is the monthly interest rate, *n* is the number of working months per year (assumed to be 9), and *T* is the total contract period in years.

A.4 Calculation of Consumption Streams

Using a \$0.07 daily wage, the non-migrant worker in China earns \$25.55 per year. This is also the smoothed level of consumption over the lifetime. Normalized to Canadian price levels for $\frac{P_{ca}}{P_{cn}} = 1, 5, 7.5$, the ratios convert annual earnings of \$25.55, \$127.75, and \$191.63, respectively.

Assuming a 40 year (working) lifetime, and a monthly marginal product, *MP*=\$27.3, the annual wage for a rail worker is \$245.70. For those who stay in Canada after the completion of the railway, assuming he still earns the same as before but can now work 12 months a year, it would be \$327.60. The taxes and other fees amounted to \$10 a year, which leaves the annual net income for a rail worker in Canada at \$235.7 per year ($MP_{ca}^{n=9}$); and those who stay in Canada after the completion of railway, gets \$317.6 per year ($MP_{ca}^{n=12}$). Using equations (8), (12), (15), and (18), and *i=0.04*, *L=40*, $P_d = 20$, $P_{ow} = 25$, T=3, and $\frac{P_{ca}}{P_{cn}}$=5, the calculation is given by:

$$Y^{r*} = \frac{MP_{ca}^{n=9}}{i}\left(1-\frac{1}{(1+i)^T}\right) - P_R + \frac{MP_{cn}}{i}\left(1-\frac{1}{(1+i)^{L-T}}\right) * \frac{1}{(1+i)^T}$$

$$= \frac{235.7}{0.04}\left(1-\frac{1}{1.04^3}\right) - \left(50+\frac{45}{1.04^3}\right) + \frac{127.75}{1.04^3} * \left(1-\frac{1}{1.04^{37}}\right) * \frac{1}{0.04}$$

$$= 2760.32$$

$$C^{r*} = \frac{Y^r * i}{1 - \frac{1}{(1+i)^L}} = \frac{Y^r * 0.04}{1 - \frac{1}{1.04^{40}}} = 139.46$$

$$Y^{m*} = \frac{MP_{ca}^{n=9}}{i}\left(1 - \frac{1}{(1+i)^T}\right) - P_f + \frac{MP_{ca}^{n=12}}{i}\left(1 - \frac{1}{(1+i)^{L-T}}\right) * \frac{1}{(1+i)^T}$$

$$= \frac{235.7}{0.04}\left(1 - \frac{1}{1.04^3}\right) - 50 + \frac{317.75}{1.04^3} * \left(1 - \frac{1}{1.04^{37}}\right) * \frac{1}{0.04} = 6011.5$$

$$C^{m*} = \frac{Y^m * i}{1 - \frac{1}{(1+i)^L}} = \frac{Y^m * 0.04}{1 - \frac{1}{1.04^{40}}} = 303.72$$